National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Yukon-Charley Rivers National Preserve

Natural Resource Condition Assessment

Natural Resource Report NPS/YUCH/NRR—2012/527

ON THE COVER
A view of the Yukon River and Calico Bluff in Yukon-Charley Rivers National Preserve
Photograph by: David Curl

Yukon-Charley Rivers National Preserve

Natural Resource Condition Assessment

Natural Resource Report NPS/YUCH/NRR—2012/527

Kevin Stark

Kathy Kilkus

Eric Norton

Andy Nadeau

Lindsey Danielson

Shannon Amberg

Eric Iverson

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

June 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado 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.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available from the Central Alaska Network http://science.nature.nps.gov/im/units/cakn/ *and the Natural Resource Publications Management* website (http://www.nature.nps.gov/publications/nrpm/).

Please cite this publication as:

Stark, K. J., K. Kilkus, E. Norton, A. J. Nadeau, L. Danielson, S. Amberg, and E. Iverson. 2012. Yukon-Charley Rivers National Preserve: Natural resource condition assessment. Natural Resource Report NPS/YUCH/NRR—2012/527. National Park Service, Fort Collins, Colorado.

NPS 191/114573, June 2012

Contents

Contents (continued)

Figures

Page

Figures (continued)

Figures (continued)

Page

Figures (continued)

Page

Tables

Page

Tables (continued)

Page

Photos

Photos (continued)

Page

Plates

Page

Plates (continued)

Page

Appendices

Page

Appendices (continued)

Page

Executive Summary

The Natural Resource Condition Assessment (NRCA) Program aims to provide documentation about the current conditions of important park natural 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 YUCH 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); and report program performance (e.g., Department of the Interior's Strategic Plan "land health" goals, Government Performance and Results Act).

The objectives of this assessment are to evaluate and to report on current conditions of key park resources, to evaluate critical data and knowledge gaps, and to highlight selected existing stressors and emerging threats to resources or processes. For the purpose of this NRCA, staff from the National Park Service (NPS) and Saint Mary's University of Minnesota – GeoSpatial Services (SMUMN GSS) identified key resources, referred to as "components" in the project. The selected components included natural resources and processes that are currently of the greatest concern to park management at YUCH. The final project framework contained 21 resource components, along with measures, stressors, and reference conditions for each. Seven of the components in the framework were recognized by NPS staff during project scoping as having little or no data and information available to conduct a detailed assessment. These components, considered "placeholders", list proposed measures, possible stressors, and past studies that may provide limited baseline information to future assessments. No statements regarding their condition are made.

This study involved reviewing existing literature and data for each of the components in the framework and, where appropriate, analyzing the data in order to provide summaries. Existing data for each measure were compared to reference conditions, when possible, and a weighted scoring system was applied to express the current condition of the components. Weighted condition scores ranging from zero to one, were divided into three condition categories: low concern, moderate concern, and significant concern. In some cases condition was not assigned because data were lacking or reference conditions were not yet developed. The discussions for each component in the report represent a summary of available information regarding the current conditions of these resources. These discussions were derived from published literature, but in some cases included unpublished park data and the perspectives of the park biologist and other NPS topical experts.

Multiple threats and stressors to park resources were identified. Climate change is a threat to multiple resources in the preserve. Predicted increases in air temperatures and an effectively drier climate has the potential for widespread ecological consequences, altering such things as hydrologic processes (e.g., surface water dynamics), permafrost extent and dynamics, fire regime, and vegetation succession. Some evidence of lake drying and draining exists in the preserve in comparing historic data to present day aerial photography. The causes of which may be tied to climate change. Alterations to natural processes may result in changes to various habitats of the preserve's biota. For example, some rare and endemic plant species in steppe communities may be favored by warmer and effectively drier climatic conditions while others may be negatively impacted by increased temperatures, reducing overall species diversity. Some specific examples of possible climate change effects are alterations to fire regime resulting in reduced caribou winter habitat, or the alteration of forage quantity and availability for both caribou and sheep.

Harvest is considered a stressor to multiple focal mammal species in the preserve. However, harvest is managed with the intention of sustaining healthy populations of each species, and evidence generally suggests that this is occurring. Some large, focal mammal species are also affected by natural factors/stressors such as high summer air temperatures, deep winter snow, insect harassment, and predation. Wolf populations in the preserve may be affected by predator control activities near the preserve. While wolf harvest by trapping occurs within the preserve, at its present-day levels it has had little effect on the wolf population. Wolf populations, however, are affected by natural factors such as fluctuations in ungulate population, ungulate nutritional health, and winter snow depths.

A primary anthropogenic stressor on preserve resources was past mining. Mining activities altered riparian areas of some the preserve's streams, namely Coal, Woodchopper, Sam, Ben, and Fourth of July Creeks. Potentially lasting effects of mining are not well understood as they have not been thoroughly reexamined since the late 1980s. Though lesser in area and in severity of impacts than that of mining, OHV use in the preserve has resulted in localized vegetation and soil disturbance. This can also act as a stressor to permafrost, creating thermokarst features in certain areas. The Alaska NPS is interested in understanding the extent of thermokarst features on the landscape caused by natural dynamic processes, by climate change, and by direct human disturbance. Presently, little is known about it permafrost and thermokarst in the preserve. Finally, another notable stressor is the presence of nonnative invasive plants in the preserve. Invasive plants are relatively few in number and density, compared with some Alaska NPS units, limited to more heavily used areas such as trail corridors, air-strips, and public use cabins in the preserve.

Little data are available that speak to the current status of several wildlife components in the preserve, including groups such as furbearers, small mammals, breeding birds, and particular species such as brown and black bears, ptarmigan, wood frogs, and boreal toads. Air quality of the preserve is not well understood as existing air quality monitoring sites are too far from the preserve. However, airborne contaminants are entering Alaska through trans-Pacific and trans-Arctic mechanisms. In addition to air quality, contaminants may threaten freshwater ecosystems (e.g., shallow lakes) of the preserve. Water quality data for the preserve are limited primarily to short term sampling efforts in various streams and lakes and long term records at just one location on the Yukon River upstream of the preserve. Despite this, water quality across the preserve is generally considered excellent. Future efforts to monitor aquatic ecosystems in the preserve will incorporate biological index methods. This will allow for a more holistic understanding of aquatic ecosystems in the preserve that incorporates the concept of biological integrity.

Given available data, several resource components in this assessment were considered to be of low concern (i.e., good condition). Peregrine falcons numbers steadily increased from the early 1970s through the early 2000s, and recent counts suggest the preserve's population may be stabilizing. Several others components examined in this assessment lacked enough information in order to assign an overall condition (i.e., level of concern). Only two components, anadromous fish species and hydrology (of the Yukon River) were considered of moderate concern. Stocks of Chinook salmon that pass through the preserve into Canada are considered a “stock of yield concern”, but what role, if any, the preserve’s aquatic ecosystems play into recent low numbers is not clear. While Chum salmon are abundant in terms of numbers migrating through the preserve, other anadromous fish species are comparatively low in numbers. The hydrology of the Yukon River is a concern because like other locations in Alaska ice break is on average occurring earlier each decade, which may represent a physical response to anthropogenic climatic changes. If this trend continued, it could have a set of consequences both ecological and cultural.

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, and technical expertise. Specifically, thank you to Sara Wesser for her support, advocacy, and coordination. Thank you to Alaska Regional NPS employees, Central Alaska Network (CAKN) staff, Yukon-Charley Rivers National Preserve (YUCH) staff, employees of YUGA (Yukon-Charley Rivers National Preserve and Gates of the Arctic National Park), and employees of Denali National Park and Preserve. Specifically, thank you to Jennifer Barnes (NPS - Alaska Regional fire ecologist), Andrew Ruth (NPS forestry technician),Trey Simmons (CAKN aquatic ecologist), Amy Larsen (YUGA aquatic ecologist), Carl Roland (CAKN botanist), David Swanson (ARCN ecologist), John Burch (YUGA biologist), and Melanie Flamme (YUGA Biologist). We appreciate additional expertise and review from the following individuals: Dave Daum (USFWS fish biologist), Jeff Gross (ADF&G area biologist), and Skip Ambrose (former USFWS Biologist, now of the Sandhill Company).

Acronyms and Abbreviations

ac - acre

ADF&G – Alaska Department of Fish and Game

AHAP - Alaska High Altitude Photography

AK DNR DOG – Alaska Department of Natural Resources, Division of Oil & Gas

ANILCA – Alaska National Interest Lands Conservation Act

ARCN – Arctic Network

CAKN – Central Alaska Network

cfs – cubic feet per second

CIR – color-infrared

EPA – Environmental Protection Agency

EPMT – Exotic Plant Management Team

GIS – Geographic Information Systems

GMU – Game Management Unit

GPRA – Government Performance and Results Act

ha – hectare

I&M – Inventory and Monitoring

m – meter

NHD - National Hydrography Dataset

NPS – National Park Service

NRCA – Natural Resource Condition Assessment

NRCS – Natural Resources Conservation Service

NWI - National Wetland Inventory

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

YUCH – Yukon-Charley Rivers National Preserve

YUGA – Yukon-Charley Rivers National Preserve / Gates of the Arctic National Park

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

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)

[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

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.

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

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 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 Yukon-Charley Rivers area was first protected as a National Monument by Presidential Proclamation on 1 December 1978. On 2 December 1980, the monument was redesignated as a National Preserve by the Alaska National Interest Lands Conservation Act (ANILCA, Pub. L. 96-487):

> to maintain the environmental integrity of the entire Charley River Basin, including streams, lakes, and other natural features, in its undeveloped natural condition for public benefit and scientific study; to protect habitat for, and populations of, fish and wildlife, including but not limited to the peregrine falcons and other raptorial birds, caribou, moose, Dall's sheep, grizzly bears, and wolves; and in a manner consistent with the foregoing, to protect and interpret historical sites and events associated with the gold rush on the Yukon River and the geological and paleontological history and cultural prehistory of the area. (ANILCA, section 201(10)).

ANILCA additionally provides for continued subsistence harvests within the preserve by native peoples and local residents.

2.1.2 Geographic Setting

Yukon-Charley Rivers National Preserve (YUCH) is located in the eastern interior of Alaska along the border with Canada's Yukon Territory. Its 2.5 million acres encompass 260 km (161 mi) of the Yukon River, the third longest river in North America, and the entire Charley River watershed. The preserve can be divided into two major ecoregions based on geology and divided by the east-west running Tintina Fault: the Ogilvie Mountains in the north and the Yukon Tanana Uplands in the south. The YUCH office and visitor center are located in the nearby town of Eagle as there are no roads running into the preserve. Access to the interior of the preserve is limited to boat or airplane.

The majority of YUCH escaped the most recent period of glaciation and was part of an important migration route for prehistoric people (Figure 1). As a result the preserve contains many rare and endemic plant populations as well as "an internationally significant assemblage of diverse geological and paleontological resources" that stretch back at least 600 million years (NPS 2004). YUCH also contains historical sites associated with the more recent gold rush, several of which are listed on the National Historic Register. The preserve maintains a number of historical cabins for public use, including a restored roadhouse and a mining camp both dating back to the early 1930s.

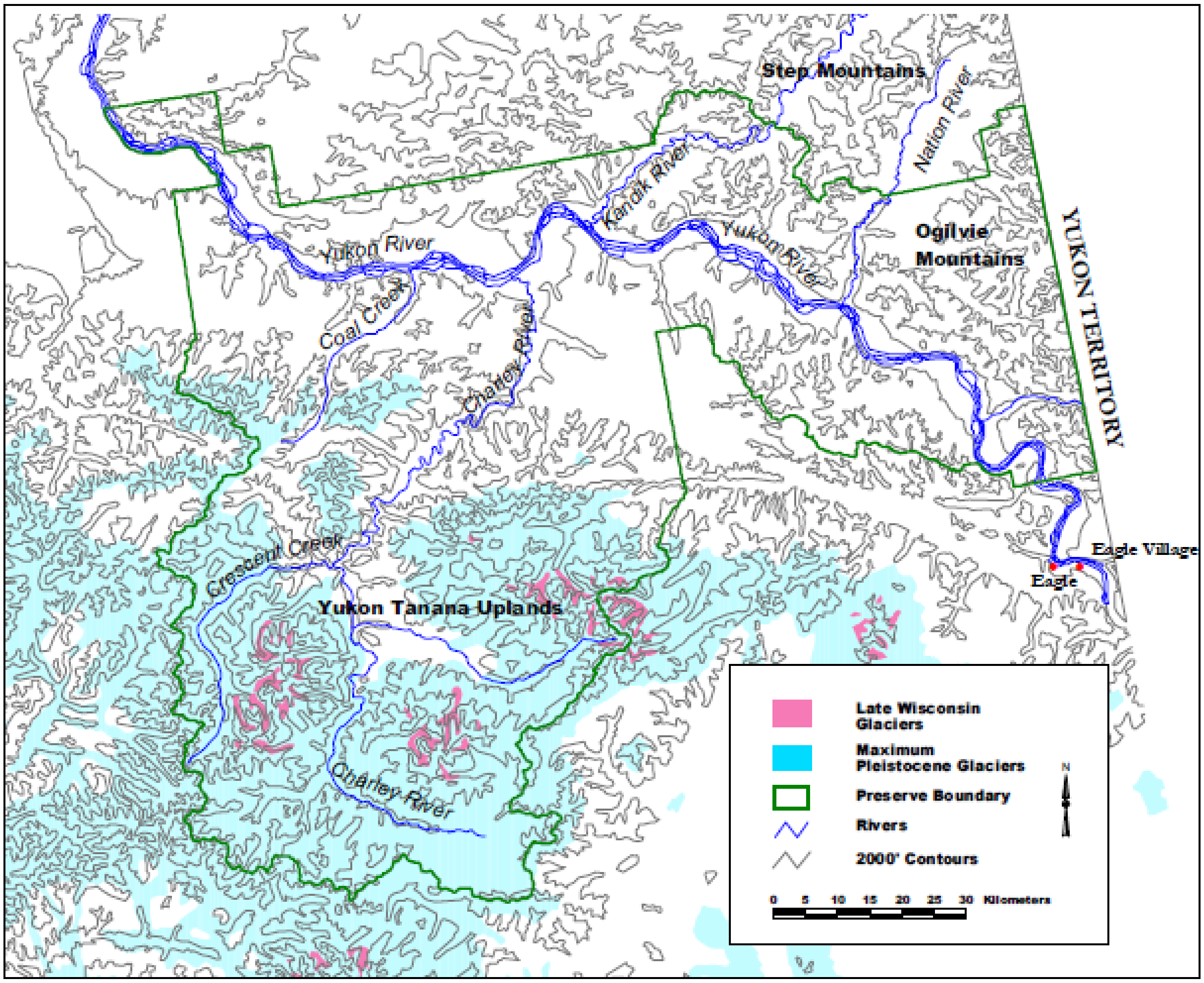


Figure 1. The maximum extent of glaciation during the Pleistocene within the current boundaries of YUCH (Larsen et al. 2004).

Climate

Climate is widely recognized as one of the most fundamental drivers of ecological condition and ecological change, particularly in Alaska (Sousanes 2007, CAKN 2010). As a primary driver behind many other ecosystem components (vegetation, wildlife, disturbance regime, etc.), climate also has numerous management consequences and implications. Extreme weather and climate phenomena often threaten the very survival of many subarctic plant and animal species (Redmond and Simeral 2006).

YUCH is subject to long, very cold winters and short, warm summers. It receives very little precipitation, which contributes to the role of fire as a major natural disturbance. On average, 8,100 ha (20,000 acres) burn within the preserve each year, nearly all of which are ignited by lightning. These fires are generally allowed to burn, as they play an important role in the fire dependent ecosystems of the preserve. Historical weather data has been gathered at Eagle, just south of YUCH, consistently since 1949. Table 1 shows the long-term temperature and precipitation means for this weather station.

Table 1. Eagle weather station mean monthly climate summary, period of record: 9/1/1949 to 6/30/2007 (adapted from Sousanes 2008).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C)													
Max	-19.8	-14.9	-5.5	5.5	15.0	21.5	22.7	19.3	12.1	0.1	-11.6	-17.1	2.3
Min	-29.7	-27.3	-22.2	-10.0	-0.1	6.5	8.3	5.1	-0.8	-9.4	-20.7	-26.5	-10.6
Average Precipitation (cm)													
Total	1.3	1.1	0.9	0.8	2.5	4.2	5.6	4.7	3.1	2.5	1.7	1.8	30.3
Snow Fall	19.8	17.5	13.5	7.9	2.0	0	0	0	2.3	24.4	27.2	29.2	144
Snow Depth	43.2	50.8	53.3	33.0	0	0	0	0	0	5.1	20.3	33.0	20.3

Climate normals, defined as the arithmetic mean computed over three consecutive decades (NCDC 2008), are also available for the Eagle weather station. Temperature and precipitation normals are available for Eagle, while a precipitation normal is also available for Circle City to the northwest of YUCH. The most recent climate normals available are for the years 1971 to 2000, calculated from data provided by the NPS Alaska Region Inventory and Monitoring Program in partnership with the Oregon State University PRISM Climate Group. Monthly temperature and precipitation normals are shown in Figure 2 and Figure 3. Average snow depth normals were available for three snowcourses near YUCH and are shown in Figure 4. Plate 1 shows the locations of some of the weather stations included in these figures.

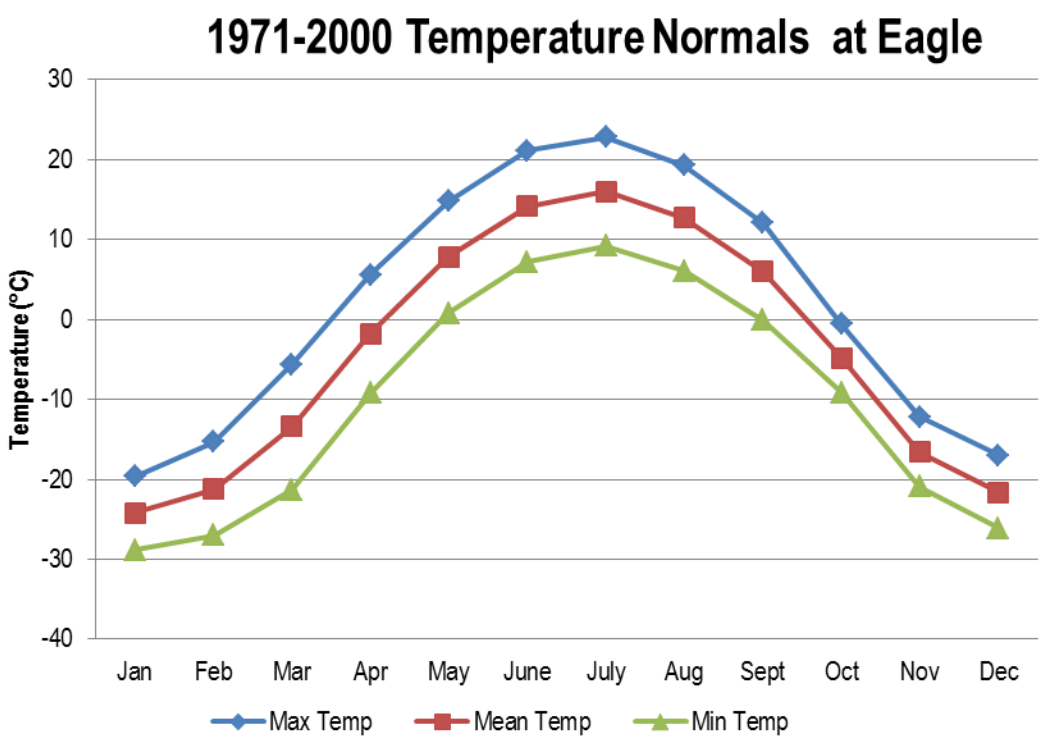


Figure 2. Monthly temperature normals in °C (mean, maximum, and minimum) for the Eagle weather station near YUCH, 1971-2000 (Keen 2008).

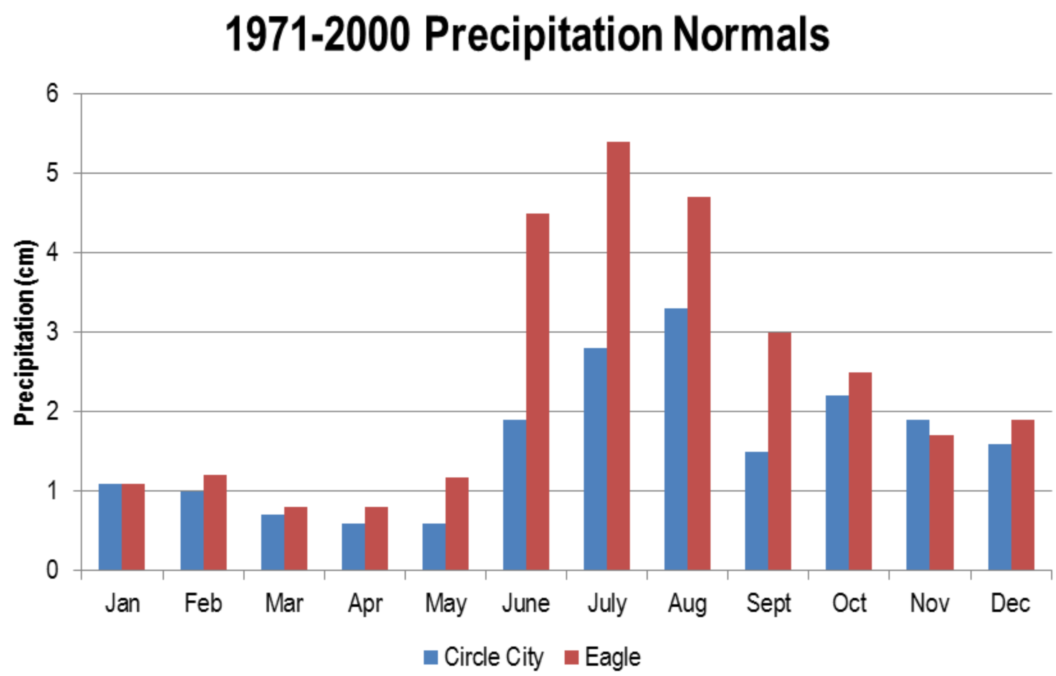


Figure 3. Monthly precipitation normals in cm for the Circle City and Eagle weather stations near YUCH (Keen 2008).

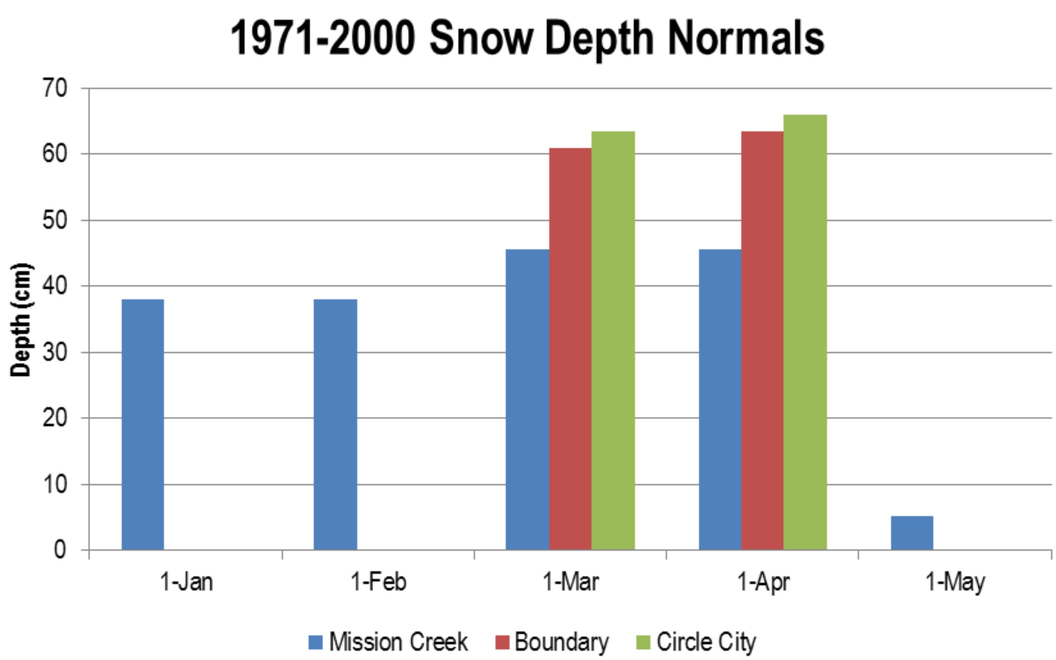


Figure 4. Snow depth normals in cm for three snowcourse measurement sites near YUCH (Keen 2008).

Several Remote Automated Weather Stations (RAWS) have been established in YUCH as part of the CAKN climate monitoring program but have not yet produced consistent long-term data.

The Ben Creek RAWS site was established in 1990 but only has three calendar years (1994, 1997, 2001) with data from every month of the year (Redmond and Simeral 2006). RAWS sites were also established at Coal Creek in 2004 and Upper Charley River in 2005. These monitoring stations, shown on Plate 1, will likely be invaluable to future analyses of climate and climate change within YUCH.

Photo 1. The Coal Creek RAWS station (photo by Pam Sousanes, NPS, 2004).

Climate in Alaska is constantly fluctuating on multiple temporal scales (Redmond and Simeral 2006). One climate fluctuation of particular importance in Alaska is the Pacific Decadal Oscillation (PDO) (Keen 2008). Mantua et al. (1997) formally identified this pattern of climate variability in a study relating climate oscillation to salmon production. The PDO, which is related to sea surface temperatures in the northern Pacific Ocean, affects atmospheric circulation patterns and alternates between positive and negative phases (Wendler and Shulski 2009). A positive phase is associated with a relatively strong low pressure center over the Aleutian Islands, which moves warmer air into the state, particularly during the winter (Wendler and Shulski 2009). Some of the variation in Alaska's climate over time can be explained by major shifts in the PDO which occurred in 1925 (negative to positive), 1947 (positive to negative), and 1977 (negative to positive) (Mantua et al. 1997). Hartmann and Wendler (2005) found that much of the warming that occurred in Alaska during the last half of the twentieth century was likely due to the PDO shift in 1976-77.

2.1.3 Visitation Statistics

Since 1982, YUCH has received just over 100,000 visitors. For the first 15 years of its existence as a National Preserve, annual visitation at YUCH averaged between 1,000 and 2,000 per year. The number of visitors rose in the early 2000s, peaking around 12,750 in 2005, then declining to around 6,400 in 2009 and 6,211 in 2010 (NPS 2010a). In 2010, YUCH ranked tenth in the total number of recreational visitors to Alaskan park units, behind parks such as Glacier Bay, Denali, Kenai Fjords, Wrangell-St. Elias, and Gates of the Arctic. Nearly 80% of visitors come to the preserve between June and August on average, with visitation peaking during August in recent years.

Photo 2. Visitors rafting on the Charley River in YUCH (NPS photo).

2.2 Natural Resources

2.2.1 Ecological Units and Watersheds

Three major ecoregions have been identified within YUCH: Yukon-Tanana Uplands, Ogilvie Mountains, and Yukon Old Crow Basin (Figure 5, Larsen et al. 2004). The Yukon-Tanana Uplands lie primarily south of the Tintina Fault and contain broad, rounded mountains (Photo 3, left). The region is underlain by discontinuous permafrost on north-facing slopes and in valley bottoms (Larsen et al. 2004). The Ogilvie Mountains to the north of the Tintina Fault contains flat-topped hills with barren ridgetops and eroded upper slopes (Photo 3, right). The area is dominated by rock outcrops (primarily limestone) and extensive scree slopes typical of an unglaciated region (Larsen et al. 2004). Low lying areas are frequently underlain by extensive permafrost. The Yukon Old Crow Basin covers a small area in the northwest corner of the preserve. It is a shallow gently sloping region that contains vast wetlands (Larsen et al. 2004).

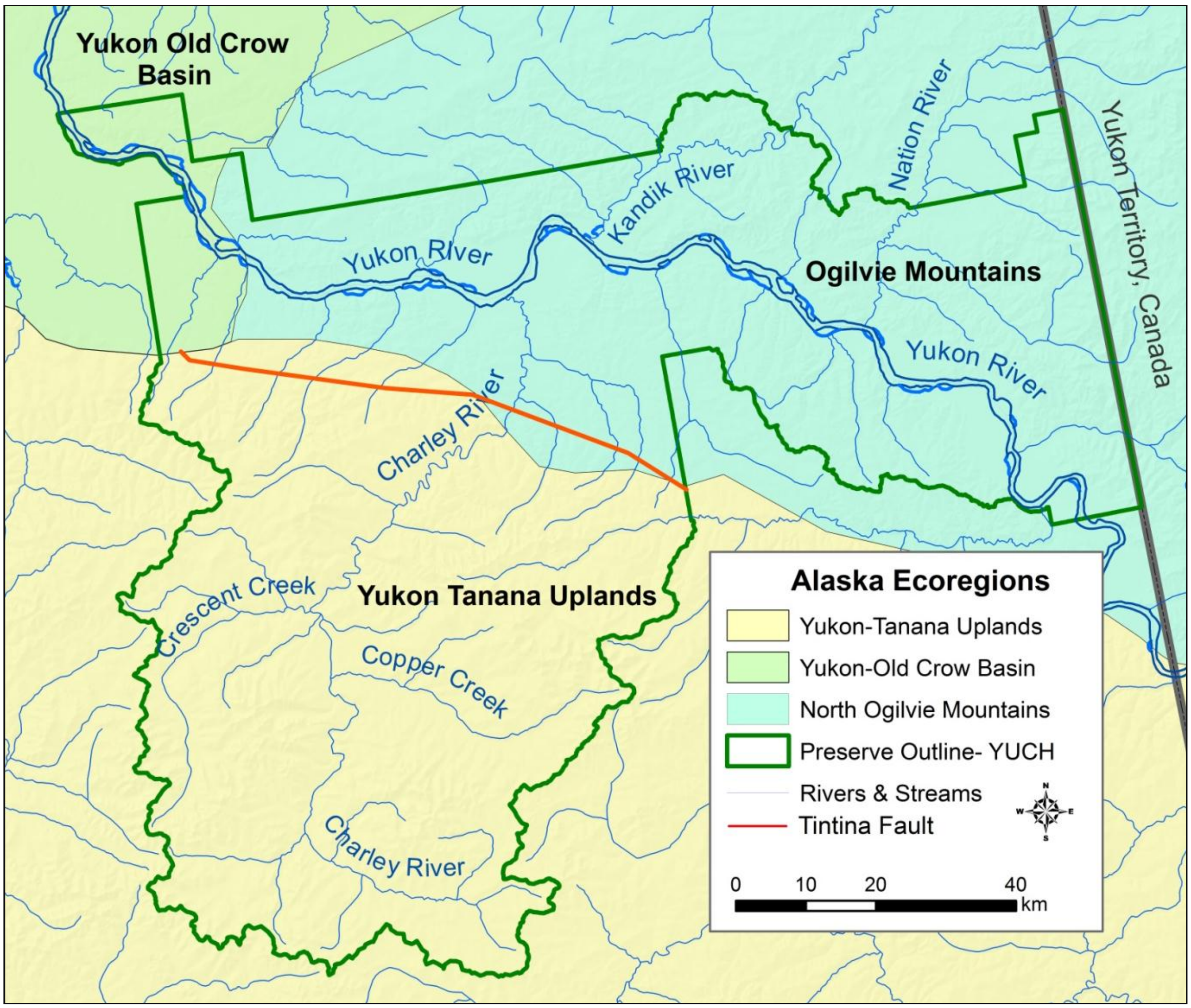


Figure 5. The three major ecoregions within YUCH. Reproduced from Larsen et al. (2004).

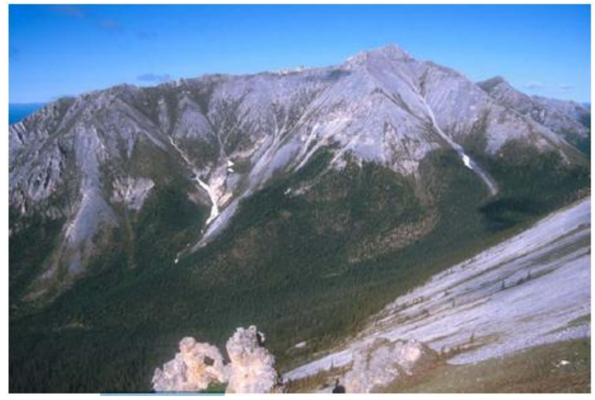
 

Photo 3. Views of the Yukon-Tanana Uplands (left, NPS photo by S. Swanson) and Ogilvie Mountains (right, NPS photo by C. Roland) ecoregions.

The preserve has also been divided into 14 ecological subsections. These subsections and their extent within YUCH are listed in Table 2. Detailed descriptions of each ecological subsection can be found in Swanson (2001).

Table 2. Ecological subsections of YUCH and their area within the preserve (Swanson 2001).

Subsections primarily north of the Tintina Fault	Area (km^2)
Biederman Hills	571
Hard Luck Lowland	161
Kandik Tableland	116
Little Black River Hills	239
Ogilvie Foothills	1,211
Ogilvie Lime/Dolostone Mountains	208
Snowy Domes	12
Thanksgiving Loess Plain	301
Tintina Hills	1,158
Yukon River Valley	1,177
Subsections primarily south of the Tintina Fault	
Charley Foothills	1,134
Three Fingers Subalpine Basin	273
Upper Charley Mountain Tundra	2,468
Upper Charley Valleys	1,167

YUCH contains the entire Charley River drainage as well as portions of four other rivers. The preserve contains a 260 km stretch of the Yukon River. Originating in Canada, the Yukon is a turbid, deeply channelized glacial river when it enters YUCH. The river rises and falls 3 to 6 m during the year, with the riverbed occasionally shifting, causing regular zones of disturbance along its banks (Larsen et al. 2004). The three rivers that enter the Yukon from the north within YUCH boundaries are, from west to east, the Kandik, Nation, and Tatonduk. The Charley River flows north 171 km from its headwaters in the Yukon-Tanana Uplands to the Yukon River. Its channel is generally narrow and deeply incised, undercutting steep rocky bluffs (Photo 4, Larsen et al. 2004). Major tributaries of this clear, high gradient river include Copper and Crescent Creeks.

Photo 4. The confluence of the Nation and Yukon Rivers (left, NPS photo) and the Charley River (right, photo by C. Roland) within YUCH.

2.2.2 Resource Descriptions

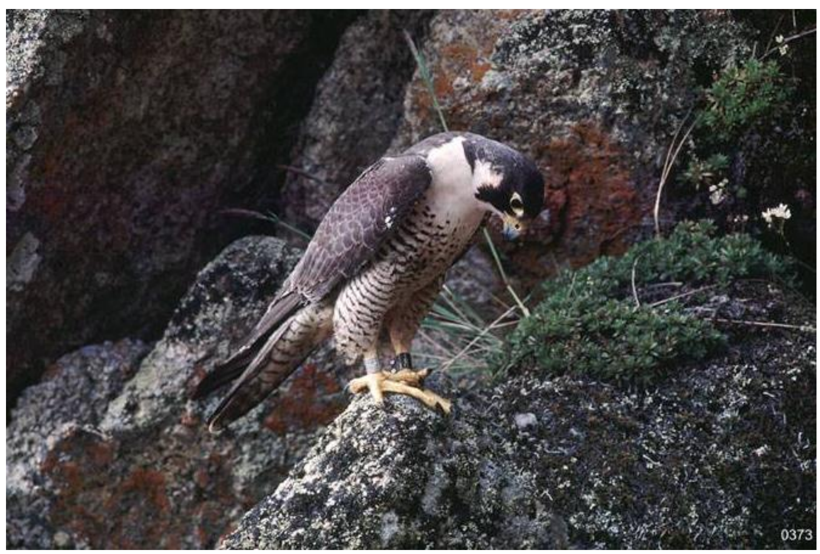


Photo 5. Peregrine falcon on a YUCH cliff (NPS photo).

Visitors to YUCH are often attracted by the scenic bluffs and mountains that rise along the Yukon River. The preserve contains boreal forests of spruce, primarily along its rivers, and poplar and birch in drier areas. At higher elevations, scrub and alpine tundra dominate the landscape. Wildlife within the preserve include caribou (*Rangifer tarandus*), moose (*Alces alces*), Dall's sheep (*Ovis dalli*), grizzly bears (*Ursus arctos*), wolves (*Canis lupus*), and one of the highest density populations of nesting peregrine falcons (*Falco peregrinus*) in the country (Photo 5).

Photo 6. Calico Bluff along the Yukon River (left), and a close-up of its visible rock layers (right) (NPS photos).

<u>Geology and Soils</u>

Surficial geology affects many components within the park landscape including hydrology and soils, which in turn influence vegetation and wildlife. The preserve is divided into two distinct geological areas by the Tintina Fault, a strike-slip fault that runs parallel to the Yukon River corridor and extends 965 km (600 mi) from northeast British Columbia into Alaska (NPS 2010b). The greatest bedrock diversity is found northeast of the fault in a triangular area formed by the Nation and Yukon Rivers and the Canadian border (NPS 2010b). This region, comprised of unmetamorphosed sediments, is thought to be part of the original North American plate. Southwest of the Tintina Fault there are igneous, metamorphic sedimentary, and volcanic rocks. These younger rock layers were likely metamorphosed and reformed when several small plates collided to form Alaska during the Cretaceous Period (NPS 2010b). The distribution of various rock types throughout the preserve is shown in Figure 6. Table 3 shows some of the geological formations that can be seen within the preserve and their position on a geological time line.

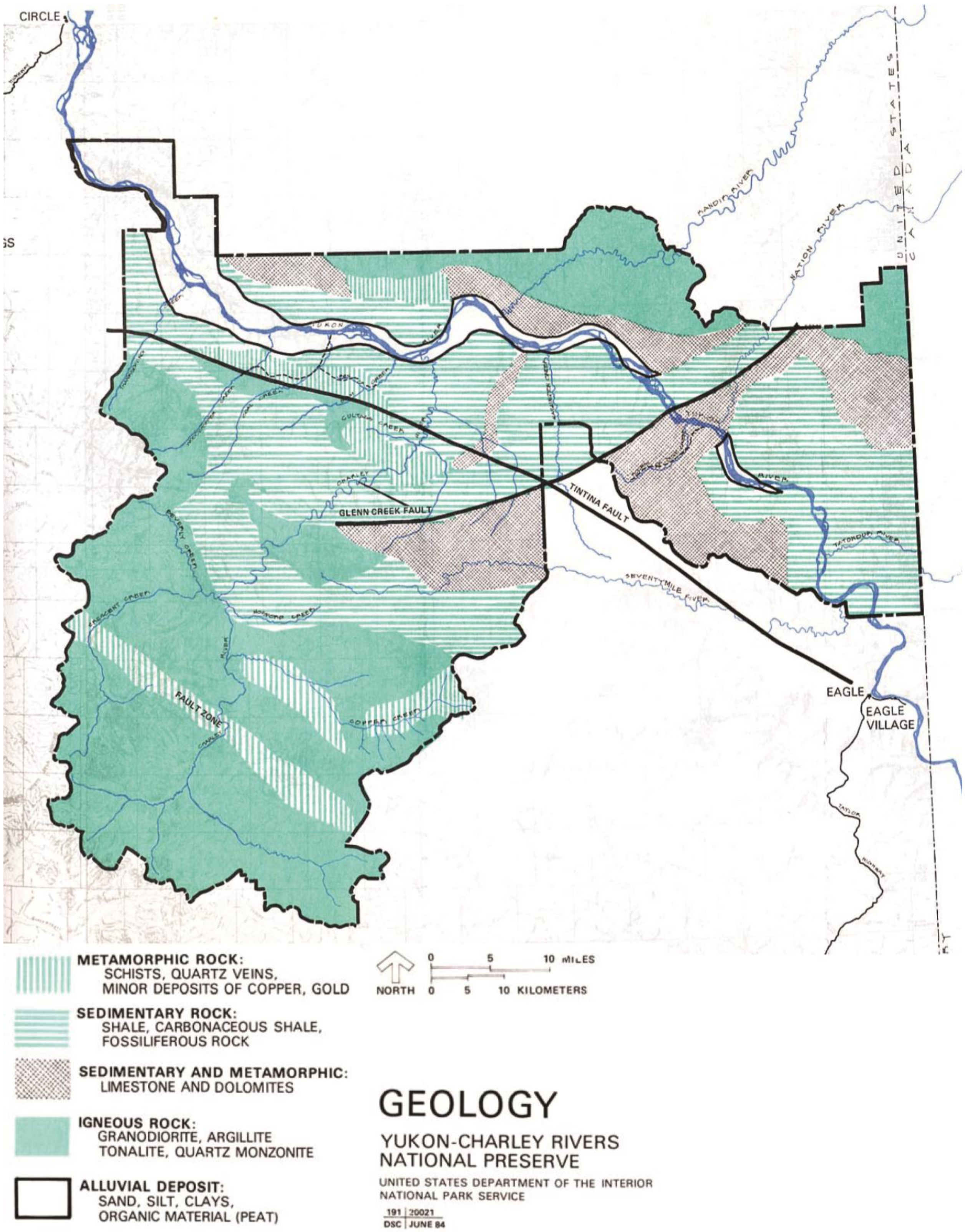


Figure 6. Generalized surficial geology of YUCH (NPS 1985).

Table 3. Geological time scale showing significant geological formations within YUCH and related paleontological events (NPS 2010b).

ERA	PERIOD	FORMATIONS	PALEONTOLOGY
	Quaternary	Qal flood plain	*Homo erectus*
CENOZOIC		Qt river terrace	*Australopithecus*
	Tertiary		Early horses
			Large mammals
65 m.y.}====	=======	Tks unit	Extinction of dinosaurs
		Kathul Graywacke	
	Cretaceous	Biederman Argillite	
MESOZOIC			
			Early flowering plants
	Jurassic	Glen Shale	Early birds & mammals
	Triassic		Dinosaurs
248 m.y.}===	=======		Extinction of trilobites
	Permian	Tahkandit Limestone/ Step Conglomerate	
	Pennsylvanian		Early reptiles
		Calico Bluff Formation	
	Mississippian		Coal formation
		Ford Lake Shale	
	Devonian	Nation River Formation	Early trees
PALEOZOIC		McCann Hill Chert	
	Silurian	Road River Formation	Early land plants
	Ordovician		Early fishes
		Hillard Limestone	
	Cambrian	Adams Argillite	
		Funnel Creek Limestone	Shelled fossils
545 m.y.}===	=======		
		Tinder Group	Early multi-celled organisms
PRECAMBRIAN			

Soils greatly influence many other landscape and ecosystem characteristics including vegetation patterns, hydrology, nutrient dynamics, habitat development, and landscape evolution (Martyn 2010). Soil structure, texture, and permeability can impact vegetational succession and nutrient cycling. Soils also influence the atmosphere by emitting or absorbing gasses such as carbon dioxide, methane, and water vapor (Martyn 2010). In Alaska, particularly in areas with permafrost, soils serve as an important carbon reservoir, sequestering it from the atmosphere (Martyn 2010). The Natural Resources Conservation Service (NRCS) conducted field work from 2008 to 2011, as part of a soil and ecological survey of YUCH. The final products of this effort (report, soils database, and GIS layers) are to be completed during 2012 (NPS, Pete Biggam, Soils Program Manager, pers. comm., 2011).

<u>Paleontological Resources</u>

The rocks north of the Yukon River within YUCH contain a remarkably unbroken history of the area from the Precambrian Era 800 million years ago to the Cenozoic Era 40 million years ago NPS 2010c, Table 3). Since this area was never glaciated, the paleontological record of this area is not buried under glacial debris and is more accessible, unlike much of Alaska. According to NPS (1985, p. 1), ―In terms of occurrence in a relatively small geographic area, completeness of record, and persistent presence of fossils, the Yukon-Charley Rivers vicinity has no peer in America.” The general location of significant paleontological resources within the preserve is shown in Plate 2.

Some of the oldest microfossils (e.g., pollen, spores, bacteria) in northwestern North America have been found in YUCH near the mouth of the Nation River (NPS 1985). In 1976, scientists discovered fossils of tiny single-celled organisms as well as flatworms and jellyfish that were found to be 700 million years old in the Tindir formation near the Tatonduk River (NPS 2010c, NPS n.d.). The Tahkandit limestone of the Nation River and Fourth of July Creek drainages also contains abundant fossil brachiopods up to 7.5 cm long and 5 cm wide (NPS n.d.). These invertebrates were composed of two hinged shells, giving them a bivalve appearance (NPS n.d.).

An ―outstanding record of marine faunal evolution” including ammonites and other mollusks, trilobites, corals, and crinoids can also be found in this region (NPS 2010b, p. 1, NPS n.d.). These marine invertebrates thrived during the Mississippian Period of the Paleozoic Era, 310-345 million years ago. Around one hundred species of fossil from this period have been uncovered within Calico Bluff along the Yukon River (NPS n.d.). The paleontology of the area is further discussed by Knoll and Tiffeny in Young (1976).

Between the late 1970s and the mid 2000s, very little paleontological exploration occurred in YUCH. In recent years, paleontologist Dr. Tony Fiorillo of the Dallas Museum of Nature and Science has been working within the preserve and is contracted with NPS to continue his research through 2014 (T. Fiorillo, phone conversation, 29 March 2011). His findings are currently under peer review and will be released when the review process is complete.

2.2.3. Resource Issues Overview

<u>Climate Change</u>

Unusually mild winters throughout much of Alaska in recent years and a substantial increase in temperatures during the 1990s is interpreted by many as a sign of large scale global warming (Redmond and Simeral 2006). Winter temperatures in interior Alaska have increased approximately 4°C (7°F) over the past few decades, and average arctic temperatures have reportedly increased at a rate that is nearly twice the average for the rest of the world over the last century (NPS 2007a). Changes in climate are expected to have a significant impact on vegetation, lakes and streams, chemical cycling, microbial biology, and wildlife distribution (Redmond and Simeral 2006, CAKN 2010). The frequency of extreme weather events, insect and disease outbreaks, and wildfires may also be influenced by climate change (SNAP et al. 2009).

There is a scientific consensus that human activities, particularly those that produce greenhouse gasses, have contributed to a general warming trend in global climate (IPCC 2007). Current warming has accelerated natural processes that release greenhouse gases into the atmosphere, such as permafrost thawing and ebullition (methane bubbling) from northern lakes, further contributing to global warming (Anisimov 2007, Walter et al. 2007). The decline of sea ice in the Arctic Ocean as a result of warming could also affect climate patterns in central Alaska (CAKN 2008).

Over the next century YUCH is expected to become warmer and drier. Temperatures are projected to increase at an average rate of about 0.6°C (1°F) per decade (SNAP et al. 2009). This will likely result in a transition from average annual temperatures below freezing (~-4°C) across the preserve, to temperatures near or above the freezing point (~0.6° C) (SNAP et al. 2009). Winter temperatures will change most dramatically, possibly increasing by 5.8°C (10.4°F) over the historical average by 2080. Precipitation is predicted to increase, yet increased evapotranspiration due to warmer temperatures and a longer growing season will likely lead to an overall drier climate (SNAP et al. 2009).

Non-native, Invasive Species

Traditionally Alaska has been protected from non-native species by its location, climate, and inaccessibility (Weidman and Mahovlic 2008). As a result, non-native invasive plants are a relatively recent threat to Alaskan ecosystems. These species can outcompete native plants and sometimes threaten the genetic integrity of native flora by interbreeding (Heys and Bauder 2005). They can also affect ecosystem structure and function by altering geochemical and geophysical processes (Heys and Bauder 2005). Given their hardiness and tolerance, many invasive plant species establish themselves in heavily disturbed areas such as road and trail corridors, landing strips and gravel bars (Schrader and Hennon 2005).

As of 2010, a total of 15 invasive plant species had been found within YUCH, although only in disturbed areas around cabins, trails, and airstrips (Heys and Bauder 2005, Passmore and Sherman 2010). The 2010 Exotic Plant Management Team (EPMT) reported 4.5 ha (11.25 ac) infested with invasive plants and treated 0.5 ha (1.3 ac) of these infestations (Passmore and Sherman 2010). This issue will be discussed in more detail in Chapter 4.

Mining History

One of the purposes of YUCH, as defined in its enabling legislation, is ―to protect and interpret historical sites and events associated with the gold rush on the Yukon River.” The first gold claim within the current YUCH boundary was filed on Coal Creek in 1901 (NPS 2011). Additional claims and mining activity occurred on Ben, Sam, Woodchopper, and Fourth of July Creeks. Slaven‘s Roadhouse was built in 1932 to support mining operations on Coal Creek and still stands today (Photo 7, left). Early mining was done by hand, until the arrival of the Coal Creek Dredge in 1936 when placer mining began (NPS 2011). The Coal Creek Dredge last operated in 1977 but remains within the preserve near Slaven‘s Roadhouse and can still be visited today (Photo 7; NPS 2009a). Preserving these and other historic structures are an important part of preserve management. Further information on YUCH‘s mining history can be found in Beckstead (2003).

Photo 7. Slaven’s Roadhouse (left, NPS photo) was placed on the National Register of Historic Places in 1987. The Coal Creek Dredge (right, NPS photo by Josh Spice) can be found just 1.6 km from Slaven’s Roadhouse.

Placer mining activity also had severe environmental impacts on watersheds in the preserve, especially Coal Creek (Brabets et al. 2000). The increased sediment transport associated with placer mining can affect water quality (Bjerklie and LaPerriere 1985) and damage aquatic habitat, particularly fish spawning areas (Brabets et al. 2000). While most mining sites within the preserve have been cleaned up, heavily-mined areas may still be impacted by the historic activity.

Subsistence

Providing subsistence harvest opportunities for traditional native users was a key purpose of the establishment of Alaska national parks and preserves by ANILCA. As a result, subsistence is an important consideration for YUCH managers. Due to its remoteness, subsistence harvest within the preserve has been relatively light and focused along the more easily accessed Yukon River corridor (Caulfield 1979). During the winter, snow machines are occasionally used for transportation along historic mail routes through the preserve. A traditional cycle of annual subsistence is shown in Table 4.

Table 4. Cycle of annual subsistence activities in the YUCH area (Caulfield 1979).

Season	Activities
Summer	Chinook salmon fishing; berry picking and gathering other plant materials for crafts
Fall	Chum salmon and other fishing; moose, sheep and bear hunting
Winter	Furbearer trapping; game bird and occasional large mammal hunting; firewood gathering
Spring	Beaver and muskrat trapping; black bear hunting; non-salmon fishing; occasional moose and waterfowl hunting

In 1976-77, Richard Caulfield conducted a comprehensive study of subsistence use in the proposed Yukon-Charley National Rivers area (Caulfield 1979). He identified four “resident user groups” in the region: residents of Eagle, Eagle Village, Circle, and households along the Yukon River between Eagle and Circle. Town residents (native and non-native) utilized the Yukon-Charley area primarily for moose and black bear (*Ursus americanus*) hunting and salmon fishing (chinook and chum) (Caulfield 1979). Twenty-eight residents (all non-native) in 13 households along the Yukon River utilized the area's resources for subsistence to a greater degree. They hunted moose, black bear, waterfowl, and game birds, fished for salmon and other species, and trapped marten (*Martes americana*), lynx (*Lynx canadensis*), wolf, beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*). Caulfield (1979, p. 88) determined that "Native people from Eagle Village and Circle do not currently make heavy use of subsistence resources within the Yukon-Charley proposal." However non-natives had "moved into traditional subsistence areas and are now actively dependent on the land" (Caulfield 1979, p. 87). He also found that traditional subsistence wildlife populations (moose, caribou, and salmon) appeared to be at a "low spot" and suggested that subsistence harvest could intensify if wildlife populations increased (Caulfield 1979, p. 82).

In the early 1980s, the NPS estimated that approximately 20 people resided in the preserve year-round, with 400 people visiting for subsistence purposes annually (NPS 1985; Table 5). The average subsistence visit lasted 21 days (NPS 1985).

Table 5. Subsistence visits to YUCH and backcountry overnight stays by month in 1982 and 1983 (NPS 1985).

Month	Subsistence visits 1982	Subsistence visits 1983	Backcountry overnight stays - 1982	Backcountry overnight stays - 1983
January	19	19	589	589
February	19	19	532	532
March	27	25	837	775
April	30	25	900	750
May	29	30	899	930
June	40	58	1200	1740
July	90	65	2790	2015
August	39	65	1209	2015
September	34	40	1020	1200
October	19	25	589	775
November	19	20	570	600
December	19	20	589	620
Total	384	411	11724	12541

Currently, the subsistence situation at YUCH is believed to be similar to that of 30 years ago. Harvest levels are generally low as hunting within the preserve is still limited by the inaccessibility of many areas and, for some species, by low population densities (i.e., moose). The Fortymile Caribou Herd is rarely hunted within the preserve but is often targeted when they migrate outside the YUCH boundaries. Subsistence fishing remains a significant activity in the communities of Eagle and Circle, with over 20,000 salmon harvested in some years. The most commonly harvested species are chinook and fall chum salmon (*Oncorhynchus tshawytscha* and *O. keta*), with some summer chum salmon and occasionally coho salmon (*O. kisutch*). The most recent harvest numbers reported by the ADF&G are shown in Table 6.

Table 6. Subsistence salmon harvest numbers (individual fish) in 2007 by species for Eagle and Circle (Fall et al. 2009).

	Households surveyed	Chinook	Summer chum	Fall chum	Total
Circle	11	1,057	200	1,286	2,543
Eagle	36	1,999	15	18,676	20,690

While subsistence harvest is an important part of the preserve's purpose, most wildlife harvested in the area in and around YUCH is completed under sport (i.e., state) regulations. The ADF&G manages and regulates harvest according to game management units (GMUs). The GMUs as they relate to the preserve boundaries are displayed in Plate 3. Individual sections of this document (e.g., moose) refer to this plate.

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

According to the vision statement for YUCH, "Since its establishment in 1980, the preserve has focused on establishing basic visitor services, resource protection and basic inventories, and an understanding of the natural and cultural values of this large, remote wilderness park" (NPS 2007b, p. 1). The preserve's centennial strategy (NPS 2007b) lists the following goals:

- Better understand the natural and cultural resources and values of the park.
  - Work on the need for basic inventories of resources and monitoring of natural systems.
  - Decision making is guided by well designed and planned research.
  - Natural ecosystems are preserved and healthy wildlife populations are intact.
  - Climate change effects are better understood and actions are taken to reduce impacts.
  - Manage subsistence activities as a natural component of ecosystem processes, involving local users with management decisions and scientific research.
- Demonstrate sustainable design, environmental leadership in park facilities. Inventory and maintain facilities to a good condition and develop additional energy and cost-saving technologies.
- Continue to develop visitor services that will help establish this "lesser known park" as a safe and welcome place to visit, served by a professional staff that includes local residents with a diverse background of experiences and skills.
  - Provide public education on safe and appropriate recreational opportunities (new websites, outreach, backcountry orientations).
- Develop educational programs combining traditional knowledge and western science into interpretive programs to promote protection, appreciation and understanding of the parks values. Facilitate multiple partnerships in meeting our land stewardship responsibilities, through resident participation, research and educational programs.

The Charley River was designated as a National Wild and Scenic River in 1980. It is protected by the Wild and Scenic Rivers Act of 1968 (Public Law 90-542) which states:

> It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The Congress declares that the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital conservation purposes (Wild and Scenic Rivers Act, Section 1(b)).

2.3.2 Status of Supporting Science

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

To facilitate this effort, 270 parks with significant natural resources were organized into 32 regional networks. YUCH is part of the Central Alaska Network (CAKN), which also includes Wrangell-St. Elias National Park and Denali 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. The CAKN identified 35 Vital Signs: 15 related to animal life, 11 to the physical environment, five to plant life, and four to human use (Table 7; MacCluskie and Oakley 2005).

Fourteen of these Vital Signs had existing monitoring or research programs, allowing CAKN monitoring to begin in 2006. Several additional monitoring programs have been implemented since and others are in the final stages of protocol development.

Table 7. Vital Signs of the Central Alaska Network Inventory & Monitoring Program (MacCluskie and Oakley 2005). Vital Signs in bold indicate network monitoring programs that began in 2006.

Animals	Arctic Ground Squirrel	Bald Eagles
	Brown Bears	Caribou
	Freshwater Fish	**Golden Eagles**
	Macroinvertebrates	**Moose**
	Passerines	**Peregrine Falcon**
	Ptarmigan	Sheep
	Small Mammals	**Snowshoe Hare**
	Wolves	
Physical Environment	**Air Quality**	**Climate**
	Fire	Glaciers
	Land Cover	Permafrost
	Rivers & Streams	**Shallow Lakes**
	Snow Pack	Soundscape
	Tectonics & Volcanoes	
Plants	Exotic Species	Insect Damage
	Plant Phenology	**Vegetation Structure/ Composition**
	Subarctic Steppe	
Humans	Human Population	Human Presence
	Trails	Natural Resource Consumption

Available data and reports utilized for this assessment varied significantly depending on the resource. The existing data that were used for each component to assess condition or inform reference condition are described in each component summary in Chapter 4.

Literature Cited

Anisimov, O. A. 2007. Potential feedback of thawing permafrost to the global climate system through methane emission. Environmental Research Letters 2(045016):1-7.

Beckstead, D. 2003. The world turned upside down: A history of mining on Coal Creek and Woodchopper Creek, Yukon-Charley Rivers National Preserve, Alaska. National Park Service, Fairbanks, Alaska.

Bjerklie, D. M., and J. D. LaPerriere 1985. Gold-mining effects on stream hydrology and water quality, Circle quadrangle, Alaska. American Water Resources Association 21:235-243.

Brabets, T. P., B. Wang, and R. H. Meade. 2000. Environmental and hydrologic overview of the Yukon River Basin, Alaska and Canada. U.S. Geological Survey, Anchorage, Alaska.

Caulfield, R. A. 1979. Subsistence use in and around the proposed Yukon-Charley National Rivers. Anthropology and Historic Preservation Occasional Paper No. 20. University of Alaska Cooperative Park Studies Unit, Fairbanks, Alaska.

Central Alaska Network (CAKN). 2008. Record temps recorded at network weather stations over past 7 years: Climate monitoring in the Central Alaska Network. Central Alaska Network Inventory and Monitoring Program. Online. (http://science.nature.nps.gov/im/units/cakn/Documents/resource%20summaries/RB_climateCAKN_may08.pdf). Accessed 15 February 2011.

Central Alaska Network (CAKN). 2010. Climate change resource brief. Online. (http://science.nature.nps.gov/ im/units/cakn/Documents/resource%20summaries/RB_ClimateChange_CAKN_ FINAL.pdf). Accessed 19 November 2010.

Churkin, M., H. L. Foster, R. M. Chapman, and F. R. Weber. 1982. Terranes and suture zones in east central Alaska. Journal of Geophysical Research 87:3718-3730.

Fall, J., L. Naves, C. Brown, L. Hutchinson-Scarbrough, M. Turek, T. Lemons, N. Braem, V. Ciccone, J. Simon, T. Krieg, and others. 2009. Alaska subsistence salmon fisheries 2007 annual report. Alaska Department of Fish and Game, Juneau, Alaska.

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.

Heys, J., and P. Bauder. 2005. BAER invasive plant survey, Yukon-Charley Rivers National Preserve, Coal and Woodchopper Creek watersheds: 2005 fieldwork report. National Park Service, Anchorage, Alaska.

Intergovernmental Panel on Climate Change (IPCC). 2007. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Online. (http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html). Accessed 22 November 2010.

Keen, R. S. 2008. Climate data analysis of existing weather stations in and around the Central Alaska Network: including Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve. National Park Service. Central Alaska Inventory and Monitoring Network, Fairbanks, Alaska.

Larsen, A., C. Rector, C. Roland, and M. Cook. 2004. Results of an inventory of the vascular plants of Yukon-Charley National Preserve. National Park Service Inventory and Monitoring Program, Central Alaska Network, Fairbanks, Alaska.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, R. C. Fancis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6):1069-1079.

Martyn, P. 2010. Inventorying soils in Alaska National Parks. Alaska Park Science 9(1):6-9.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Fairbanks, Alaska.

National Climatic Data Center. 2008. U.S. climate normals 1971-2000, products. (http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html). Accessed 12 March 2010.

National Park Service (NPS). n.d. Paleontology of Yukon-Charley Rivers National Preserve (Draft). National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

National Park Service (NPS). 1985. Yukon-Charley Rivers National Preserve, Alaska: General management plan, land protection plan, Charley Wild River management plan, and wilderness suitability review. National Park Service, Washington, D.C.

National Park Service (NPS). 2004. Central Alaska Network geologic resources evaluation scoping meeting summary. National Park Service, Alaska Region, Fairbanks, Alaska.

National Park Service (NPS). 2007a. Monitoring climate change. National Park Service, Denali National Park and Preserve. Online. (http://www.nps.gov/dena/naturescience/upload/Monitoring-Climate-Change.pdf). Accessed 15 February 2011.

National Park Service (NPS). 2007b. First annual centennial strategy for Yukon-Charley Rivers National Preserve. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

National Park Service (NPS). 2009a. Historic sites - Yukon-Charley Rivers National Preserve. Online. (http://www.nps.gov/yuch/historyculture/historicsites.htm). Accessed 16 March 2011.

National Park Service (NPS). 2009b. Program brief: Inventory and monitoring program. National Park Service, Natural Resource Program Center, Inventory and Monitoring Division, Fort Collins, Colorado.

National Park Service (NPS). 2010a. Yukon-Charley Rivers National Preserve Alaska reports. National Park Service public use statistics office. Online. (www.nature.nps.gov/stats). Accessed 31 January 2011.

National Park Service (NPS). 2010b. Geology down the Yukon - Yukon-Charley Rivers National Preserve. National Park Service. Online. (http://www.nps.gov/yuch/planyourvisit/upload/GeologyYukonRiver.pdf). Accessed 16 November 2010.

National Park Service (NPS). 2010c. Fossils in Alaska National Parks. National Park Service. Online. (http://www.nps.gov/akso/ParkWise/Students/ReferenceLibrary/Paleontology/FossilsinAKNPS.htm). Accessed 2 February 2011.

National Park Service (NPS). 2011. Mining history and techniques - Yukon-Charley Rivers National Preserve. Online. (http://www.nps.gov/yuch/planyourvisit/upload/Mining_History_Techniques.pdf). Accessed 16 March 2011.

Passmore, C., and M. S. Sherman. 2010. Invasive and exotic species management for Yukon-Charley Rivers National Preserve: 2010 Summary Report. Natural Resource Data Series NPS/YUCH/NRDS—2010/103. National Park Service, Fort Collins, Colorado.

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 (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 23 February 2011.

Schrader, B., and P. Hennon. 2005. Assessment of invasive species in Alaska and its national forests. Online. (http://akweeds.uaa.alaska.edu/pdfs/literature/Schrader_R10_Inv_Spp_Assessmt.pdf). Accessed 18 February 2011.

Sousanes, P. J. 2007. Monitoring seasonal and long-term climate changes and extremes in the Central Alaska Network. Alaska Park Science 6(2):22-25.

Sousanes, P. J. 2008. Annual climate summary 2006. Central Alaska Network. Natural Resource Technical Report NPS/CAKN/NRTR-2008/141. National Park Service, Fort Collins, Colorado.

Swanson, D. 2001. Ecological subsections of Yukon-Charley Rivers National Preserve. Photos by Shelli Swanson. National Park Service, Alaska Region, Anchorage, Alaska.

Walter, K. M., L. C. Smith, and F. S. Chapin, III. 2007. Methane bubbling from northern lakes: Present and future contributions to the global methane budget. Philosophical Transactions of The Royal Society 365:1657-1676.

Weidman, K., and W. Mahovlic. 2008. Exotic plant management report, Denali National Park. Online. (http://www.nps.gov/akso/NatRes/EPMT/Reports/DENA_EPMT_2008.pdf). Accessed 10 November 2010.

Wendler, G. and M. Shulski. 2009. A century of climate change for Fairbanks, Alaska. Arctic 62(3):295-300.

Young, S. B. 1976. The environment of the Yukon-Charley Rivers area, Alaska. Center for Northern Studies, Wolcott, Vermont.

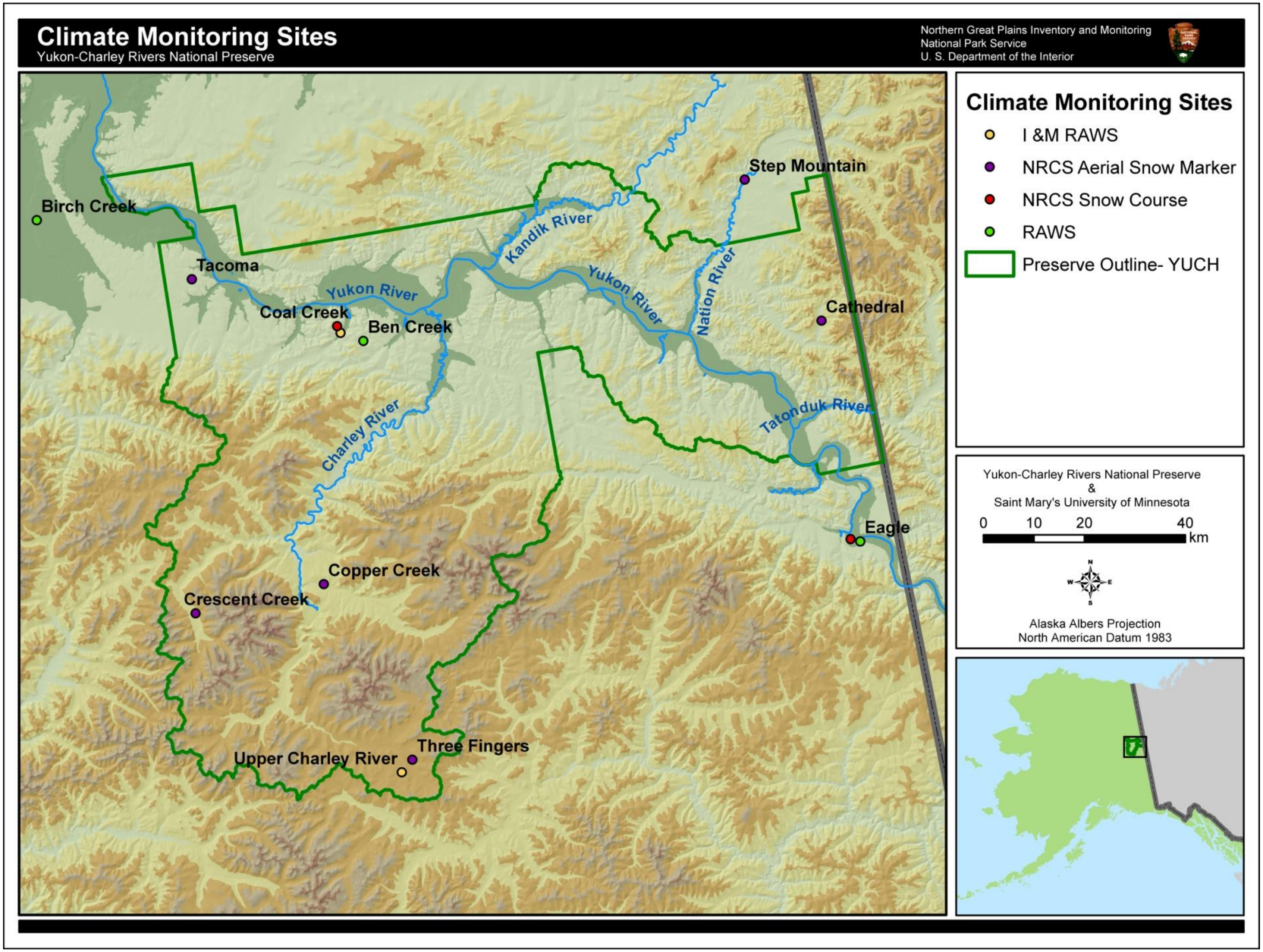


Plate 1. Climate monitoring sites in YUCH.

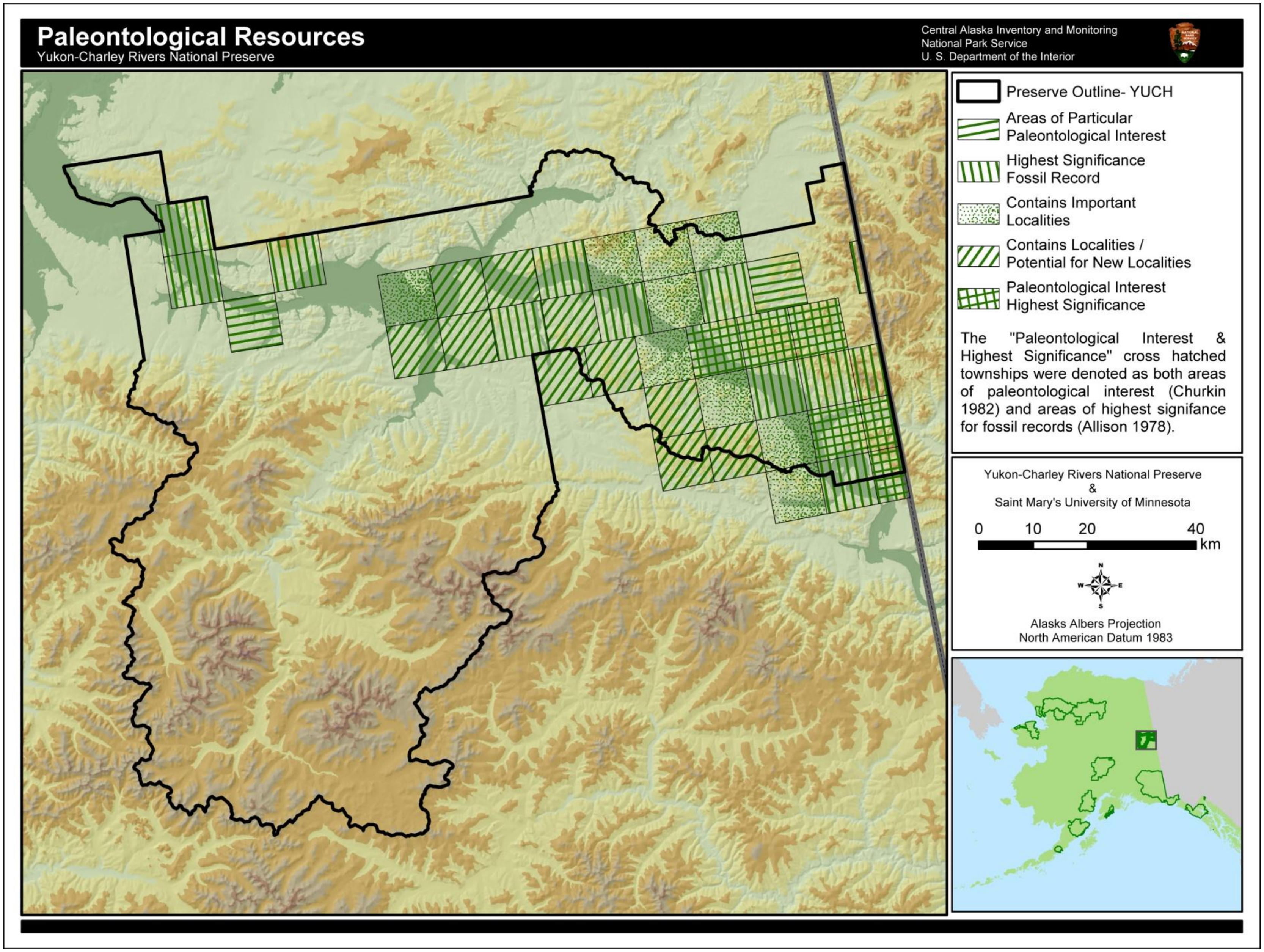


Plate 2. General location of significant paleontological resources within YUCH (adapted from NPS 1985).

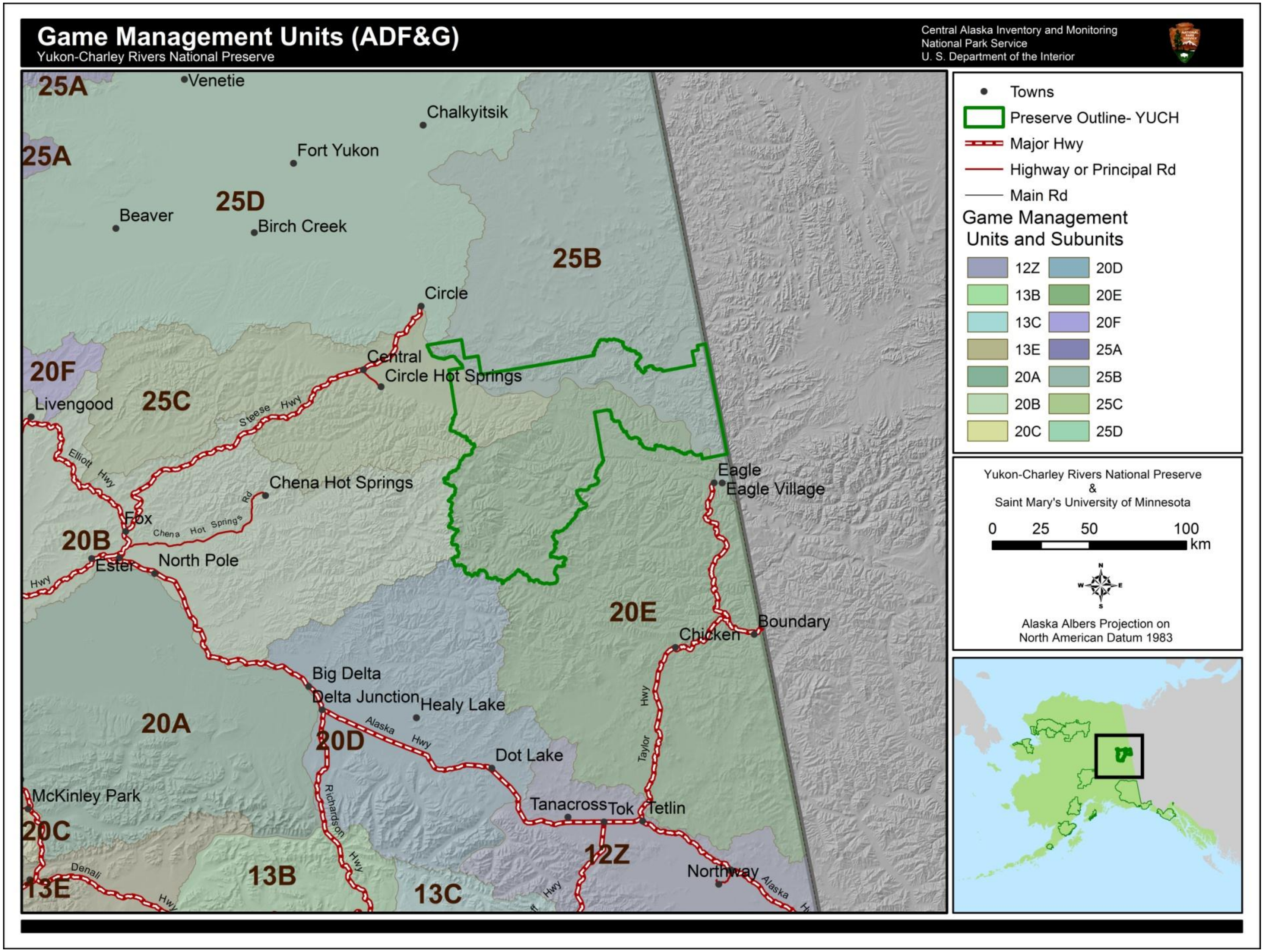


Plate 3. Game management units and subunits in and around YUCH.

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). Project stakeholders include the YUCH resource management team, YUGA staff, CAKN and ARCN Inventory and Monitoring Program staff. Before embarking on the project, it was necessary to identify the specific roles of the NPS and SMUMN GSS. Preliminary scoping meetings were held, and a task agreement and a scope of work document were created cooperatively between the NPS and SMUMN GSS.

3.1 Preliminary scoping

A preliminary scoping meeting was held on 4 August 2010. At this meeting, SMUMN GSS and NPS staff confirmed that the purpose of the YUCH 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 YUCH 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 YUCH resource management.

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

- Develop near-term management priorities (how to allocate limited staff and funding resources);
- Engage in watershed or landscape scale partnership and education efforts;
- Consider new preserve planning goals and take steps to further these;
- Report program performance (e.g., Department of Interior Strategic Plan "land health" goals, Government Performance and Results Act [GPRA]).

Specific project expectations and outcomes included the following:

- For key natural resource components, consolidate available data, reports, and spatial information from appropriate sources including: YUCH resource staff, NRInfo, Inventory and Monitoring Vital Signs, and available third-party sources. The NRCA report will provide a resource assessment and summary of pertinent data evaluated through this project.

- When appropriate, define a reference condition so that statements of current condition may be developed. The statements will describe the current state of a particular resource with respect to an agreed upon reference point.

- Clearly identify "management critical" data (i.e., those data relevant to the key resources). 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.

- Utilize "gray literature" and reports from third party research to the extent practicable.

3.2 Study Design

3.2.1 Component Framework, Focal Study Resources and Components

Selection of Resources and Measures
As defined by SMUMN GSS in the NRCA process, a "framework" is developed for a park or preserve. This framework is a way of organizing, in a hierarchical fashion, bio-geophysical resource topics considered important in park management efforts. The primary features in the framework are key resource components, measures, stressors, and reference conditions.

"Components" in this process are defined as natural resources (e.g., caribou), ecological processes or patterns (e.g., natural fire regime), or specific natural features or values (e.g., geological formations) that are considered important to current park management. Each key resource component has one or more "measures" that best define the current condition of a component being assessed in the NRCA. Measures are defined as those values or characterizations that evaluate and quantify the state of ecological health or integrity of a component. In addition to measures, current condition of components may be influenced by certain "stressors" which are also considered during assessment. A "stressor" is defined as any agent that imposes adverse changes upon a component. These typically refer to anthropogenic factors that adversely affect natural ecosystems, but may also include natural processes or disturbances such as floods, fires, or predation (adapted from GLEI 2010).

During the YUCH NRCA scoping process, key resource components were identified by NPS staff and are represented as "components" in the NRCA framework. While this list of components is not a comprehensive list of all the resources in the preserve, it includes resources and processes that are unique to the preserve in some way, of greatest concern or of highest management priority in YUCH. Several measures for each component, as well as known or potential stressors, were also identified in collaboration with NPS resource staff.

Selection of Reference Conditions
A "reference condition" is a benchmark which current values of a given component's measures can be compared to determine the condition of that component. A reference condition may be a historical condition (e.g., flood frequency prior to dam construction on a river), an established ecological threshold (e.g., EPA standards for air quality), or a targeted management

goal/objective (e.g., a caribou herd of at least 200 individuals) (adapted from Stoddard et al. 2006).

Reference conditions in this project were identified during the scoping process using input from NPS resource staff. In some cases, reference conditions represent a historical reference in which human activity and disturbance was not a major driver of ecological populations and processes, such as “pre-cattle/sheep grazing” or "pre-fire suppression.” In other cases, peer-reviewed literature and ecological thresholds helped to define appropriate reference conditions. Several of the reference conditions listed in the YUCH framework include the phrase “within the range of natural variability”. In these instances, efforts were made to utilize existing research and documentation of historical conditions to identify the range of natural variation for reference conditions.

Finalizing the Framework

An initial framework was adapted from the organizational framework outlined by the H. John Heinz III Center for Science’s “State of Our Nation’s Ecosystems 2008” (Heinz Center 2008). Key resources for the preserve were adapted from the CAKN Vital Signs monitoring plan (MacCluskie and Oakley 2005) and natural resource reports from YUCH. This initial framework was presented to preserve resource staff to stimulate meaningful dialogue about key resources that should be assessed. Significant collaboration between SMUMN GSS analysts and NPS staff was needed to focus the scope of the NRCA project and finalize the framework of key resources to be assessed.

The NRCA framework was finalized in November 2010 following acceptance from NPS resource staff. It contains a total of 21 components (Table 8) and was used to drive analysis in this NRCA. This framework outlines the components (resources), most appropriate measures, known or perceived stressors and threats to the resources, and the reference conditions for each component for comparison to current conditions. Seven of the components in the framework were identified as important to the preserve, but recognized by NPS staff during project scoping as having little or no data and information available to conduct a detailed assessment. These components, considered “placeholders”, list proposed measures, possible stressors, and past studies that may provide limited baseline information to future assessments. The YUCH framework also contains five components that were contextually important natural resource topics in the preserve; these were climate, geology, soils, paleontological resources, and subsistence harvest. During scoping the project stakeholders agreed to address these in Chapter 2 of the report, as the first three are primarily broad ecological characteristics of the preserve and the others are natural resource aspects important to preserve visitors, researchers, and local residents.

Table 8. Yukon-Charley Rivers National Preserve natural resource condition assessment framework.

Component	Measures	Stressors	Reference Condition
Ecosystem Extent and Function			
Land Cover			
Land Cover (1997 Mapping)	Landcover summaries by ecological subsection; NWI summaries and lake surface area; Fire extent; Number of acres of classes (riparian, floodplain, tundra, and steppe); Human footprint (location of mining claims, timber harvest, trails, and trap-lines)	Mining; Recreation/residential/ commercial development; OHV use; Non-native invasive plants; Climate change; Fire; Flooding	Not yet determined
Lake Ecosystem Function	Total surface area of lakes over 1 acre; Number of lakes over 1 acre of surface; Selected standard measurements of limnological ecosystem function (i.e., total N, total P, chlorophyll A, macroinvertebrates)	Non-native aquatic species; Permafrost degradation and catastrophic lake drainage; Airborne contaminants; Flood dynamics of the Yukon River; Climate change	Lake surface area - total acres is within range of natural variation; # of lakes - no change from range of natural variation; To be determined
Permafrost	Number of acres of thermokarst; Carbon balance; Soil temperature; Acreage of human-initiated erosion and soil degradation (including sensitive soils)	Management actions - development, land use pattern; Climate change (fire regime change); Increasing visitation; Increasing OHV use	Thermokarst - all changes within range of natural variation; Carbon balance - within range of natural variation; Soil temperature - within range of natural variation; Number of acres of human-initiated erosion and sensitive site disturbance - remains at or below level in 2007
Disturbance Regimes			
Fire	Number of acres burned per year; Number of natural fire starts per year; Annual fire season duration; Percentage of burns by severity class annually	Climate change; Habitat fragmentation; Lightning; Fire size/occurrence outside historic range of variability	Number of acres burned per year, Number of natural fire starts per year, and total duration - remain within range of natural variability (1952-current); Fire season duration and timing - remain within range of natural variability (1993-Current); % of burns by severity class annually - remain within range of natural variability (1983-Current)

Table 8. (continued) Yukon-Charley Rivers National Preserve natural resource condition assessment framework.

Component	Measures	Stressors	Reference Condition
Biological Composition			
Mammals			
Forty-Mile Caribou Herd	Population size estimates; Composition (bull:cow, calf:cow spring and fall ratios); Nutritional state (fall calf weights); Range/distribution; Harvest rates	Possible loss of forage quality and quantity due to climate and vegetation (specifically lichen) change; Fire and climatic effects of forage quantity and quality; Sport and subsistence harvest; Overflights; Predation (wolf & bear); Winter snowfall (depth/accumulation); Summer temps and precip.; Insect harassment	Historic population estimates (Skoog 1956 and 1964, Valkenburg 1994)
Dall's Sheep / Fannin Sheep	Pop. size estimates (plus confidence intervals); Composition (lamb:ewe, ram:ewe ratios); Nutritional state (body condition and pellet analysis); Harvest rates	Forage quality and availability; Snow/ice depth (limiting factor); Sport harvest; Disease; Predation; Insect harassment	Within the range of natural variability (early summer estimates from census data starts in the early 1980s, results comparable from 1997 on)
Moose	Population size estimates; Composition (calf:cow ratios, bull:cow ratios); Harvest rates	Sport and subsistence harvest; Forage availability and nutritional quality; Snow depth (limiting factor); Predation (wolf & bear)	Within the range of natural variability (sampling began in 1987 and methods have changed since, results comparable starting from 1994 on)
Wolves	Population size; Population distribution; Density estimates; Change in numbers from Oct. to April; Dispersal rates; Mortality and harvest rates	Predator control activities near the park; Harvest; Ungulate population change and nutritional health; Snow depth/accumulation	Population size and demography remains within the range observed 1993-2009
[1]Bears	Abundance and distribution	Harvest	Within the range of natural variability
[1]Small Mammals / Hares	Abundance and distribution	Harvest; Predator changes	Within the range of natural variability
[1]Furbearers	Abundance and distribution	Harvest	Within the range of natural variability
Birds			
Peregrine Falcons	Number of pairs in the upper Yukon River index study area; Reproductive performance (percent pairs successful, number of young/pair); Contaminants	Contaminants; exposure of aerie sites; falconry (potential threat to sensitive period)	Pre endangered levels unknown - Within the range of natural variability (Ambrose data begins in 1973)
[1]Ptarmigans	Abundance and distribution	Habitat change; Climate warming	Within the range of natural variability
[1]Breeding Birds (Passerines)	Diversity, population size and distribution	Habitat change; Loss of wintering habitat	Within the range of natural variability

Table 8. (continued) Yukon-Charley Rivers National Preserve natural resource condition assessment framework.

Component	Measures	Stressors	Reference Condition
Fish			
Anadromous Species	Population size (annual escapement); Distribution	Subsistence and sport harvest; Habitat loss; Climate warming (low H2O flow)	Within the range of natural variability
Amphibians			
[1]Wood Frogs and Boreal Toads	Distribution; Mutation rates	Habitat change; Climate warming	Within the range of natural variability
Ecological Communities			
Native Plant Communities	Plant species composition as measured in vegetation monitoring program; Status of rare and unique species; Species distribution; Summary of land cover by ecological sub-section	Invasive and non-native plants (seed sources, vectors for spread, effects of climate change); Willow leaf miner; Spruce beetle; Subsistence activities	Original plant monitoring program for CAKN inventory
Steppe Community	Spatial locations; Number of unique sites; Unique species composition	Climate change (precipitation amount and pattern); Forest encroachment; Erosion and flooding events; Human use (walking creating erosion); Invasive plants	Vegetative structure and locations from earliest research
Environmental Quality			
Water Quality (Chemical and Biological Integrity)	Standard water chemistry parameters including dissolved oxygen, fecal coliform, pH, specific conductance, temperature, and turbidity; Observed vs. expected macroinvertebrate species; Presence and concentration of nutrients including dissolved organic carbon, nitrates, and phosphates; Presence and concentration of heavy metals	Legacy effects of past mining and current mining activities; Effluent discharge from Dawson; Floaters/rafters causing degradation of riparian corridor; Administrative and research activities; Airborne contaminants; Climate change; Oil and gas exploration	100% of streams and lakes within the range of natural variation for physical, biological and chemical measures of water quality.
[1]Air Quality	Atmospheric concentration and deposition (sulfur, nitrogen and mercury oxides); Visibility/ Arctic haze	Intercontinental transport of contaminants; Increasing local and global development; Climate warming and carbon flux	Air quality parameters - remain stable or improve - as measured for NPS Performance Management Data System (PMDS)
Hydrology	Discharge ; Snowpack; Ice freeze-up/break-up; Flood frequency and magnitude	Climate warming causing increased precipitation (snow melt, timing, etc); Mining activity	Within the range of natural variability estimated from +/- 60 year record of the Yukon River at Eagle. Limited other gauging to draw from.

Table 8. (continued) Yukon-Charley Rivers National Preserve natural resource condition assessment framework

Component	Measures	Stressors	Reference Condition
[2]Climate	Undetermined	Undetermined	Undetermined
[2]Geology	Undetermined	Undetermined	Undetermined
[2]Soils	Undetermined	Undetermined	Undetermined
[2]Paleoentilogical Resources	Undetermined	Undetermined	Undetermined
[2]Subsistence Harvest	Firewood harvest; Cabin logs harvest; Trapping harvest; Hunting harvest; Fishing harvest, Mushroom and berry harvest	Roads and trails; Erosion; Excessive legal harvest; Illegal harvest; Vegetative loss; Clear cutting and alteration of stand composition; Eagle flood event; Rising water temperatures in the Yukon (increase disease); Land selections now conveyed along the eastern parts of YUCH (increase pressure on resources); Mineral and oil exploration	Within the traditional range of subsistence activity within and around the preserve.

[1] These components (e.g., small mammals, ptarmigan, etc.) are considered placeholders; allowing for identification of an important resource where little data exist and measures, stressors, and reference conditions are not well developed. Their condition will not be assessed, nor will data be summarized for them; only a brief description and brief overview of past studies or data sources will be presented.

[2] Broad ecological characteristics of the preserve will be discussed in Chapter 2 of the NRCA report under the Resource Setting section. These will include the following: climate, geology, and soils. Also, unique paleontological resources and subsistence will be discussed separately. Subsistence may be framed as a stressor and a value determined by the preserve's enabling legislation.

3.2.2 General Approach and Methods

This study involved gathering and reviewing existing literature and data relevant to each of the key resource components included in the framework. No new data were collected for this study; however, where appropriate, existing data were further analyzed to provide summaries of resource condition or to create new spatial representations. After all data and literature relevant to the measures of each component were reviewed and considered, a qualitative statement of overall current condition was created and compared to the reference condition when possible.

Data Mining

The data mining process (acquiring as much relevant data about key resources as possible) began at the initial scoping meeting, at which time YUCH staff provided data and literature in multiple forms, including: NPS reports and monitoring plans, reports from various state and federal agencies, published and unpublished research documents, databases, tabular data, and charts. GIS data were provided by NPS staff (Alaska Regional Office, CAKN, YUGA, and YUCH). Access was also granted to NPS online data and literature sources, such as NatureBib and NPSpecies (now IRMA – Integration of Resource Management Applications). Additional data and literature were also acquired through online bibliographic literature searches and inquiries on various state and federal government websites. Data and literature acquired throughout the data mining process were inventoried and analyzed for thoroughness, relevancy, and quality regarding the resource components identified at the scoping meeting.

Data Development and Analysis

Data development and analysis was highly specific to each component in the framework and depended largely on the amount of information and data available for the component and recommendations from NPS reviewers and sources of expertise including NPS staff from YUCH, YUGA, CAKN, and the AK Regional Office. Specific approaches to data development and analysis can be found within the respective component assessment sections located in Chapter 4 of this report.

Scoring Methods and Assigning Condition

A set of measures are useful in describing the condition of a particular component, but all measures may not be equally important. A "significance level" represents a numeric categorization (integer of 1-3) of the importance of each measure in explaining the condition of the component; each significance level is defined in Table 9. This categorization allows measures that are more important for determining condition (higher significance level) of a component to be more heavily weighted in calculating an overall condition.

Table 9. Scale for a measure's significance level in determining a component's overall condition.

Significance Level (SL)	Description
1	Measure is of low importance in defining the condition of this component.
2	Measure is of moderate importance in defining the condition of this component.
3	Measure is of high importance in defining the condition of this component.

After each component assessment is completed (including any possible data analysis) a condition level is assigned for each measure. This is based on a 0-3 integer scale and reflects the data mining efforts and communications with park experts (Table 10).

Table 10. Scale for condition level of individual measures.

Condition Level (CL)	Description
0	Of **NO** concern. No net loss, degradation, negative change, or alteration.
1	Of **LOW** concern. Signs of limited and isolated degradation of the component.
2	Of **MODERATE** concern. Pronounced signs of widespread and uncontrolled degradation.
3	Of **HIGH** concern. Nearing catastrophic, complete, and irreparable degradation of the component.

After the significance levels (SL) and condition levels (CL) are assigned, a weighted condition score (WCS) is calculated via the following equation:

$$WCS = \frac{\sum_{i=1}^{\#\ of\ measures} SL_i * CL_i}{3 * \sum_{i=1}^{\#\ of\ measures} SL_i}$$

The resulting WCS value is placed into one of three possible categories: condition of low concern (WCS = 0.0 – 0.33); condition of moderate concern (WCS = 0.34 - 0.66); and condition of significant concern (WCS = 0.67 to 1.00). Figure 7 displays all of the potential graphics used to represent a component’s condition in this assessment. The colored circles represent the categorized WCS; red circles signify a significant concern, yellow circles a moderate concern and green circles a condition of low concern. Gray circles are used to represent situations in which there is currently insufficient data to make a statement about the condition of a component. The arrows inside the circles indicate the trend of the condition of a resource component. An upward pointing arrow indicates the condition of the component has been improving in recent times. A right-pointing arrow indicates a stable condition or trend and an arrow pointing down indicates a decline in the condition of a component in recent times. These are only used when it is appropriate to comment on the trend of condition of a component. A gray, triple-pointed arrow is reserved for situations in which the trend of the component's condition is currently unknown.

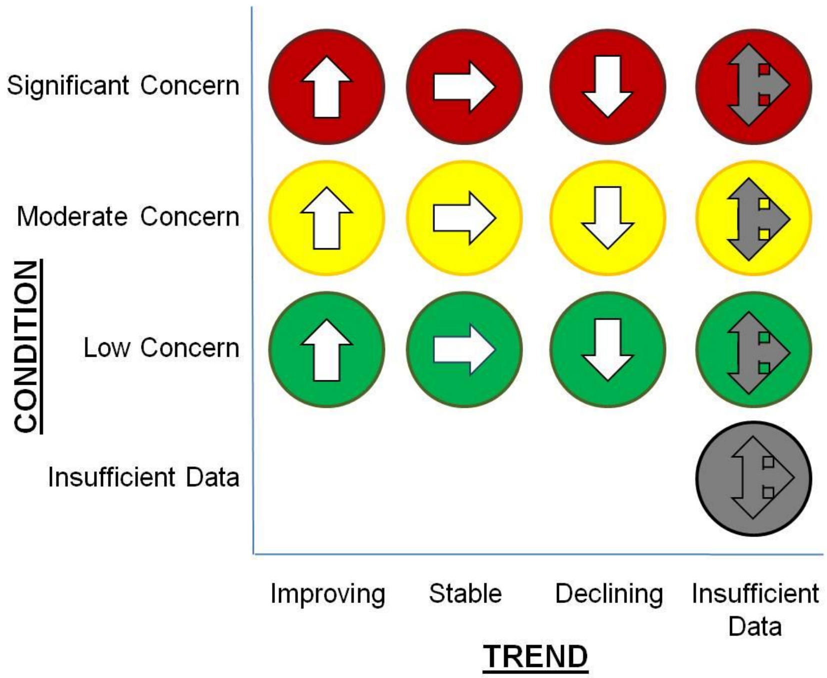


Figure 7. Symbols used for individual component assessments with condition or concern designations along the vertical axis and trend designations along the horizontal.

Preparation and Review of Component Draft Assessments

The preparation of draft assessments for each component was a highly cooperative process among SMUMN GSS analysts and YUCH and other NPS staff. Though SMUMN GSS analysts rely heavily on peer-reviewed literature and existing data in conducting the assessment, the expertise of NPS resource staff also plays a significant and invaluable role in providing insights into the appropriate direction for analysis and assessment of each component. This step is especially important when data or literature are limited for a resource component.

The process of developing draft documents for each component began with a detailed phone or conference call with an individual or multiple individuals considered local experts on the resource components under examination. These conversations were a way for analysts to verify the most relevant data and literature sources that should be used and also to formulate ideas about current condition with respect to the NPS staff opinions. Upon completion, draft assessment were forwarded to component experts for initial review and comments.

Development and Review of Final Component Assessments

Following review of the component draft assessments, analysts used the review feedback from resource experts to compile the final component assessments. As a result of this process, and based on the recommendations and insights provided by YUCH resource staff and other experts, the final component assessments represent the most relevant and current data available for each component and the sentiments of park resource staff and resource experts.

Format of Component Assessment Documents

All resource component assessments are presented in a standard format. The format and structure of these assessments is described below.

Description
This section describes the relevance of the resource component to the preserve and the context within which it occurs in the preserve setting. For example, a component may represent a unique feature of the preserve, it may be a key process or resource in preserve ecology, or it may be a resource that is of high management priority in the preserve. Also emphasized are interrelationships that occur among a given component and other resource components included in the broader assessment.

Measures
Resource component measures were defined in the scoping process and refined through dialogue with resource experts. Those measures deemed most appropriate for assessing the current condition of a component are listed in this section, typically as bulleted items.

Reference Conditions/Values
This section explains the reference condition determined for each resource component as it is defined in the framework. Explanation is provided as to why specific reference conditions are appropriate or logical to use. Also included in this section is a discussion of any available data and literature that explain and elaborate on the designated reference conditions. If these conditions or values originated with the NPS experts or SMUMN GSS analysts, an explanation of how they were developed is provided.

Data and Methods
This section includes a discussion of the data sets used to evaluate the component and if or how these data sets were adjusted or processed as a lead-up to analysis. If adjustment or processing of data involved an extensive or highly technical process, these descriptions are included in an appendix for the reader or a GIS metadata file. Also discussed is how the data were evaluated and analyzed to determine current condition (and trend when appropriate).

Current Condition and Trend
This section presents and discusses in-depth key findings regarding the current condition of the resource component and trends (when available). The information is presented primarily with text but is often accompanied by detailed maps or plates that display different analyses, as well as graphs, charts, and/or tables that summarize relevant data or show interesting relationships. All relevant data and information for a component is presented and interpreted in this section.

Threats and Stressor Factors
This section provides a summary of the threats and stressors that may impact the resource and influence to varying degrees the current condition of a resource component. Relevant stressors were described in the scoping process and are outlined in the NRCA framework. However, these are elaborated on in this section to create a summary of threats and stressors based on a combination of available data and literature, and discussions with resource experts and NPS natural resources staff.

Data Needs/Gaps
This section outlines critical data needs or gaps for the resource component. Specifically, what is discussed is how these data needs/gaps, if addressed, would provide further insight in determining the current condition or trend of a given component in future assessments. In some

cases, the data needs/gaps are significant enough to make it inappropriate or impossible to determine condition of the resource component. In these cases, stating the data needs/gaps is useful to natural resources staff who wish to prioritize monitoring or data gathering efforts.

Overall Condition
This section provides a qualitative summary statement of the current condition that was determined for the resource component using the WCS method. Condition is determined after thoughtful review of available literature, data, and any insights from NPS staff and experts, which are presented in the Current Condition and Trend section. The Overall Condition section summarizes the key findings and highlights the key elements used in determining and justifying the level of concern, if any, that analysts attribute to the condition of the resource component. Also included in this section are the graphics used to represent the component condition.

Sources of Expertise
This is a listing of the individuals (including their title and affiliation with offices or programs) who had a primary role in providing expertise, insight, and interpretation to determine current condition (and trend when appropriate) for each resource component.

Literature Cited
This is a list of formal citations for literature or datasets used in the analysis and assessment of condition for the resource component. Note, citations used in appendices and plates referenced in each section (component) of Chapter 4 are listed in that section's "Literature Cited" section.

Literature Cited

Great Lakes Environmental Indicators Project (GLEI). 2010. Glossary, Stressor. Online (http://glei.nrri.umn.edu/default/glossary.htm). Accessed 9 December 2010.

The H. John Heinz III Center for Science, Economics, and the Environment. 2008. The state of the nation's ecosystems 2008: Measuring the land, waters, and living resources of the United States. Island Press, Washington, D.C.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service Central Alaska Network, Fairbanks, Alaska.

Stoddard. J. L., D. P. Larsen, C. P. Hawkins, R. K. Johnson, and R. J. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications. 16(4):1267-1276.

Chapter 4 Natural Resource Conditions

This chapter presents the background, analysis, and condition summaries for the 14 key resource components and seven placeholder components in the project framework. The following sections discuss the key resources and their measures, stressors, and reference conditions. The summary for each component is arranged around the following sections: 1. Description; 2. Measures; 3. Reference Condition; 4. Data and Methods; 5. Current Condition and Trend (threats/stressor factors, data needs/gaps, and overall condition); 6. Sources of Expertise; and 7. Literature Cited.

The order of components follows the project framework (Table 8, pg. 58):

4.1 Land Cover
4.2 Lake Ecosystem Function
4.3 Permafrost
4.4 Fire
4.5 Fortymile Caribou
4.6 Dall's Sheep / Fanin Sheep
4.7 Moose
4.8 Wolves
4.9 Bears
4.10 Small Mammals / Hares
4.11 Furbearers
4.12 Peregrine Falcons
4.13 Ptarmigan
4.14 Breeding Birds
4.15 Anadromous Fish Species
4.16 Wood Frogs & Boreal Toads
4.17 Native Plant Communities
4.18 Steppe Community
4.19 Water Quality
4.20 Air Quality
4.21 Hydrology

4.1 Land Cover

Description

Land cover is the physical surface of the earth, often described using classes of vegetation and land use (e.g., vegetation: alpine tundra, closed needleleaf; land use: developed, transportation). Land cover is portrayed in maps created through field surveys and/or analyses of remotely sensed imagery (Comber et al. 2005). The size and shape of land cover types is important because land cover is associated with habitat. The reduction in size of available habitat is often correlated with a decline in species richness (EPA 2002). 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).

Photo 8. Aerial view of the Charley River entering the Yukon River (Photo by USGS).

YUCH's land surface is primarily vegetated with boreal forests (Photo 8) that transition to mountains slopes and alpine tundra (generally above 915 m in elevation) (NPS 1989, Boggs and Sturdy 2005). Fire and flooding are the primary natural disturbances that drive changes in the vegetation (land cover) over time. Land cover is also influenced by permafrost dynamics, surface hydrology, and climate variables. Land cover in turn affects wildlife habitat and hydrology. It has been designated as a Vital Sign by the CAKN I&M Program (MacCluskie and Oakley 2005). CAKN plans to monitor land cover by measuring changes in area of each land cover type in the preserve (MacCluskie and Oakley 2005). Since the CAKN monitoring protocol is currently in development and existing GIS datasets are not readily comparable for meaningful change detection, the measures chosen for this assessment represent baseline information that can be used for comparison with future land cover data.

Landscape-scale human disturbances in YUCH are small in area. There are no roads or maintained trails within the preserve, and human disturbance and development is primarily limited to historic mining activity and historic structures such as roadhouses and cabins. Today, YUCH maintains historic structures related to mining and several public use cabins. Visitor numbers are low compared with many Alaska NPS units. According to the NPS Office of Public Use Statistics, in 2010 there were 6,211 reported visitors in YUCH. Visitation is largely centered around float trips (e.g., canoeing, rafting, kayaking) on the Yukon and Charley Rivers.

The following measures characterize multiple land cover-related aspects in the preserve. First, land cover classes, according to the Ducks Unlimited (1997) GIS dataset, are summarized for each ecological subsection, a GIS dataset developed by Swanson (2001). Secondly, summaries of wetland classes and lakes provide preserve-wide area and composition estimates. Estimates for the extent of recent fires (1950 to 2010), the dominant natural disturbance across the preserve, indicate areas where vegetation or land cover class will change in response to fire. The total areas of broad physiographic classes or habitat types (e.g., riparian areas, floodplains, tundra, and steppe) are not well characterized in the available data. Finally, the human footprint in the preserve, described using the available NPS GIS datasets, provides baseline inventory of human-visited sites and of areas with human activity.

Measures

- Land cover summaries by ecological subsection
- Wetland type summaries and lake surface area
- Fire extent
- Area of classes (riparian, floodplain, tundra, and steppe)
- Human footprint (location of human influenced sites such as mining claims, timber harvest, trails, trap-lines, cabins, etc.)

Reference Conditions/Values

The reference condition for land cover in YUCH is not yet determined. Mapping efforts occurred just prior to the preserve establishment and again in the early 1990s (Racine 1976 and Ducks Unlimited 1997 [1991 satellite imagery]). These data are not immediately comparable for producing a meaningful land cover change analysis. However, Boggs and Sturdy (2005) describe vegetation successional trajectories following fire, providing an indication of expected natural vegetation responses to fire over time. Data presented in the current condition section of this document can act as baseline information for comparison in future examinations of land cover. As new imagery and/or land cover data become available it will be important to differentiate between changes in land cover composition and dynamics driven by natural disturbances (fires, flooding) and those potentially due to climate change or due to localized human impacts.

Data and Methods

Ecological subsection GIS data from Swanson (2001) are useful in applying a stratified sampling design, where inventory and monitoring sampling efforts in such large geographic areas can be stratified by ecosystem region (ecological subsection). These data can also ensure appropriate coverage over different ecosystems while accounting for economics of sampling efforts (Swanson 2001). The ecological subsection mapping is based on the principle that “tiers of the ecosystem (geology, landforms, soils, vegetation, etc.) are linked, they tend to change together and can be used in concert to define and map ecosystem regions” (Swanson 2001, p. 1). This GIS data was developed using a mental synthesis (interpretation) of color infrared aerial photographs (AHAP) (1:60,000 scale), geologic maps (1:250,000 scale), and the Ducks Unlimited (1997) land cover map (1:63,360). The ecological subsections are used in this assessment to report the area and composition of land cover types and wetland types, fire area, and the area and number of lakes/ponds in the preserve.

The NPS possesses two land cover GIS datasets specific to the preserve (Figure 8). The primary source of land cover information available for this assessment comes from the Ducks Unlimited (1997) GIS dataset. These GIS data used the Viereck et al. (1992) classification scheme and were derived from LandSat TM5 Path 66 Row 14 shifted 40% south, 08/20/1991, combined with field observations, aerial photography, and other GIS data. This land cover dataset is a raster file with a cell size of 30 m, providing a relatively coarse representation of major land cover types in YUCH. According to the metadata associated with the GIS files, the overall accuracy of the land cover categories is 80%. In addition, there are significant areas of “terrain shadow.” Terrain shadows occur when the sun angle causes a shadow from topographically prominent features in the landscape, preventing the actual land cover type from being categorized in these areas. The associated report for this GIS dataset is Ducks Unlimited (2002).

Racine (1976) provides another source of land cover GIS data for this assessment. These GIS data indicate broad vegetation types and land cover for a large portion of the preserve, but not preserve-wide coverage. GIS data are the results of a conversion of a paper map created by Charles H. Racine in 1975, in Young and Racine (1976). The polygons were created from field studies in 1974-75 and from interpretation of 1:250,000 LandSat color-infrared (CIR) imagery supplemented (checked for accuracy) using 1:5,000 aerial photograph strips (Boggs and Sturdy 2005). These data contain some areas attributed as an “unknown” land cover class, due to difficulty in interpreting the original land cover class in the hard copy map during the digital conversion process. No assessment of its accuracy is published.

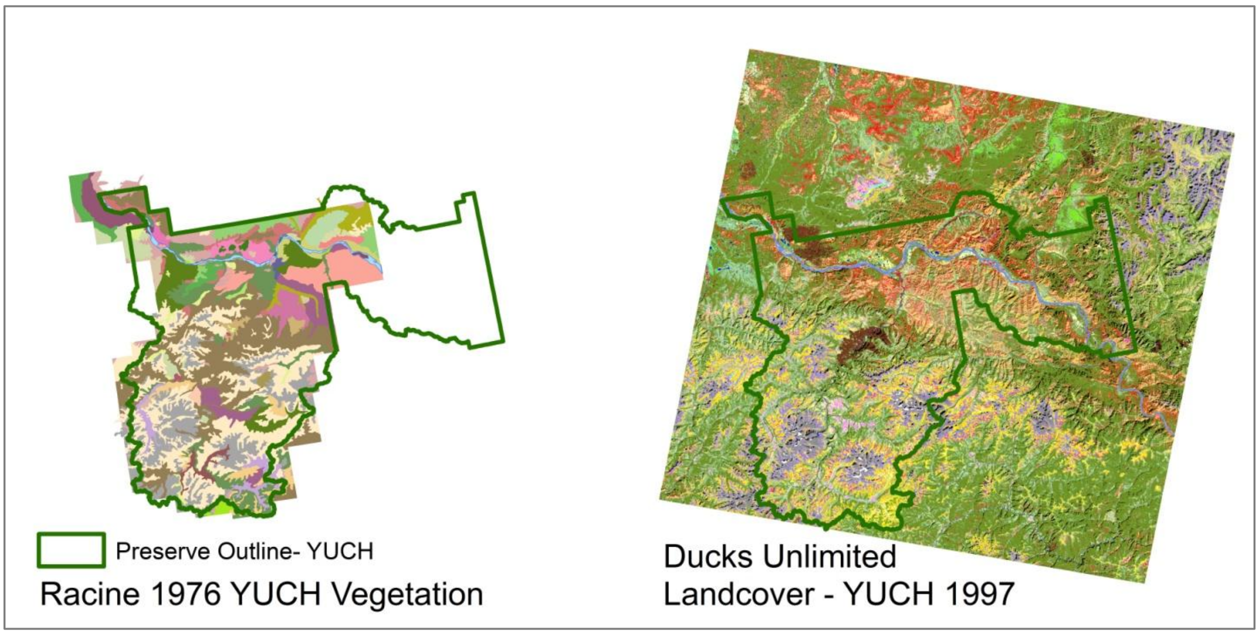


Figure 8. Available GIS land cover datasets for YUCH.

National Wetland Inventory (NWI) GIS data contained within the NPS permanent GIS datasets provides wetland information for the entire preserve. USFWS originally interpreted wetland vegetation signatures on Mylar over hard-copy Alaska High Altitude Photography (AHAP) using aerial-photo interpretation techniques. The photography dates range from 1978 to 1984. However, in examining dates of AHAP flight lines and photo points, most photos were taken over the preserve during August 1984. The data provide an indication of the prevalence and distribution of wetland types (according to the Cowardin et al. 1979 classifications) across the preserve. Note, in examining the NWI data contained within the NPS’s permanent datasets, discrepancies appear to exist between 1:63K quad boundaries. Additional examination of these discrepancies is recommended before the NPS uses the tabular and graphical summaries presented in this report for preserve planning efforts.

GIS fire perimeter data from the Alaska Interagency Coordination Center (AICC) provide information for summaries of fire area by ecological subsection in YUCH.

Current Condition and Trend

<u>Land Cover Summaries by Ecological Subsection</u>

The Racine (1976) GIS dataset only covers a portion of the preserve. Therefore, a land cover summary of this data by all of the ecological subsections in Swanson (2001) is not feasible. Given the lack of documentation in the methods for the original map creation, the unresolved classifications during digital conversion, the potential differences in data accuracy due to map scale, and the different land cover classes between datasets, a comparison of the two datasets to detect broad changes in land cover classes is not feasible. Refer to Appendix 1 for a list of Racine (1976) land cover class area and percent composition within the preserve.

The major land cover types according to the Ducks Unlimited (1997) GIS land cover dataset include open needleleaf, woodland needleleaf, and low shrub at 30, 15 and 11 percent, respectively. Other common land cover types include closed deciduous, low shrub – tussock, closed mixed needleleaf/deciduous, dwarf shrub, open mixed needleleaf/deciduous, rock/gravel, sparsely vegetated, fire (burned), turbid water, tall shrub, and tussock tundra (Ducks Unlimited 1997) (Figure 9). Refer to Appendix 2 for a complete list of classes by area and percent composition in the preserve according to Ducks Unlimitied (1997) GIS data.

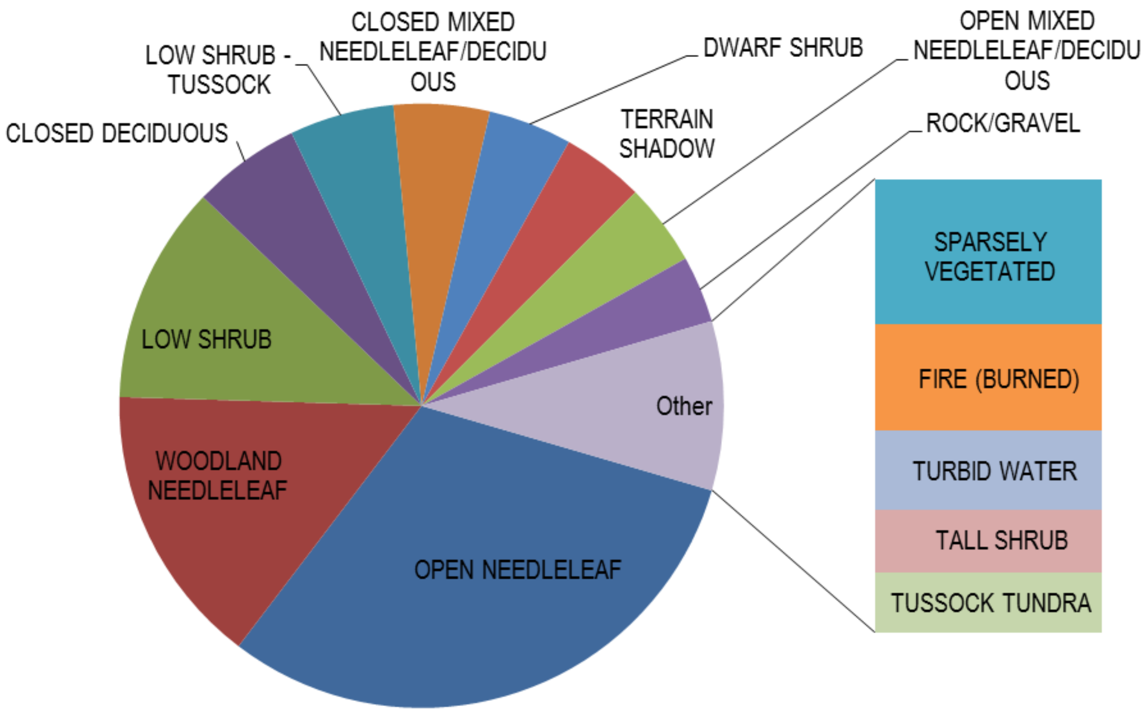


Figure 9. Land cover composition in YUCH according to Ducks Unlimited (1997). Only classes comprising greater than one percent of the total preserve area are displayed here; all other classes together comprise 2.5% of the preserve. Refer to Appendix 2 for a complete list of classes by area and percent composition.

Swanson (2001) divided YUCH into 14 distinct ecological subsections. The author describes characteristics of these ecological subsections, included here in Table 11. Methods used to map these ecological subsections were originally developed by Bailey (1996). It is important to note that the subsections are further divided into detailed ecological units; in YUCH, there are 29 detailed ecological units. Figure 10 displays the percent composition for each ecological subsection by preserve area. Refer to Swanson (2001) for further information regarding detailed ecological unit areas. Plate 4 depicts the subsections in the preserve.

Table 11. Ecological subsections of YUCH (adapted from Swanson 2001).

Ecological Subsection	Area (km^2)	Delineation Criteria
Upper Charley Mountain Tundra	2,468	Mountains with many broad, rounded ridgetops, but steep cliffs and sharp ridge crests in some areas. Composed of granitic rocks and schist; located almost entirely above treeline.
Ogilvie Foothills	1,211	Steep hills, almost entirely below treeline but with some exposed rock on ridgetops. Composed of a variety of sedimentary rocks, complexly faulted.
Yukon River Valley	1,178	Nearly level or gently sloping areas along the Yukon River and its tributaries, composed of river deposits (overlain by loess on older surfaces).
Upper Charley Valleys	1,168	Various landforms in the valleys of the upper Charley River region at elevations near or below treeline; includes U-shaped valleys with scattered trees, steeper slopes, some distinctive gentle slopes with tussock tundra, and riparian areas.

Table 11. continued, Ecological subsection of YUCH (adapted from Swanson 2001).

Ecological Subsection	Area (km^2)	Delineation Criteria
Tintina Hills	1,158	Hills and rounded low mountains at elevations below treeline, composed mostly of soft sandstone, mudstone, and conglomerate.
Charley Foothills	1,134	Hills and low mountains composed of granitic and metamorphic rocks, south of the Yukon River and Tintina Fault. Mostly below treeline.
Biederman Hills	570	Hills and rounded low mountains with elevations below treeline, composed of well-cemented sedimentary rocks (mostly argillite).
Thanksgiving Loess Plain	301	Gently sloping plain with thin loess cover over bedrock of unknown composition.
Three Fingers Subalpine Basin	273	Gentle hills composed of granitic rocks and schist at elevations near treeline, surrounded by higher mountains in the upper Charley River region
Little Black River Hills	239	Gentle hills with elevations well below treeline, composed of basalt gabbro, and argillite.
Ogilvie Lime/dolostone Mountains	208	Rugged mountains with steep, mostly forested slopes and sharp ridge crests that extend above treeline. Bedrock is mostly carbonate rocks and shale, and is exposed on ridge crests.
Hard Luck Lowland	161	Gently sloping basin north of the Yukon River near the Ogilvie Mountains. Sediments are slope deposits and loess over bedrock.
Kandik Tableland	116	Undulating plain dissected by small streams and surrounded by higher hills; composed of argillite.
Snowy Domes	12	Rounded mountains north of the Yukon that are mostly above treeline and composed of sedimentary rock (mostly conglomerate, with minor limestone and shale).

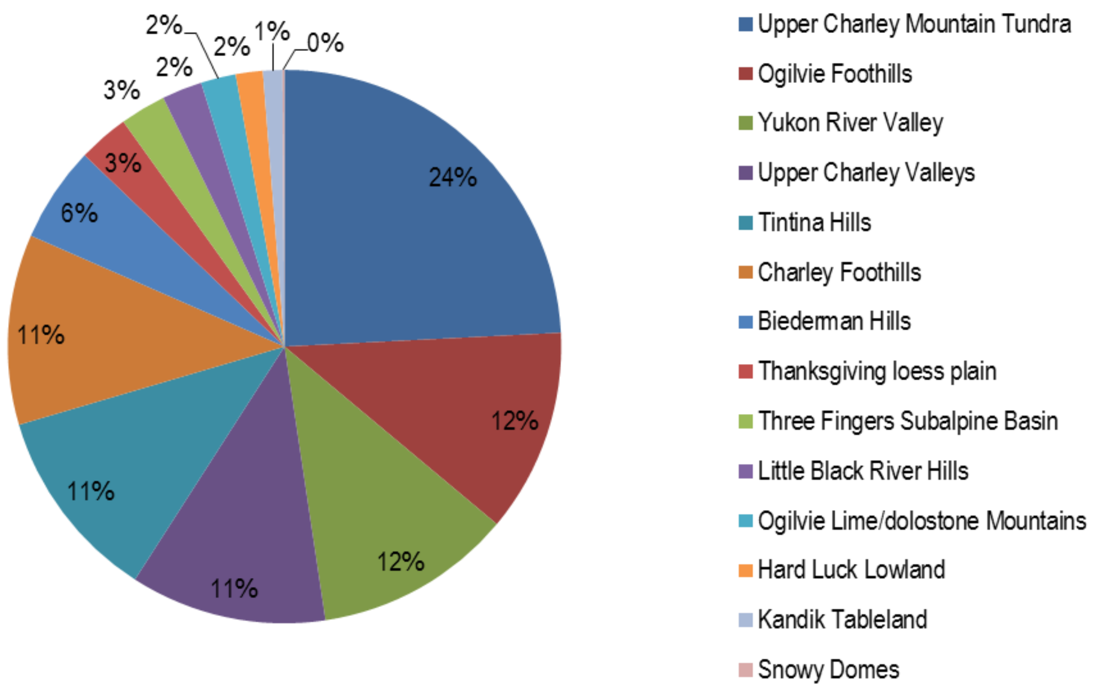


Figure 10. Percent composition of the preserve by ecological subsection area in YUCH.

The following section provides a brief description of each of the ecological subsections according to Swanson (2001). Provided in the second paragraph under each ecological subsection is a breakdown of the major land cover types (in terms of relative area) according to

Ducks Unlimited (1997) land cover GIS data. The land cover data was developed from 1991 LandSat Thematic Mapper imagery. Note, Swanson (2001) determined that the line placements (boundaries of ecological subsections) are accurate within 500 m and that the ecological subsection GIS data are intended for use at a map scale of 1:250,000; therefore, the area and proportions of each subsection may contain some spatial inaccuracy when spatially clipped to the preserve boundaries. However, this error is insignificant when compared to the reported accuracy of 80% for the 17 major land cover categories (Ducks Unlimited 1997). Refer to Appendix 3 for the area of each land cover class by ecological subsection. For further detail (i.e., summary of each detailed ecological unit [subunits of the ecological subsections]), refer to Table 5 in Swanson (2001) or Table 11 in Boggs and Sturdy (2005).

Upper Charley Mountain Tundra (MT)

The Upper Charley Mountain Tundra subsection makes up the greatest percentage of the preserve at 24% (2,468 km^2) (Figure 10). It includes gently sloping areas with low vegetation and higher areas with more exposed rock and steeper slopes. Soils here are mostly dry and rocky, derived from bedrock and colluvium, with some finer-grained wetter soils with permafrost on gentle slopes (Swanson 2001). This subsection is sparsely vegetated with considerable rock rubble, although low shrub and herbaceous plants and some tussock tundra can be found in valleys or on slopes. No significant fires have been recorded here as there is little fuel present (Swanson 2001). Smaller fires (<120 ha or 300 ac) occurred in the early and late 1990s and again in 2004.

The Upper Charley Mountain Tundra subsection is comprised primarily of open needleleaf forests (40%), followed by closed deciduous (17%), closed mixed needleleaf/deciduous (16%), terrain shadow (7%), fire (burned) (6%), open mixed needleleaf/deciduous (5%), and woodland needleleaf (4%).

Ogilvie Foothills (OF)

The Ogilvie Foothills in the east comprise 1,211 km^2 of the preserve. These steep hills with dry rocky soils are forested with mixed birch-aspen, spruce (*Picea* spp.), and paper birch (*Betula papyrifera*) (especially in burned areas) (Swanson 2001). Some steppe vegetation is mixed with rubble and exposed rock on steeper slopes. According to Swanson (2001) and AICC GIS fire perimeter data, significant wildfires occurred in this subsection in 1950, 1969, 1971, 1999, 2004, and 2005.

The majority of land cover by area is open needleleaf (42%) and woodland needleleaf (21%). Other land cover types include fire (burned) (9%), terrain shadow (7%), open mixed needleleaf/deciduous (4%), and low shrub (4%).

Yukon River Valley (YV)

The third largest subsection in YUCH is the Yukon River Valley at 1,178 km^2. The soils here are mostly derived from river deposits of sand, silt, gravel, and possibly loess, with a surface peat layer and permafrost in some areas (Swanson 2001). This subsection includes highly disturbed areas with little vegetation along the river, dense spruce forests, wetlands with sedges and low shrubs, and wet terraces with thermokarst lakes. There are small areas of birch forest on burned slopes. Most of the Yukon River Valley is unburned due to the presence of natural firebreaks (rivers, sloughs, and ponds) and the low flammability of its vegetation. Drier areas within the subsection were affected by wildfires in 1950, 1969, and 1986 (Swanson 2001). It is difficult to determine long-term burn history in many areas because the herbaceous vegetation recovers quickly after fires (Swanson 2001); however, fires over 2,000 ha occurred in 1969, 1986, 1999, and 2004.

The YV subsection is primarily classified as open needleleaf (32%), followed by woodland needle leaf (18%), turbid water (13%), closed deciduous (7%), low shrub – tussock (6%), and open mixed needleleaf/deciduous (4%).

Upper Charley Valleys (UC)
The Upper Charley Valleys subsection consists of 1,168 km^2 in the south of the preserve. It contains gently sloping valley bottoms and lower slopes surrounded by higher mountains (Swanson 2001). Soils are derived from bedrock and colluvium, and are dry and rocky on higher slopes, while wetter lowlands have a surface peat layer and permafrost. The vegetation is primarily spruce forest on slopes with tussocks and low shrubs in valley bottoms. Some slopes also support tussock tundra while floodplain white spruce forests can be found in riparian zones (Swanson 2001). A small area of tussock tundra may have burned here in 1994, but there were no recorded fires in the rest of the subsection, until an over 2,600 ha fire occurred in 1999.

The UC subsection is primarily either woodland needleleaf (33%) or open needleleaf (32%). It is also comprised of low shrub (12%), low shrub – tussock (11%), and tussock tundra (6%).

Tintina Hills (TH)
The Tintina Hills, just south of the Yukon River, comprise 1,158 km^2 of the preserve. Soils are primarily dry and rocky on upper and south-facing slopes while wetter soils with permafrost can be found on some lower or north-facing slopes (Swanson 2001). These rounded hills are forested, mostly with paper birch (particularly in burned areas) and white spruce (*Picea glauca*). Black spruce (*Picea mariana*) is occasionally found on lower north-facing slopes. A small portion of this subsection was affected by wildfire in 1950 and most of the area burned in 1969. Areas that appear to be unburned occur only in the far western and far eastern parts of the subsection (Swanson 2001). More recently a 2,671 ha fire burned here in 2007.

The TH subsection is primarily open needleleaf (31%), followed by woodland needleleaf (16%), open mixed needleleaf/deciduous (15%), closed deciduous (13%), closed mixed needleleaf/deciduous (10%), low shrub (6%), low shrub – tussock (5%), terrain shadow (2%), and open deciduous (2%).

Charley Foothills (CF)
The Charley Foothills make up 1,134 km^2 of the preserve, consisting mostly of rounded hills with spruce forest. Soils here are also dry and rocky, derived from bedrock and colluvium, with wetter soils and permafrost on north-facing slopes and nearly level summits (Swanson 2001). Paper birch can be found on south-facing slopes and sedge tussocks or low shrubs on some hilltops. The 1991 wildfire was confined largely to the Charley Foothills, which were also affected by fires in 1950, 1969, and 1993 (Swanson 2001). Another larger fire (5,324 ha) occurred in 1999.

The CF subsection is nearly all open needleleaf (42%) or woodland needleleaf (21%). Significant area is also classified as fire (burned) (9%) or terrain shadow (7%). Other areas include low shrub (4%), open mixed needleleaf/deciduous (4%), closed mixed needleleaf/deciduous (3%), closed deciduous (3%), and low shrub – tussock (3%).

Biederman Hills (BH)
The Biederman Hills subsection, at 570 km^2, straddles the Yukon River in the northern part of the preserve. Soils and vegetation here are similar to in the Charley Foothills, although black spruce occurs on some north-facing or lower slopes (Swanson 2001). Steeper slopes contain steppe or other sparse vegetation mixed with scree and exposed rock. Major wildfires occurred here in 1950 and 1986 (Swanson 2001). Both 2004 and 2007 saw large fire areas in this subsection, 21,442 ha and 3,456 ha, respectively.

The BH subsection contains open needleleaf (40%), closed deciduous (17%), closed mixed needleleaf/deciduous (16%), terrain shadow (7%), fire (burned) (6%), open mixed needleleaf/deciduous (5%), woodland needleleaf (4%), and low shrub (1%).

Thanksgiving Loess Plain (TL)
The northwest corner of the preserve contains 301 km^2 of the Thanksgiving Loess Plain subsection with its nearly level or gently sloping land, forested primarily in black spruce (Swanson 2001). Soils are mostly wet and fine-grained with permafrost in unburned areas and drier soils on steep slopes. Burned areas contain birch forest or scrub, which may persist on steeper slopes. Portions of this plain were affected by wildfires in 1957, 1993, and 1996 (Swanson 2001). Another fire, 1,956 ha in size, occurred in 2007.

The TL subsection is dominated by open needleleaf (50%) and woodland needleleaf (22%). Other land cover types include closed deciduous (8%), closed mixed needleleaf/deciduous (8%), open mixed needleleaf/deciduous (4%), low shrub - tussock (3%), and some terrain shadow (1%).

Three Fingers Subalpine Basin (TF)
On its far southern edge, YUCH contains 273 km^2 of the Three Fingers Subalpine Basin. This subsection consists of low rounded hills surrounded by higher mountains. Soils are derived from bedrock and colluvium with a surface peat layer and permafrost in low areas (Swanson 2001). The area is covered with tussock sedges and low shrubs in low areas, shrubs with a few trees on slopes, and herbaceous vegetation or dwarf shrubs on hilltops. No wildfires have been recorded in the subsection (Swanson 2001, AICC 2011).

The TF subsection is primarily low shrub (38%) and open needleleaf (25%). It also contains significant areas of low shrub – tussock (15%) and woodland needleleaf (15%). Other small areas include tussock tundra (2%), tall shrub (2%), and dwarf shrub (2%).

Little Black River Hills (LB)
The Little Black River Hills subsection consists of 239 km^2 north of the Yukon in the western part of YUCH. This subsection includes both gentle hills and the steep slopes connecting these hills to the Yukon River valley (Swanson 2001). Soils vary greatly with fire history and slope position. Unburned areas contain wetter soils and permafrost while burned areas and bluffs

contain dry and perhaps rocky soils (Swanson 2001). Vegetation is mostly black spruce forest with paper birch forest or scrub in burned areas and aspen forest or steppe mixed with scree on steeper bluffs. This area was affected by wildfires in 1954, 1977, and 1986 (Swanson 2001). In 2004 and 2009, large fires burned within the LB subsection covering 10,156 ha and 2,497 ha, respectively.

The LB subsection contains primarily open needleleaf (44%) or fire (burned) (26%). It also is comprised of a mix of woodland needleleaf (6%), closed deciduous (5%), closed mixed needleleaf/deciduous (4%), open mixed needleleaf/deciduous (4%), closed deciduous (4%), open deciduous (3%), terrain shadow (3%), and low shrub (2%).

Ogilvie Lime/Dolostone Mountains (OM)
The Ogilvie Lime/Dolostone Mountains make up 208 km^2 on the eastern edge of the preserve. It consists of steep mountains with sharp ridges of exposed rock with forested lower slopes (Swanson 2001). Soils are dry and rocky, derived from bedrock and colluvium. The ridges here are sparsely vegetated while slopes support dry herbaceous vegetation or shrubs (Swanson 2001). Birch and spruce forest can be found at lower elevations. A small portion of this subsection may have been affected by wildfire in 1996, but most areas have not burned since recordkeeping began in the 1950s (Swanson 2001). Only one fire occurred since the late 1990s, burning 839 ha.

The OM subsection contains primarily open needleleaf (44%), low shrub (10%), and sparsely vegetated (8%) land cover classes. There is also a fairly large portion (17%) of the landscape that was a terrain shadow in the satellite imagery. The rest of the area is comprised of woodland needleleaf (7%), Dwarf shrub (6%), rock gravel (3%), low shrub – tussock (3%), open needleleaf deciduous (3%), tall shrub (2%), and closed mixed needleleaf/deciduous (2%).

Hard Luck Lowland (HL)
The Hard Luck Lowland subsection comprises 161 km^2 in the northern part of the preserve. It consists of rolling basins within the Ogilvie Mountains. Soils are mostly wet and fine-grained, although drier in burned areas where permafrost has receded (Swanson 2001). Vegetation is primarily black spruce forest and tussock wetlands with low shrubs. The southern half of this subsection appears to have burned in 1957 and 1967, but no wildfires have been recorded in the northern half (Swanson 2001). Large fires occurred in 1999 and 2004, 1,981 ha and 7,596 ha, respectively.

The HL subsection is almost exclusively open needleleaf (67%) or woodland needleleaf (15%). The remaining area is a mix of open mixed needleleaf/deciduous (4%), closed mixed needleleaf/deciduous (2%), low shrub (2%), closed deciduous (2%), woodland needleleaf – lichen (2%), and terrain shadow (2%).

Kandik Tableland (KT)
The Kandik Tableland makes up just 116 km^2 of YUCH. The soils here are also mostly wet and fine-grained with permafrost, but are likely drier and possibly rocky in steeper areas (Swanson 2001). The subsection's gentle slopes are covered with black spruce forest, although some birch forest can be found on steeper slopes, especially those that have burned. Wildfires occurred here

in 1950 and 1969 in all but the far northeastern portion of the subsection (Swanson 2001). No significant fires have burned in this subsection since the Swanson (2001) publication.

The primary land cover class in the KT subsection is open needleleaf (38%), along with closed deciduous (16%), closed mixed needleleaf/deciduous (16%), and woodland needleleaf (14%). Other classes include open mixed needleleaf/deciduous (8%), terrain shadow (2%), low shrub (2%), and low shrub – tussock (1%).

Snowy Domes (SD)
The smallest subsection at just 12 km^2 is the Snowy Domes on the northern boundary of the preserve. Soils are dry and rocky but with some wetter soils and permafrost in tussocky areas (Swanson 2001). The vegetation consists of mostly low or dwarf shrubs and tussock tundra, although some spruce woodland occurs near treeline. A 1986 wildfire likely affected the wooded portion of this subsection but stopped at the tree line due to lack of fuel (Swanson 2001). Another fire burned the entire subsection (approximately 1,158 ha) in 2004, a large fire year in all of Interior Alaska.

The SD subsection represents a small proportion of the preserve's total area (< 0.1%). According to the Ducks Unlimited (1997) classification, it is a mix of different land cover classes: fire (burned) (22.2%), woodland needleleaf (16%), tussock tundra – lichen (14%), low shrub (14%), and low shrub tussock (13%). Other classes include open needleleaf (7%) dry herbaceous (3%), tussock tundra (3%), dwarf shrub (2%), closed mixed needleleaf/deciduous (2%), and tall shrub (1%).

<u>National Wetland Inventory (NWI) Summaries and Lake Surface Area</u>

NWI Summaries
NWI data relevant to YUCH were converted to digital GIS data in the mid 1990s, at a map scale of 1:63,360. Figure 11 provides an example of these data overlaid on a 2006/07 CIR aerial photo mosaic.

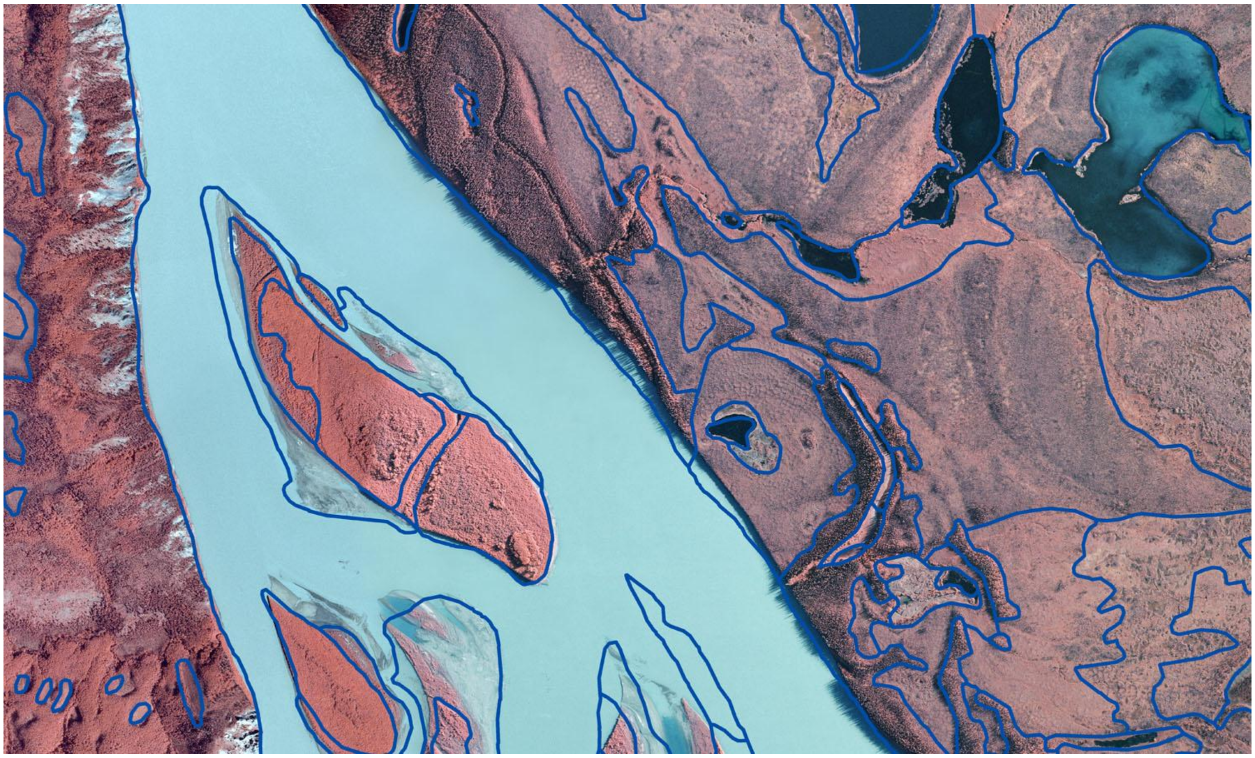


Figure 11. NWI GIS polygon boundaries (1978 to 1984) on 2006/2007 CIR aerial photography. This is an image of a portion of the Yukon River and surrounding wetlands near the northwest corner of the preserve, scale 1:24,000.

Analysis of NWI data indicates that approximately 32% or 328,117 ha (810,795 ac) of the preserve is wetland. The vast majority (94%) of wetland types by area are vegetated wetlands and fall within the Palustrine System of Cowardin et al.'s (1979) classification (Table 12). The next major wetland class by area is Riverine habitats, primarily representing the Yukon River itself and the surrounding riparian area. Lacustrine habitats, lakes over 8 ha (20 ac) according to Cowardin et al. (1979), are nearly equally balanced in area between limnetic (L1) and littoral (L2) subsystems.

Table 12. National Wetland Inventory data (1978 to 1984) area summary by broad wetland category in YUCH.

Category*	ha	ac	% of total area	% of total wetland area
Upland (non-wetland)	693,711	1,714,197	67.89	NA
Palustrine, vegetated	307,318	759,400	30.07	93.66
Riverine habitat	20,061	49,573	1.96	6.11
Lakes	674	1,666	0.07	0.21
Palustrine, ponds	64	158	0.01	0.02
Palustrine, non-vegetated	2	4	<0.01	<0.01
Blank	24	60	<0.01	NA
Grand Total:	**1,021,854**	**2,525,057**		
Total Wetland:	**328,119**	**810,801**		

*Palustrine vegetated areas in this summary include all types of vegetated palustrine wetlands (e.g., scrub shrub, forest, emergent, moss-lichen). Riverine habitats include all NWI codes in the dataset that are within the Riverine System (R). Lakes are the Lacustrine System (L); these areas are larger than 8 ha (20 ac) and include both littoral and limnetic subsystems according to Cowardin et al. (1979). Ponds are all palustrine, unconsolidated-bottom areas less than 8 ha (20 acres) in size. Palustrine, non-vegetated areas are unconsolidated shore areas (e.g., lake or pond shorelines). Areas categorized as “blank” are an error due to the 1:250,000 map scale ecological subsection GIS data not precisely aligning with the boundaries of the preserve.

Wetland types comprising the largest total area in YUCH were primarily palustrine scrub shrub with a saturated water regime (e.g., PSSIB). The NWI codes that comprise the largest areas of wetlands in YUCH are displayed in Table 13. Note, the “/” indicates an approximate split of 70% to 30%, where the first NWI code (wetland class abbreviation) constitutes 70% of the area in the delineated polygon and the second code constitutes approximately 30% of the area (i.e., a dual attribute or dual wetland class code, dominated by the first in the string). However, a dual attribute can range between a 51/49 to 80/20 split. Refer to Appendix 4 for a summary of all NWI codes (wetland classes) in YUCH by area.

Table 13. Major National Wetland Inventory (NWI) classifications (Cowardin 1979) by area in YUCH.

NWI Code	NWI Description	Percent of total wetland area*
PSS1/EMIB	Palustrine, scrub shrub, broadleaf deciduous/emergent, persistent, saturated substrate	36
PSS1/SS4B	Palustrine, scrub shrub, broadleaf deciduous/scrub shrub, needleleaf evergreen, saturated substrate	34
PSS4/SS1B	Palustrine, scrub shrub, broadleaf deciduous/scrub shrub, broadleaf deciduous, saturated substrate	13
R2UBH	Riverine, lower perennial, unconsolidated bottom, permanently flooded	4
PSS1/EM1C	Palustrine, scrub shrub, broadleaf deciduous/emergent, persistent, seasonally flooded	4

*The remaining 9% of wetland types in YUCH are comprised of 86 different wetland codes.Lake/pond Surface Area

According to a photo-interpretation using 2006/2007 CIR aerial-photo mosaic, there are a total of 484 lakes (over one acre in size), covering a total of 1,509 ha (3,729 ac) in YUCH. The vast majority (81%) of lakes over one acre in size occur in the Yukon River Valley subsection. NWI classification (Cowardin et al. 1979) defines lacustrine habitats (lakes) as non-riverine water bodies larger than 8 ha (20 ac). Given this size definition, there are 36 lakes covering a total area of 757 ha (1,870 ac) in YUCH. The Yukon River Valley subsection also contains the majority of these, 30 lakes in total. The Little Black River Hills, Ogilvie Foothills, Tintina Hills, and Thanksgiving Loess Plain subsections each contain one lake over 8 ha and the Upper Charley Mountain Tundra subsection contains two lakes over 8 ha. For more information regarding YUCH lakes and ponds (those over one acre in size), refer to the lake ecosystem function section, Chapter 4.2.

Fire Extent

Fires can have a landscape-level influence on the structure and composition of vegetation (Allen 2005). High summer temperatures, low precipitation, and high lightning occurrence create ideal conditions for many wildfires, burning an average of 8,100 ha (20,000 ac) per year in the preserve (Allen 2005). Refer to Boggs and Sturdy (2005) for specific information regarding plant associations and post-fire vegetation successional trajectories of boreal forests in the preserve. See Appendix 5 for a summary of area burned by ecological subsection from 1950 to 2010. The source of this fire information is fire perimeter GIS data (AICC 2011), downloaded from the Alaska Interagency Coordination Center (AICC) website in April 2011.

Some ecological subsections have been more highly influenced by fire during the period of record than others (Table 14). Taking into account repeated burn areas (i.e., cumulative burn area) from 1950 to 2010, Snowy Domes (SD), Little Black River Hills (LB), Hardluck Lowlands (HL), Tintina Hills (TH), Kandik Tableland (KT), Biederman Hills (BH), Ogilvie Foothills (OF), and Thanksgiving Loess Plain (TL) experienced more fire than other ecological subsections (Column B of Table 14). However, the Yukon Valley (YV) contains a significant area of open water (the Yukon River itself).

Other subsections, including Ogilvie Lime/Dolostone Mountains (OM), Charley Foothills (CF), and Upper Charley Valleys (UC) contain higher elevations and less needleleaf forest than other subsections, contributing to less frequent and less extensive fires. The only subsection not to experience larger fires in the past 60 years is the Three Fingers Subalpine Basin (TF). However, according to GIS point data from the NPS, three small fires (<16.2 ha or <40 ac) occurred here. Refer to the fire regime section, Chapter 4.4, of this document for more information on the fire regime in YUCH.

Table 14. Ecological subsection burned area, number of fires, number of fire years, and percents.1950-2010 information is from the Alaska Interagency Coordination Center (AICC 2011). GIS fire perimeter data and 1959-2009 info is from NPS GIS fire point data (NPS 2011a).

Subsection code	(A) Total subsection area (ha)	(B) Cumulative fire area (ha)	(C) % area (B/A)	(D) No. of years fire present	(E) No. of individual fire perimeters (1959-2009) [a]	(F) fire area* (ha)	(G) % area burned
SD	1,157	1,620	140.0	3	3	1,112	96
KT	11,585	10,223	88.2	3	1	10,205	88
TH	116,090	102,712	88.5	7	19	100,545	87
LB	23,950	27,808	116.1	7	12	20,225	84
OF	121,402	74,081	61.0	15	51	86,173	71
HL	16,113	15,990	99.2	7	5	11,253	70
BH	57,187	44,753	78.3	7	8	37,412	65
TL	30,126	16,790	55.7	6	4	13,943	46
YV [b]	117,991	43,290	36.7	18	25	44,443	38
CF	113,626	29,986	26.4	8	18	29,777	26
OM	20,844	1,583	7.6	4	6	1,579	8
UC	116,998	2,736	2.3	2	5	2,736	2
MT	247,374	1,520	0.6	5	5	1,487	1
TF	27,413	0	0	0	3	0	0

* Non-cumulative fire area (i.e., area that experienced fire once or more over the period of record). All polygons were merged from original (AICC) GIS fire perimeter data to represent area burned versus unburned. These data were joined via a spatial "union" (ESRI Spatial Analyst tool) to the ecological subsection data and data were queried to represent burned and non-burned areas.

[a] NPS fire point data (1956 to 2009). Discrepancy between the perimeter data and these data is primarily because smaller fires are not captured by the perimeter data.

[b] This subsection contains several detailed subsections. The detailed subsection, "YV5: high terraces – undulating", has the most evidence of fire history (Swanson 2001).

In order to examine land cover changes in the future, without completely repeating a preserve-wide mapping, areas subject to fire since 1991 (date of imagery used for Ducks Unlimited [1997] land cover data) could be the focus of land cover mapping efforts. The land cover class in these areas may have changed due to fire effects. A total of 52,199 ha (128,986 ac) have burned since 1991 in the preserve, with fires most prevalent in the following subsections of the preserve: SD, LB, HL, OF, and BH.

Area of Classes (riparian, floodplain, tundra, and steppe)

Data that strictly define riparian or floodplain areas in YUCH is lacking. However, Swanson's (2001) detailed ecological units YV1 through YV6 (e.g., "Yukon River active floodplain", "wet terraces with oxbows", "wet terraces with few ponds") in the Yukon River Valley (YV) ecological subsection broadly define floodplains, valleys and terrace areas. The total area of Swanson's (2001) detailed ecological subsection, YV1 (Active Floodplain of the Yukon River), is approximately 131 km^2 (50.5 mi^2). The active Yukon River floodplain recently experienced an ice-jam flood (spring of 2009) which caused significant alterations in the riparian vegetation. Many islands and riverbanks were completely stripped of vegetation, even areas with mature white spruce trees (YUGA, Jennifer Barnes, Regional Fire Ecologist, pers. comm., 2011). This active scouring could cause significant changes to land cover classifications in the riparian and floodplain areas of the Yukon River in the preserve.

Other detailed subsections of YV that may include floodplains and significant riparian areas include YV2 (wet terraces with oxbows), YV3 (wet terraces with few ponds), YV6 (Nation/Kandik/Bonanza Valleys, which includes the lower portion of the Charley River valley and the Hardluck Creek drainages), and YV7 (Tatonduk Valley). It is important to note that these detailed subsections were originally created at a 1:250,000 scale, and therefore size, shape, and area are not precise enough to accurately define the river floodplains.

Tundra is defined as a "treeless region north of the Arctic Circle (arctic tundra) or the tree line of high mountains (alpine tundra)...", "...characterized by very low winter temperatures, short cool summers, permafrost below a surface layer subject to summer melt, short growing season, and low precipitation" (Boggs and Sturdy 2005, p. 189, glossary terms from Gabriel and Talbot 1884, Viereck et al. 1992, Gallant et al. 1995). Most tundra vegetation in the preserve occurs at elevations above 914 m (3,000 ft) (NPS 1989), making it primarily alpine tundra (Boggs and Sturdy 2005); however, it is not well described in literature specific to the preserve. Direct indications of "tundra" in the Ducks Unlimited (1997) land cover dataset were two land cover classes, tussock tundra and tussock tundra-lichen, totaling 27,899 ha (68,940 ac). These two classes represent a relatively small portion (~2.7%) of the total preserve area. However, Boggs and Sturdy (2005) note dwarf shrub and herbaceous land cover classes and their plant associations may often be grouped as "mountain tundra". Although a different classification, the Racine (1976) land cover dataset contains a total of 148,902 ha (367,945 ac) of alpine tundra vegetation type, comprising over 19% of the entire area in the dataset (not the entire preserve). Refer to Figure 8 for a representation of the coverage of the dataset compared with the preserve boundaries. The upcoming NRCS soil/ecological site inventory products (e.g., GIS dataset and publication) may provide more information regarding tundra areas in the preserve.

Information regarding the preserve-wide extent and locations of steppe communities in YUCH is quite limited and most research in YUCH or the surrounding area is now over 15 years old. The available information regarding steppe community locations, especially those with unique species compositions, is presented in steppe communities, Chapter 4.18 of this report.

Human Footprint

During project scoping, NPS staff identified the location of mining claims, timber harvest, trails, and trap-lines as specifically important aspects of the present-day and historic human footprint in the preserve. Here we define human footprint, loosely, as the spatial locations (points and areas) indicating areas of human activity.

See the threats and stressors section below for more information regarding mining in YUCH as it relates to land cover.

Timber harvest for fuel and for construction of cabins, roadhouses, and various mining related structures occurred historically in the present-day preserve. Estimates of the extent and precise locations of timber harvest in YUCH are unknown; however, Barnes (pers. comm., 2011) suggests that a project utilizing appropriate historic photography could estimate the area, extent, and location of timber harvest. Present-day use of timber, specifically the cutting of live standing timber greater than 3 inches in diameter for non-commercial subsistence use, is an activity requiring a permit 13.485(a)(1), according to the Superintendent's 2012 Proposed Compendium (NPS 2012). No data quantifying or describing locations of this harvest are available.

The NPS mapped OHV trails in the Coal Creek region using GPS units and collected field data regarding the trail condition into GIS datasets. Other trails in the preserve distinguishable in the CIR aerial photography (2006/07) were not mapped as a part of this effort. According to the Coal Creek Trail Conditions GIS dataset, the total length of the trails in this area is 128.2 km (79.7 mi). Assuming an average trail width of 2.5 m (8.2 ft) for all trail segments, the trails would cover a total area of 32 ha (79.2 ac). However, the GIS data also contain width estimates that vary by segment, expressed as a range of width values. Multiplying the median of these width ranges for each segment (double wheeled and wide-track trail segments) by each trail segment's length, results in a trail area estimate for that segment. Combining this with single-track width estimates (doubling the median of the width range multiplied by the trail segment length), the total area of the Coal Creek trails is roughly 575 ha (1,421 ac). The difference in the area estimates (average width vs. segment by segment calculation) illustrates that a significant increase in trail area is caused by braided trail areas (i.e., trail takes multiple paths to avoid muddy or impassable conditions).

While there are no roads in the preserve, RS2447 trails represent historic rights of way. The total length of RS2447 trails in the preserve (Alaska DNR RS2477 trails dataset clipped to preserve boundaries) is approximately 290 km (180 mi) (Table 15). These data were extracted from the AKDNR Land Information Section on 26 December 2007 with approximate lengths (after the spatial clip) summarized by trail name (AKDNR 2006).

Table 15. RS2447 trail (right of way) approximate lengths in the YUCH.

Trail Name	Length (km)	Length (mi)
Bielenberg Trail	27.8	17.3
Eagle-Alder Creek Trail	5.0	3.1
Eagle-Circle Mail Trail	165.7	103.0
Fourth of July Creek Trail	16.6	10.3
Nation River-Rampart House	19.6	12.2
North Fork of Fortymile-Big Delta	1.0	0.6
Trout Creek Trail	10.4	6.5
Washington Creek Trail	13.7	8.5
Woodchopper-Coal Creek	30.1	18.7
Grand Total	290.0	180.2

While trapping is an important subsistence harvest activity in the preserve, trap-line locations are not currently captured in GIS data or in available literature, representing a data gap for this assessment. A recent annual park management report (2010) regarding subsistence trapping indicated a "bountiful harvest" in areas that experienced fire in 2004 and 2005 (NPS 2010, p. 15).

Archeological surveys documenting sites and artifacts related to Athabaskan and gold rush histories have examined many areas of the preserve landscape over several different years. Available archeological GIS datasets for YUCH consist of survey lines, GPS tracks, and surveyed areas (hard-copy maps converted to GIS data). However, indications of the present-day human footprint across the landscape of YUCH are not well characterized in YUCH literature. One source of information that provides some indication of present day human use sites is the fire protection point GIS dataset. It captures several different types of human-related features on the landscape (e.g., cabins, mining and fish camps, tent frames, radio repeaters, airstrips). The purpose of this dataset is to keep a running inventory of structures/features and their fire protection level status in NPS units. The Alaska Eastern Area Fire Management Staff synthesize and continually update this dataset. It contains locations, descriptions, and various fields of additional information categorizing structures in YUCH (NPS 2011b). Refer to Appendix 6 for a table of fire protection point features recorded within YUCH as of November 2011.

The fire protection point database for YUCH contains 181 records (unique site locations). Approximately 115 of these are cabins still standing in YUCH, seven of which are NPS-maintained Public Use Cabins. Eighteen cabins are noted as burned, in ruins, removed, or not located during sporadic survey efforts. There are also three sites listed as "cabins", indicating multiple structures in each site. Approximately 12 sites are described as camps, including camps in allotments, fish camps, regional corporation-owned camps, and mining camps. Two are described as mining camps; however, there are also individual records referred to as complexes and various mining related features (mines, mining ditch complex, and mining shaft). Other features include seven roadhouses, one private structure (no further classification), a saloon, a "gate estate (Doyon)", a private homestead that burned in 1969, four tent-frame sites, a town site which was destroyed by a flood in 1989, an underground storage structure, and a village. Finally, the fire protection point GIS data contain locations of four radio repeaters and two airstrips in YUCH.

The historic structures GIS point database (ASMIS 2010) from the Archeology Site Management System includes all of the currently known historic structures in YUCH, providing an indication of the historic human footprint (human activity) of the preserve. The dataset used in this assessment (listed in Appendix 6**)** is current though the 2010 field-season. The information is updated annually. Currently, a significant overlap exists between this GIS dataset and the Fire Protection Points data, as they are intended for differing purposes. Most of the overlap between the two datasets are features that are still standing and are considered historic, primarily cabins. The spatial accuracy of each of the historic features and the fire protection points varies from 2-5 m to >100 m. Many of the points shared between the datasets, intended to represent the same feature, may register far apart in a GIS. However, the historic structures data contain many sites with cabin ruins, artifact scatter, and mining features not represented in the fire protection point data.

Several other GIS datasets provide an indication of the human footprint, both present day (since the creation of the preserve) and historic (prior to the preserve). The total footprint or area of each of these human related sites according to GIS data is not readily quantifiable given the different types of data (e.g., points, polygons, lines), the variety of site types (e.g., cabins, roadhouses, mines, survey monuments), and ages of sites. In addition, different types of human activities and the associated site locations can result in different disturbance effects (e.g., hydrologic alterations to a stream, trampling or clearing of vegetation) and differing levels of intensity. Finally, the human use intensity varies over time and by site type. Therefore, in order to provide baseline information, an inventory of readily available GIS data and the numbers of sites (records) related to human use or human footprint in the preserve is provided in Appendix 7.

<u>Threats and Stressor Factors</u>
NPS resource staff have identified the following as threats or stressor factors to land cover in YUCH: mining; recreation, residential, and commercial development; OHV use; non-native invasive plants; climate change; fire; and flooding. Fire and flooding are natural disturbances that drive land cover change. Fires influence vegetation structure and composition (Allen 2005), and overbank flooding of streams and rivers results in changes to the surrounding land cover.

Mining
While one purpose identified in YUCH's enabling legislation is "to protect and interpret historical sites and events associated with the gold rush on the Yukon River", past mining (occurring from 1905 to the late 1970s) altered the riparian areas of creeks such as Ben, Coal, Fourth of July, Sam, and Woodchopper. According to a draft Environmental Impact Statement (NPS 1989), as of 1985, past placer mining activities disturbed a total of ~452 ha (1,116 ac), including primarily riparian vegetation and some upland vegetation in the entire study area (i.e., Woodchopper Creek basin, Coal Creek basin and the Sam/Ben Creek basins) (Table 16). Riparian vegetation damage also occurred along Fourth of July Creek (NPS 1989). Additional small historic mining disturbances were indicated in EIS maps contained within NPS (1989). These included places such as along the Charley River and some of its tributaries and near the Seventymile River (NPS 1989).

Table 16. Study area acreages for pre-mining, existing, and past-disturbed riparian wildlife habitat in YUCH. Reproduced from NPS (1989).

Drainage Study Area	Riparian Wildlife Habitat				Total Riparian Corridor Disturbed *
	Pre-mining	Current	Lost	%Lost	
Woodchopper Creek Basin	1,127	1,101	126	10.3	337
Coal Creek Basin	2,081	1,376	705	33.9	769
Sam/Ben Creeks	1,158	1,148	10	0.86	10
Study Area Total	4,466	3,625	841	18.8	1,116
Fourth of July Creek	833	777	56	6.7	80

* Includes riparian and some adjacent upland vegetation

Placer mining is known to cause extensive changes to stream channel morphology and stability (Miles and Associates 2003). These changes can have adverse effects on aquatic organisms, including fish. The changes that would affect land features and vegetation at a broad scale often described in land cover classification maps are related to associated changes to the permafrost and thermokarst features (Reyes et al. 2010), and changes in vegetation of disturbed areas. For example, dredge spoil piles typically are poorly re-vegetated due to rapid drainage and a lack of fine sediment (Miles and Associates 2003). Therefore, they are more clearly visible areas of disturbance in recent aerial photography. An area of dredge spoil piles, pits, pre-settling ponds, and settling ponds are still visible in recent (2006, 2007) aerial photography of the Coal Creek area (Figure 12). In placer mined study areas in nearby Yukon Territory, Canada, Miles and Associates (2003) suggest that in ice-rich permafrost areas it may take many decades or centuries for spoil piles (tailings) to erode, a floodplain to develop, and erosion resistant vegetation to become re-established.

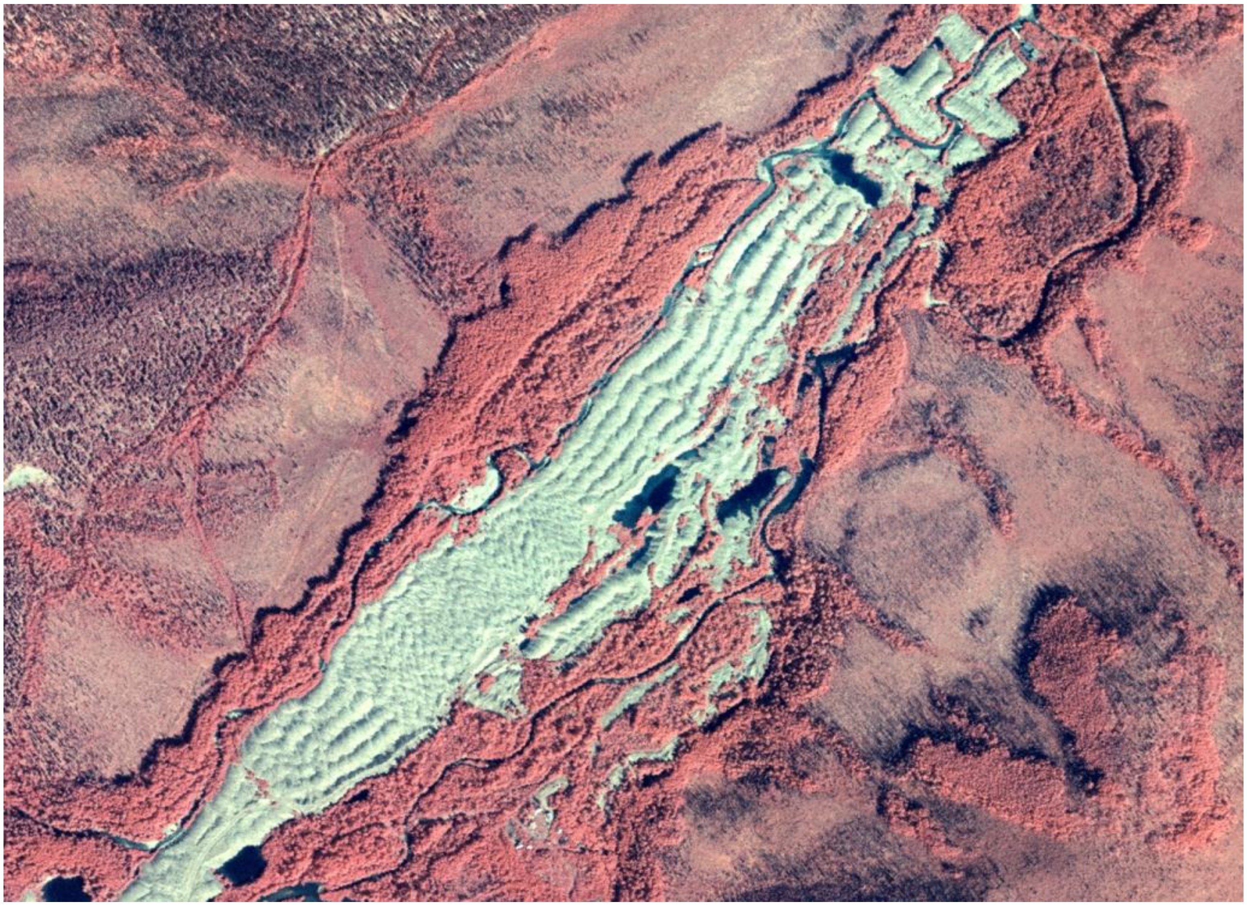


Figure 12. Example of the Coal Creek area dredge spoils and ponds in color-infrared (CIR) 2006/2007 aerial photography. Scale 1:10,000.

Large-scale mining activity ceased decades ago, prior to the preserve establishment, but is now of historical interest in the preserve. Present day mining activity is limited to small commercial operations and to some recreational mining. However, there are still active mining claims, and given the large increase in the price of gold, interest has increased in Alaska. According to the Land Information Section GIS data from the Alaska Department of Natural Resources (AKDNR) (last updated in 2006), 203 mining claims exist in YUCH. The sections (Public Land Survey System) containing these claims and prospects are primarily along Woodchopper Creek with some along Coal Creek (Plate 5).

Recreational/Residential/Commercial Development
Development in and around the preserve is very limited, in part because of its remoteness and lack of any roads entering the preserve. Only three small towns/villages occur near the preserve. To the east and south of YUCH lies the town of Eagle and Eagle Village, with 2010 populations of 86 and 67, respectively (U.S. Census 2010). The town of Circle is another small community to the west of the preserve. Its 2010 population was 104 (U.S. Census 2010).

OHV Use
OHV use causes plant injury and soil disturbance in Alaskan shrub tussock plant communities, especially those underlain by ice-rich permafrost (Ahlstrand and Racine 1993). Ahlstrand and Racine (1993) found that while many factors affect severity of disturbance from OHVs in permafrost areas, generally, more passes (i.e., more intense use) and heavier OHVs result in deeper tracks. This can result in ground surface subsidence due to thawing of ice-rich permafrost (Racine and Ahlstrand 1991), and can create muddy areas which trail users often must navigate around. With continued use, this can result in braiding of the trail. The Coal Creek OHV trail assessment dataset characterizes trail condition; however, data regarding the number of trail users and intensity of trail use is not available. Refer to the permafrost section of this document (Chapter 4.3) for more information regarding surveyed OHV-trail lengths and estimated areas from the Coal Creek OHV GIS data.

Non-native Invasive Plants
Non-native invasive plants can alter native plant communities by outcompeting native species and altering geochemical and geophysical processes (Heys and Bauder 2005). Some invasive species or groups of invasive species become established to a level deserving a new (non-native) land cover classification. This, however, depends on the scale, purpose, and methods of a land cover mapping effort. Many invasive plant species establish themselves in heavily disturbed areas such as road and trail-corridors, landing strips and gravel bars (Schrader and Hennon 2005). In YUCH, inventory and control efforts have focused on invasive plants found primarily along trail corridors in the Coal Creek drainage and near public use cabins on the Yukon River (Passmore and Sherman 2010). The present-day extent of non-native invasive plants appears limited in YUCH, with densities and areas far too low to detect at a landscape scale (i.e., it is not affecting vegetation enough to justify additional land cover classes). Non-native invasive plants are discussed further in the native plant communities section of this report, Chapter 4.17.

Climate Change
Over the next century, YUCH is expected to become warmer and drier. Temperatures are projected to increase at an average rate of about 1°F (0.55°C) per decade (SNAP et al. 2009). Precipitation is predicted to increase, yet increased evapotranspiration due to warmer temperatures and a longer growing season will likely lead to an overall drier climate (SNAP et al. 2009). Changes in climate are expected to have a significant impact on vegetation, lakes and streams, chemical cycling, and fire regime (Redmond and Simeral 2006, SNAP et al. 2009), which are all likely to have significant influences on land cover. This is a complex subject for all Alaska NPS units and a topic worthy of scientific research within YUCH due to unique flora resources and the complex interaction of fire, hydrology, and vegetation.

Fire

Fire is the dominant natural disturbance factor in YUCH that in many areas of the preserve leads to a “patchwork of early, mid, and late seral communities across the landscape” (Boggs and Sturdy 2005, p. ii). This disturbance and its effects on vegetation succession, act as a driver of land cover change. Boggs and Sturdy (2005) described six major succession sequences, noting that the slope, aspect, and hydrology were well correlated with vegetation succession on a coarse scale. If fire regime variables such as frequency (fire return interval), timing, severity, and duration were to change (outside of their natural variability), vegetation succession patterns could change and therefore would alter broad land cover type composition and dynamics in the preserve. Fire regime variables and associated summary statistics can be found in the Fire Regime section, Chapter 4.4 of this document. Other important factors that may change the typical successional sequences after fire and therefore land cover composition, include mammal herbivory, insect infestations, windthrow, climate cycles and flooding (Boggs and Sturdy 2005). Boggs and Sturdy (2005) provide detailed descriptions of typical vegetation successional trajectories in YUCH following fire.

Flooding

Flooding is another natural disturbance that affects vegetation succession in river and stream floodplains, especially the Yukon River floodplain in the preserve. In floodplains, vegetation responds to changes in water tables, vegetation being washed downstream, increases in sediment deposition, or exposure of permafrost and formation of thermokarst features (Boggs and Sturdy 2005). Vegetation succession begins with new alluvial bars forming on the downstream side of a convex river curve (Boggs and Sturdy 2005). Abandoned river/stream channels are also colonized by trees and shrubs (Boggs and Sturdy 2005). Repeated flooding events deposit sediment on the floodplain’s soil surface; over time the soil height relative to the water increases and the river migrates away from the land surface, allowing drier soil conditions and vegetation to succeed to later seral stages. Eventually (>170 years) in older river terraces, vegetation succeeds to a black spruce sere due to permafrost formation and subsequent increases in soil moisture and organic matter depth (Boggs and Sturdy 2005). If hydrologic variables of the Yukon River or other rivers in the preserve were to change, outside of the natural variation, this could alter flooding, soil formation, permafrost dynamics, and vegetation succession, therefore potentially altering broad land cover dynamics and composition over time in river floodplains.

Data Needs/Gaps

Trap-line location information is not available for the preserve.

The “footprint” or area affected by past mining activity is delineated in maps contained in NPS (1989). However, these are large hard-copy maps and would require scanning and georeferencing in order to be used in a GIS. Past mining effects represent the largest single source of anthropogenic-caused changes in land cover in the preserve. For example, sparsely vegetated or un-vegetated dredge tailings are still distinguishable in the 2006/2007 CIR aerial photography. An effort to interpret these areas using this information could be compared to the mapped extent of mining disturbance contained in the NPS (1989) maps. Specific information regarding the extent and locations of active mining is not available.

A precise characterization of preserve-wide changes in land cover is not currently possible given the available GIS datasets. However, new imagery sources and ecological site classification work will aid in understanding land cover in the preserve. The 2006/2007 CIR aerial photograph mosaic presents a valuable data source for creating new GIS land cover datasets. Information from the NRCS soil/ecological mapping project, once published, will further describe the broad concept of land cover with ecological site information. Finally, a project between Saint Mary's University of Minnesota, GeoSpatial Services (SMUMN GSS) and the CAKN I&M Program is underway to orthorectify high resolution scans of historic black and white and CIR aerial photography from the 1950s and 1980s. Once the project is complete, the historic photography could be used to assess changes in landscape conditions such as vegetation cover classes (land cover), surface hydrology, and fire regime. These photos could also be used to interpret historic logged areas, if distinguishable, to determine extent and locations in the preserve.

Recent land cover changes due to the 2009 ice-jam flooding are not quantified. Barnes (pers. comm., 2011) has observed some of the results of the 2009 ice-jam flooding, specifically islands on the Yukon River completely cleared of their vegetation (including mature stands of spruce) by the surge of water and ice. An analysis of historic imagery (1950s and 1980s) and recent imagery/photography could identify and describe changes in the Yukon River's floodplain. In addition, Dr. Matt Nolan of the University of Alaska Fairbanks conducted an aerial photo-mission just after the spring 2009 flooding that occurred on the Yukon River in the preserve (Nolan 2010). The researcher also took over 5,000 high resolution images (20 cm ground sample distance) along the Yukon River near Coal Creek in mid-June 2010 (Nolan 2010). The primary intent of this aerial photography is to study the ecological alterations, specifically changes in moose habitat, caused by the scouring effects of ice flow and permafrost thawing (Nolan 2010).

Overall Condition

The SMUMN GSS scoring methods described in Chapter 3 are not used to assess land cover in the preserve. Data explicitly quantifying land cover change or landscape scale stressors are limited. Instead, the measures in this assessment provide a set of baseline information to which future information can be compared.

It is important to differentiate between anthropogenic-caused changes in land cover and natural processes that drive land cover change (e.g., fire or flooding), because YUCH is directed by its enabling legislation to protect natural processes and to minimize human disturbance. Specific areas in the preserve, such as along Woodchopper and Coal Creeks, have been significantly altered by historic mining activities and there is still a threat of disturbance through active mining claims. Sources of localized human disturbance in the preserve include OHV trails, river take-outs, small areas surrounding public-use cabins, and frequently visited historic sites (e.g., roadhouses). Some administrative and research activities may provide vectors for the spread of non-native invasive species; however, non-native and invasive plant species inventories have primarily focused on places such as air strips, trails, around preserve infrastructure (e.g., cabins and other buildings) and river take-outs. The area of invasive plant species infestations, the area of Coal/Woodchopper Creek OHV trails, and the areas delineated in the NPS (1989) maps are the only quantified human disturbance in terms of area in the preserve. Outside of the historic mining disturbance, human disturbances occur at such a small scale that they are not particularly relevant to the geographic scales typically used when presenting landscape scale metrics such as land cover. In fact, Boggs and Sturdy (2005, p. 3) state that "the landscape is largely unchanged by human development." Little evidence exists suggesting any immediate, direct threats (e.g., development, human disturbance) to land cover or land cover dynamics in the preserve.

Given future climate predictions offered by SNAP et al. (2009), climate change is expected to impact vegetation, lakes and streams, chemical cycling, and fire regime (Redmond and Simeral 2006, SNAP et al. 2009). Climate may also affect natural disturbances such as flooding and insect and disease outbreaks, which would be expressed as alterations in land cover composition and distribution.

Sources of Expertise

Jennifer Barnes, regional fire ecologist, Yukon-Charley Rivers/Gates of the Arctic National Parks & Preserves.
Andrew Ruth, Forestry Technician, Alaska Eastern Area Fire Management, provided fire protection point GIS data.

Literature Cited

Ahlstrand, G. M., and C. H. Racine. Response of an Alaskan, U.S.A., shrub-tussock community to selected all-terrain vehicle use. Arctic and Alpine Research 25(2):142-149.

Alaska Interagency Coordination Center (AICC). 2011. Fire perimeter GIS data since 1942. Online. (http://afsmaps.blm.gov/?site=fire). Accessed 24 May 2011.

Allen, J. L. 2005. Annual report on vital signs monitoring of the extent, severity and effects of wildland fire in Yukon-Charley Rivers NP, Denali NP/P & Wrangell-St. Elias NP/P. National Park Service, Central Alaska Network, Fairbanks, Alaska.

Alaska Department of Natural Resources (AKDNR), Land Records Information Section. 2006. Mining claims and prospecting sites – federal and state. GIS polygon dataset. Contained within the National Park Service permanent GIS dataset. Anchorage, Alaska.

Archaeology Site Management Inventory System (ASMIS). 2010. Historic structures in YUCH (24 November 2010). GIS point dataset. Alaska Regional Office, Anchorage, Alaska.

Bailey, R. G. 1996. Ecosystem geography. Springer-Verlag Publishing, New York, New York.

Boggs, K., and M. Sturdy. 2004. Plant associations and post-fire vegetation succession in Yukon-Charley Rivers National Preserve. Alaska Natural Heritage Program, Environment and Natural Resources Institute, University of Alaska Anchorage, Anchorage, Alaska.

Comber, L. 2005. What is land cover? Environment and Planning B: Planning and Design 932: 199-209.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C.

Ducks Unlimited (1997). Landcover map for Yukon-Charley Rivers National Preserve. GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska.

Ducks Unlimited. 2002. Yukon-Charley/Black River/Fortymile earth cover classification. BLM-Alaska Technical Report 48. Bureau of Land Management, Anchorage, Alaska.

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

Gabriel, W., and S. Talbot. 1984. Glossary of landscape vegetation and ecology for Alaska. BLM Alaska Technical Report 10. Bureau of Land Management, Anchorage, Alaska.

Gallant, A. L., E. F. Binnian, J. M. Omernik, and M. B. Shasby. 1995. Ecoregions of Alaska. Geological Survey Professional Paper 1567. U.S. Geological Survey, Reston, Virginia.

Heys, J., and P. Bauder. 2005. BAER invasive plant survey, Yukon-Charley Rivers National Preserve, Coal and Woodchopper Creek watersheds: 2005 fieldwork report. National Park Service, Anchorage, Alaska.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Fairbanks, Alaska.

Miles and Associates Ltd. 2003. Restoration of placer mined streams: identification of strategies to expedite recovery. Prepared for Yukon River Panel, Whitehorse, Yukon. M. Miles and Associates Ltd., Victoria, British Columbia.

National Park Service (NPS). 1989. Draft environmental impact statement – cumulative impacts of mining. Yukon Charley Rivers National Preserve. National Park Service, Alaska Regional Office, Anchorage, Alaska.

National Park Service (NPS). 2010. Yukon Charley Rivers National Preserve annual report. Online. (http://www.nps.gov/yuch/parkmgmt/upload/2010_ YUCH_Annual_Report.pdf). Accessed 10 July 2011.

National Park Service (NPS). 2011a. Fires- NPS Alaska (point data), Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska.

National Park Service (NPS). 2011b. Fire protection points YUCH. GIS dataset. Updated through November 2011, Received from Andrew Ruth, Forestry Technician, Eastern Area Fire Management. Fairbanks, Alaska.

National Park Service (NPS). 2012. Yukon-Charley Rivers National Preserve proposed compendium 2012. Online. (http://www.nps.gov/akso/management/compendium_docs/2012Proposed/YUCH2012ProposedCompendium_1-13-12.pdf). Accessed 15 January 2012.

Nolan, M. 2010. Trip report for Coal Creek aerial photography 16, 17 June 2010. Institute of Northern Engineering, University of Alaska Fairbanks. Online. (http://www.drmattnolan.org/photography/2010/airphotos_100615/coalcreek_100615_notes.txt). Accessed 3 June 2011.

Passmore, C., and M. S. Sherman. 2010. Invasive and exotic species management for Yukon-Charley Rivers National Preserve: 2010 summary report. Natural Resource Data Series NPS/YUCH/NRDS—2010/103. National Park Service, Fort Collins, Colorado.

Racine, C. H. 1976. Vegetation map of Yukon Charley Rivers National Preserve, 1976. GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska.

Racine, C. H., and G. M. Ahlstrand. 1991. Thaw response of tussock-shrub tundra to experimental all-terrain vehicle disturbances in south-central Alaska. Arctic 44:31-37.

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.

Reyes, A.V., D. G. Froese, and B. J. L. Jensen. 2010. Permafrost response to last interglacial warming: Field evidence from non-glaciated Yukon and Alaska. Quaternary Science Reviews 29(23-24):3256-3274.

Scenarios Network for Alaska Planning (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 23 February 2011.

Schrader, B., and P. Hennon. 2005. Assessment of invasive species in Alaska and its national forests. Online. (http://akweeds.uaa.alaska.edu/pdfs/literature/Schrader_R10_Inv_Spp_Assessmt.pdf). Accessed 18 February 2011.

Swanson, D.K. 2001. Ecological subsections of Yukon-Charley Rivers Nation Preserve. National Park Service, Alaska Region Inventory and Monitoring Program, Anchorage, Alaska.

U.S. Census. 2010. 2010 census interactive population search website. (2010.census.gov/2010census/popmap/). Accessed 6 December 2011.

Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR-286. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Young, S. B., and C. H. Racine. 1976. General vegetation studies. Pages 40-58 *in* S. B. Young, editor. The environment of the Yukon-Charley rivers area Alaska: results of the Center for Northern Studies biological survey of the Yukon-Charley rivers area 1974-5. Center for Northern Studies, Wolcott, Vermont.

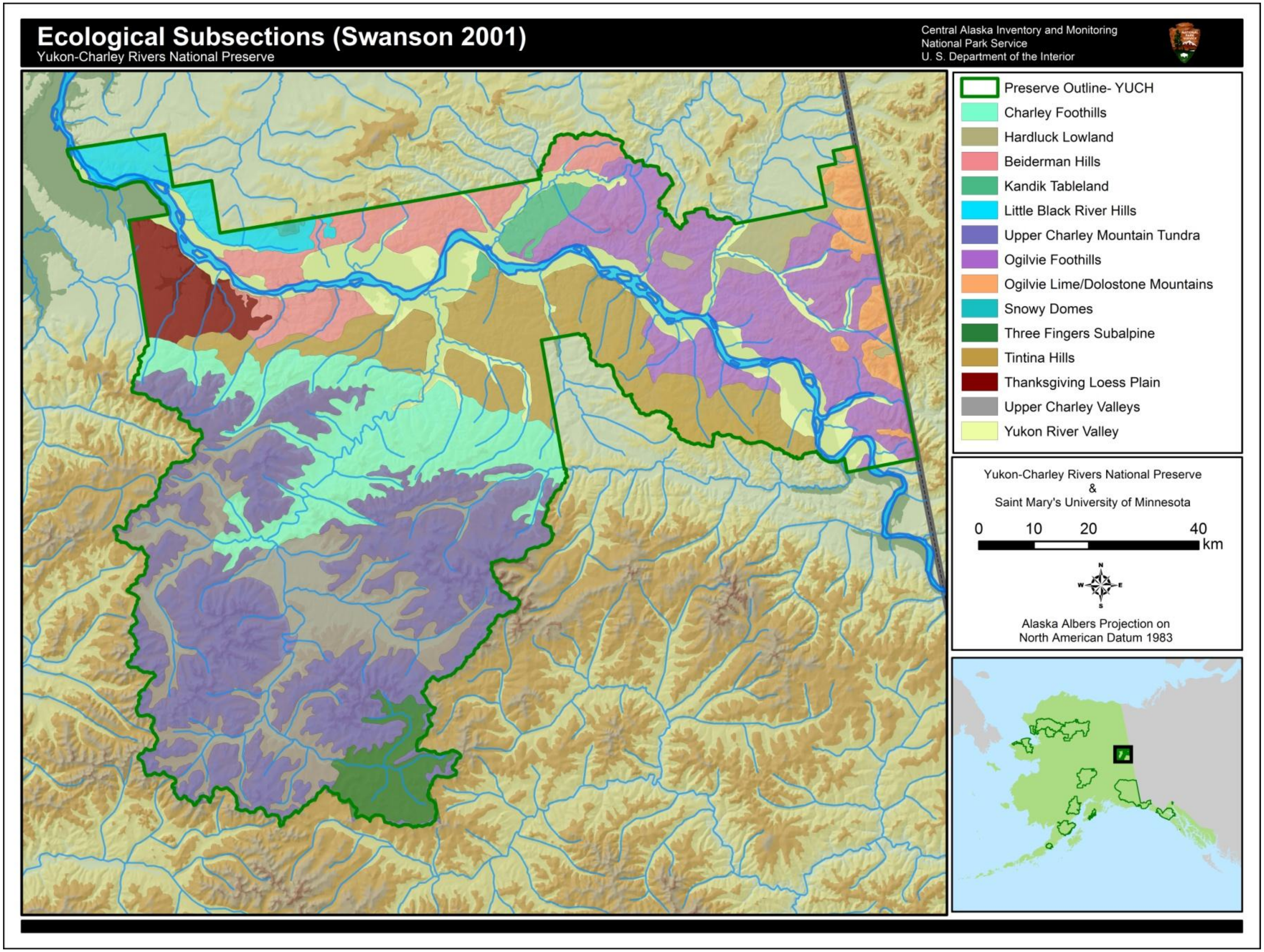


Plate 4. Ecological subsections in YUCH (Swanson 2001).

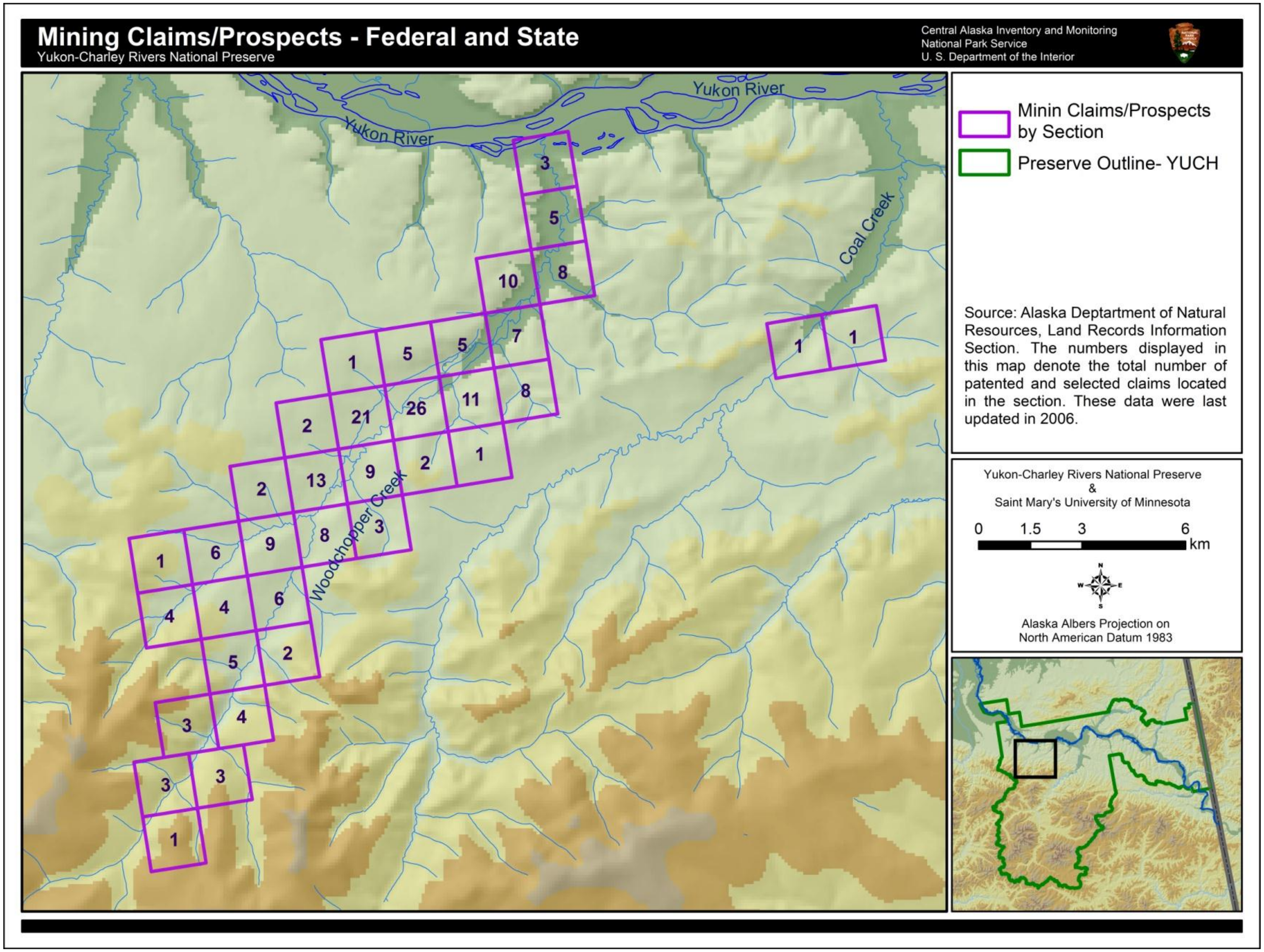


Plate 5. Mining claims and prospects in YUCH (AK DNR Land Records Information Section 2006). Numbers displayed in the sections (purple squares) indicate the total number of patented and selected claims located in the section, data last updated in 2006.

4.2 Lake Ecosystem Function

Description

Lakes and the wetlands often associated with them are among the world's most productive environments and provide a wide variety of ecological benefits (Mitsch and Gosselink 1986). They are important for water storage, flood mitigation, erosion control, groundwater recharge, water filtration, and climate stabilization (Mitsch and Gosselink 1986). Lakes and wetlands also support large populations of mammals and waterfowl, which are still important subsistence resources in some areas (Larsen et al. 2004). Shallow lakes were chosen as a Vital Sign by the CAKN inventory and monitoring program due to their abundance, small size, importance in the ecosystem, and vulnerability to climate change (Larsen 2006). Subarctic lakes are susceptible to change because a warming climate is expected to accelerate the exchange of mass and energy between the various reservoirs of the hydrologic cycle. Warming in subarctic Alaska is expected to affect precipitation patterns, permafrost stability, and vegetation dynamics as well as surface and groundwater hydrology. These environmental changes are expected to have profound impacts on the ecology of shallow lakes including changes to the nutrient regime and carbon dynamics, as well as the distribution and abundance of lakes in general. Over the past 10 years there has been mounting evidence suggesting lakes in subarctic areas are shrinking and disappearing across the state of Alaska (CAKN 2008) (Figure 13). This evidence has strengthened the concern CAKN has regarding the health and integrity of these important aquatic ecosystems.

Photo 9. A shallow lake in YUCH (NPS photo, in Larsen 2005).

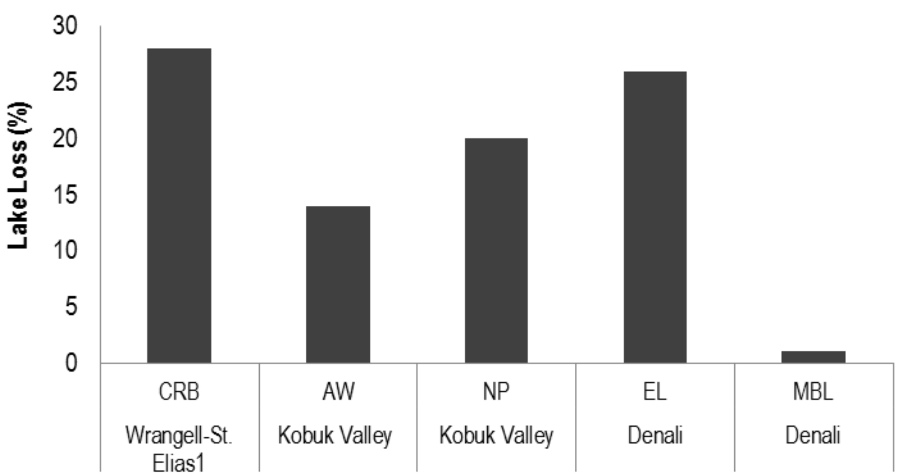


Figure 13. Summary of results from researchers illustrating changes in lake surface area over the past 30-50 years in sections of national parks located across north central Alaska. CRB = Copper River Basin, AW= Ahnewetut Wetlands, NP= Nigeruk Plain, EL= Eolian Lowlands, MBL= Minchumina Basin Lowlands. Results provided by: Riordan et al. (2006); Larsen and Verbyla (2007); Necsoiu et al. (2009).

Measures

- Total area of lakes ≥ one acre
- Number of lakes ≥ one acre
- Selected standard measurements of limnological ecosystem function (total nitrogen, total phosphorus, chlorophyll A and macroinvertebrate taxa richness)

Reference Conditions/Values

Lake Area and Number
The reference condition for these measures is “within the range of natural variation”. Using the limited imagery that is currently available for this region, it is difficult to determine what the range of natural variation is for the number and area of lakes over one acre. Therefore the data for the number and area of lakes presented in the current condition section may act as initial baseline data to which future data can be compared.

Selected Limnological Ecosystem Function Measures
The reference conditions or thresholds for the standard measures of limnological ecosystem function are to be determined. Lakes in YUCH vary in trophic level and type. The NPS is interested in changes that may have occurred over time and why they may have occurred. For example, scientists are interested in understanding if lakes are presently more eutrophic than in historic measurements.

An exploration of lakes in the Charley River area by O’Brien and Huggins (1976) in the mid-1970s found that the region’s lakes were generally shallow, warm, and oligotrophic (nutrient-poor). Dissolved oxygen concentrations were high and often above saturation levels, while most other chemical measurements were “typical of undisturbed low productivity lakes and ponds” (O’Brien and Huggins 1976, p. 305). Inorganic nitrogen levels were particularly low, contributing to a low nitrogen to phosphorous ratio. According to O’Brien and Huggins (1976, p. 307), “Whereas any ratio below 10 is a general indicator of nitrogen limitation of phytoplankton primary productivity, the N:P ratio in the lakes sampled was generally below 4.” The phytoplankton species found were primarily typical of oligotrophic lakes throughout the northern hemisphere, although the presence of several species “thought to indicate eutrophic conditions, especially the blue-green algae *Anabaena*, was interesting” (O’Brien and Huggins 1976, p. 308). Data from the O’Brien and Huggins study is included in Appendix 8. Lake sampling locations are shown in Plate 8 and geographic coordinates are given in Appendix 9.

Data and Methods

The CAKN monitoring protocol (Larsen et al. 2004), results of a pilot monitoring study in YUCH (Larsen 2005), and several journal articles were provided by preserve staff. Water chemistry and macroinvertebrate data from the CAKN shallow lake monitoring program was provided by Amy Larsen, NPS Aquatic Ecologist, YUGA.

The oldest information available indicating the number and area of lakes in YUCH are GIS data (1:63,360 Hydro polygons) created from Digital Line Graph (DLG) map data (1977 to 1985 vintage). These data were derived from topo maps, originally created in the 1950s, then converted to USGS DLGs. They were updated using 1980s Alaska High Altitude Photography (AHAP). AHAP was flown over a range of years over the state of Alaska. Within the preserve, the primary photography date in high density lake areas such as the Yukon River basin was 8 August 1984. Plate 6 displays the photograph center points, flight lines, and dates for the AHAP in YUCH. A query of the GIS data created an estimate of the number and area of lakes that existed on the YUCH landscape during approximately 1981 to 1985. Only polygons with the coded value of 421 in the "Minor_1" field were selected and clipped to the preserve outline (outer boundaries). Here forward, the results of this query are referred to as USGS lakes.

Using a color-infrared (CIR) aerial image mosaic of YUCH (created by Aerometric Inc. for the NPS), lakes were photo-interpreted using heads-up digitizing methods in a GIS. The mosaic was constructed from many individual photos taken over a total of ten different days in July 2006 and June - August 2007. Areas interpreted as unconsolidated bottom (UB) or aquatic bed (AB) lakes (lacustrine) and ponds (palustrine) in the Cowardin et al. (1979) classification system were delineated as lakes. Panning systematically across the image mosaic at a scale of 1:20,000 allowed the photo interpreter to locate lakes, and then zoom to a 1:2,000 scale to digitize the lake boundaries. In some cases this involved grouping aquatic bed areas with open water as the interpreted lake boundary.

Lake numbers and area from USGS lakes and the lake digitizing efforts (hereafter 2007 lakes) are presented in the current condition section of this assessment. Note, the data and methods used in creation of USGS lake data used the best technology available at the time and followed U.S. mapping standards. AHAP was flown at a higher altitude than the 2007 CIR photography and therefore lakes and their boundaries are more readily discernible in the 2007 photography. In addition, the USGS lake data were updated using stereoscopic interpretation of hard-copy photos, then later digitally converted into GIS data, whereas the 2007 lakes were created digitally (i.e., heads-up digitizing in ESRI's ArcMap). Differences in mapping methods and image sources may explain some of the differences in the lake area and number estimates.

Current Condition and Trend

Neither the preserve nor the CAKN monitoring program has completed a comprehensive historical analysis of lake numbers and surface area. The network (CAKN) is planning to complete this analysis in 2012 once the original 1950s photographs are digitally converted and orthorectified. These images will be compared with 1980s aerial photography and recent (2007) CIR aerial photography, allowing scientists to consistently measure lake number and surface area across the various sources of imagery. Another analysis is proposed in which LandSat imagery will be used to assess total water surface area over multiple images and determine some of the variability in hydrologic conditions between images (YUGA, Amy Larsen, aquatic ecologist, pers. comm., 2012).

Total Lake Surface Area for Lakes One Acre or Larger

A comparison of USGS lakes and 2007 lakes provides preliminary indications that lake surface area and number have decreased from the 1980s through 2007 (Figure 14). The query of USGS data reveals a total of 1,597 ha (3,947 ac) for lakes one acre in size or larger. The 2007 lake data revealed a total surface area of 1,504 ha (3,730 ac), 5.8% less area than USGS data. This may represent a real ecological change in the landscape, however, in future work, employing the same mapping protocols across available aerial photography (1950s, 1980s, and 2007) will ensure lake area and numbers are statistically comparable between image dates.

Anecdotal observations of several lakes along the Yukon River corridor corroborate that lakes are changing in this region. In some areas, the lakes identified in the USGS lake data are no longer present in the lake data/2007 CIR aerial photography. This is illustrated in one area along the Yukon River in YUCH (Plate 7). This confirms the drainage of lakes noticed by researchers; however, the extent of similar changes across the entire landscape of the preserve is not well understood.

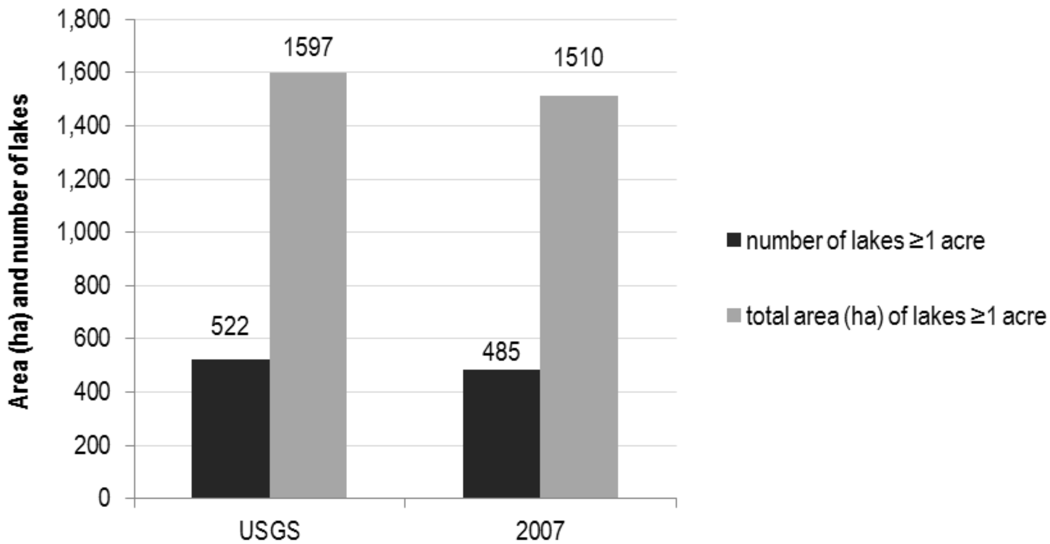


Figure 14. Area and number of lakes one acre or larger by GIS data source.

<u>Number of Lakes One Acre or Larger</u>

The USGS data contained 522 lakes one acre or larger and the 2007 lakes revealed a total of 485 lakes, a 7.6% decrease (Figure 14).

The vast majority of lakes in YUCH are within the Yukon River Valley (YV) ecological subsection described in Swanson (2001). This subsection contains approximately 82% of lakes ≥ one acre and the largest total area (~88 %) of lakes one acre or larger (Plate 6). Many of the other ecological subsections contain mountainous terrain, and lakes within them are primarily found in small Yukon River tributary valleys, many of which are abandoned river channels (meander scars) or beaver ponds.

Table 17 displays the 2007 lake area estimates by ecological subsection in YUCH. Lakes are assigned to ecological subsections (Swanson 2001) based on geographic intersection of the two GIS datasets.

Table 17. 2007 lake area estimates (lakes ≥ one acre) by Swanson (2001) ecological subsection.

Subsection		Total Area of Lakes		Max lake size		Average lake size	
	Count	ha	ac	ha	ac	ha	ac
Biederman Hills	7	3.9	9.6	0.8	1.9	0.6	1.4
Charley Foothills	3	2.5	6.1	1.3	3.3	0.8	2.0
Hardluck Lowlands	2	1.0	2.5	0.5	1.3	0.5	1.2
Kandik Tableland	--	--	--	--	--	--	--
Little Black River Hills	--	--	--	--	--	--	--
Upper Charley Mountain Tundra	13	73.8	182.3	34.7	85.7	5.7	14.0
Ogilvie Foothills	2	2.7	6.7	2.1	5.2	1.4	3.3
Ogilvie Mountains	--	--	--	--	--	--	--
Snowy Domes	--	--	--	--	--	--	--
Three Fingers Subalpine	12	17.9	44.3	4.0	9.9	1.5	3.7
Tintina Hills	4	2.4	5.8	0.8	2.1	0.6	1.5
Thanksgiving Loess Plain	29	65.6	162.1	8.9	22.0	2.3	5.6
Upper Charley Valleys	13	15.9	39.3	3.9	9.7	1.2	3.0
Yukon River Valley	400	1,324.4	3,272.7	78.5	194.1	3.3	8.2
Totals:	**485**	**1,510.1**	**3,731.5**				

Using the 2007 CIR photography, preliminary photo interpretation of small lakes 0.32 – 0.40 ha (0.08 – 0.99 acres) identified nearly four times the number of lakes compared with lakes of the same size-class in the USGS data. This size class was chosen because the smallest lake mapped in the USGS hydro data for YUCH was 0.08 acres. This may represent an actual increase in the number of small lakes across the landscape, possibly due to thermokarsting in some areas. However, it is possible that differences in image interpretation between photo-interpreters (e.g., what is interpreted as a lake, what is considered the boundary of the lake) contribute to the differences in the number of lakes across the preserve. Other possible explanations for larger numbers of small lakes in 2007 photography include lakes shrinking and becoming multiple small water bodies or variations in the hydrologic conditions at the time of photography. Unfortunately, there is not enough climate data for this remote region to determine the effect that hydrologic conditions have on the lake number and surface area estimates.

Selected Standard Measurements of Limnological Ecosystem Function

Monitoring lake ecosystems is extremely complex and it is difficult to look to a single measurement to determine the health and integrity of these systems. Monitoring the trophic state of a lake is one way to assess the health of a lake ecosystem. Total nitrogen and total phosphorus levels, as well as chlorophyll A levels, are commonly used to estimate trophic state. Nitrogen enters lakes through the decay of plant matter, nitrogen fixation by leguminous plants and microorganisms, and directly from the atmosphere. It is second only to phosphorus as an important nutrient for plant and algae growth (Shaw et al. 2004). Elevated phosphorus levels in lakes, often due to human activities, may contribute to excessive aquatic plant growth (Shaw et al. 2004). Chlorophyll A is commonly used to estimate phytoplankton biomass and is considered an indicator of primary productivity and trophic state (Lillie and Mason 1983). The abundance and type of aquatic macroinvertebrates or phytoplankton are also regularly used to assess lake ecosystem health (condition) because they are generally easy to collect and differ in their tolerance of water quality conditions (EPA 2010a).

Between 2003 and 2008, data was collected from nineteen shallow lakes along the Yukon River in YUCH (Plate 8). The CAKN monitoring program is required to collect standard data on water temperatures, pH, specific conductivity, and dissolved oxygen, as these variables strongly influence the measures discussed below. Water temperatures in the YUCH lakes sampled between 2003 and 2008 ranged from a low of 3.2°C at the end of September 2008 to 24.6°C in early July 2007 (Larsen 2011a).

In synoptic water samples, pH from YUCH lakes has ranged widely, from 5.8 to 9.2, with most measurements falling between 7 and 8.5 (Larsen 2011a). This variation may be due to different lake types (e.g., oxbow, thermokarst), connectivity with groundwater or other surface water bodies, and influences from surrounding vegetation and soil. Aquatic habitats with lower pH values, especially below 6, tend to exhibit lower biodiversity (EPA 2010c).

In synoptic sampling across lakes, specific conductance measurements ranged from 48 to 864 µS/cm and were fairly consistent within each lake over time, with the exception of lakes 012 and 013 where specific conductance increased around 40% between 2005 and 2007 (Larsen 2011a), likely due to a nearby wildfire (Larsen, pers. comm., 2011).

Total Nitrogen

Average total nitrogen levels in the lakes sampled from 2003 to 2007 ranged from 0.89 to 2.30 mg/L with a mean of 1.33 mg/L (Table 18; Larsen 2011b). In comparison, lakes sampled at Denali National Park and Preserve, also in Interior Alaska, ranged from 0.14 to 2.31 mg/L with a mean of 0.65 mg/L (Larsen 2010). The nine lakes sampled by O'Brien and Huggins (1976) in YUCH yielded much lower nitrogen levels, ranging from 0.02 to 0.04 mg/L with a mean of 0.03 mg/L (Appendix 8). It is unclear if these lower levels are a result of differences in sampling methodology, geographic variation, or actual change over time.

Table 18. Summary of total nitrogen concentration (mg/L) measurements from lakes in YUCH (Larsen 2011b).

Lake	# of samples	# below MRL	2003 average	2004 average	2005 average	2007 average	Average of all samples
YUCH-001	7	2	1.26	<MRL	--	--	1.26
YUCH-002	8	1	1.66	1.72	--	--	1.68
YUCH-003	6	1	1.56	--	--	--	1.56
YUCH-004	17	1	1.32	1.91*	1.88	1.20	1.54
YUCH-005	8	4	1.2	<MRL	--	--	1.2
YUCH-006	8	2	1.43	<MRL	--	--	1.43
YUCH-007	8	3	1.26	<MRL	--	--	1.26
YUCH-008	8	0	2.45	1.84	--	--	2.30
YUCH-009	6	0	1.83	--	--	--	1.83
YUCH-010	11	2	--	1.01*	1.43	1.18	1.30
YUCH-011	11	0	--	1.01	0.80	1.05	0.90
YUCH-012	11	0	--	2.42	1.04	0.53	1.15
YUCH-013	11	2	--	0.66	1.22	0.61	0.89
YUCH-014	2	1	--	1.01*	--	--	1.01*
YUCH-015	0	0	--	--	--	--	No data
YUCH-016	10	3	--	1.28*	1.22	0.35	0.86
YUCH-017	11	3	--	1.01*	1.45	0.72	1.12
YUCH-018	0	0	--	--	--	--	No data
YUCH-019	0	0	--	--	--	--	No data

MRL = Minimum reporting level, * = single sample above MRL

Total Phosphorous

Average total phosphorus levels in the YUCH lakes sampled ranged from 0.003 to 0.121 mg/L with a mean of 0.04 mg/L (Table 19; Larsen 2011b). In comparison, lakes sampled at Denali ranged from 0.004 to 0.143 mg/L with a mean of 0.021 mg/L (Larsen 2010). Phosphorous levels in the lakes sampled by O'Brien and Huggins (1976) ranged from 0.002 to 0.129 mg/L with a mean of 0.022 mg/L (Appendix 8).

Table 19. Summary of total phosphorus concentration (mg/L) measurements from lakes in YUCH (Larsen 2011b).

Lake	# of samples	# below MRL	2003 average	2004 average	2005 average	2007 average	Average of all samples
YUCH-001	8	7	<MRL	0.005*			0.005*
YUCH-002	8	0	0.087	0.090			0.088
YUCH-003	6	0	0.043				0.043
YUCH-004	17	11	<MRL	0.017*	0.095	0.027	0.048
YUCH-005	8	4	0.030	0.012*			0.026
YUCH-006	8	6	0.025*	0.002*			0.016
YUCH-007	8	7	<MRL	0.003*			0.003*
YUCH-008	8	0	0.121	0.063			0.106
YUCH-009	6	0	0.121				0.121
YUCH-010	11	2		0.010	0.054	0.025	0.034
YUCH-011	11	3		0.007	0.047	0.016	0.025
YUCH-012	11	2		0.018	0.076	0.027	0.041
YUCH-013	11	1		0.011	0.050	0.018	0.032
YUCH-014	2	0		0.0035			0.0035
YUCH-015	0	0					No data
YUCH-016	11	1		0.004	0.081	0.017	0.047
YUCH-017	11	5		0.007	0.029*	0.010	0.012
YUCH-018	0	0					No data
YUCH-019	0	0					No data

MRL = Minimum reporting level, * = single sample above MRL

There is a positive relationship ($R^2 = 0.5694$) between total phosphorus and total nitrogen concentrations in lakes at YUCH (Figure 15). Lakes with a measurement below MRL were excluded from this analysis, as was data from 2004 when the majority of lakes yielded either one or no samples above MRL.

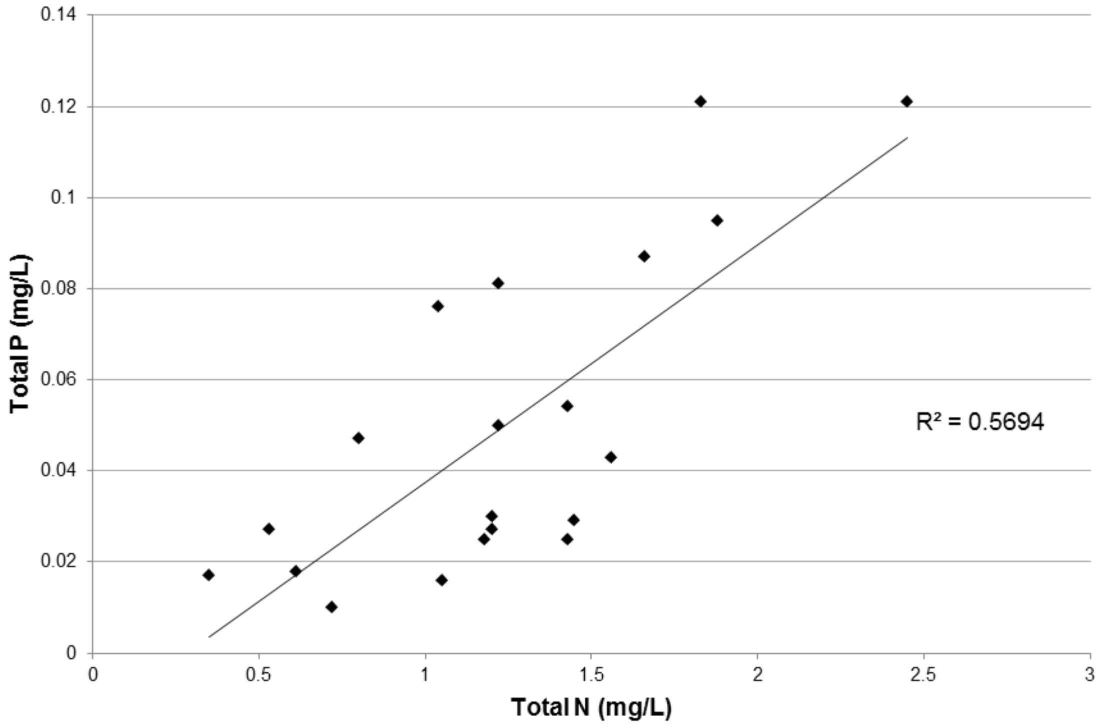


Figure 15. A comparison of total nitrogen and total phosphorus concentrations from selected lakes in YUCH. Lakes with measurements below MRL were excluded from this analysis (data from Larsen 2011b).

Chlorophyll A

Average chlorophyll A levels in sampled lakes ranged from 0.53 to 11.27 µg/L with a mean of 3.56 µg/L (Table 20; Larsen 2011b). The majority of these lakes would be considered oligotrophic (low productivity, <5 µg/L, Shaw et al. 2004) with only Lake 8 categorized as eutrophic or highly productive (>11 µg/L, Shaw et al. 2004). Chlorophyll A levels in Denali lakes were similar, ranging from 0.29 to 23.04 µg/L with a mean of 3.21 µg/L (Larsen 2010). Chlorophyll A levels were compared to nitrogen and phosphorous measurements from each lake to explore a possible link between these nutrient levels and primary productivity, but no significant relationship was detected.

Table 20. Summary of chlorophyll A (µg/L) measurements from lakes in YUCH (Larsen 2011b).

Lake	# of samples	# below MRL	2003 average	2004 average	2005 average	2007 average	2008 average	Average of all samples
YUCH-001	7	0	1.08	0.41*	--	--	--	0.99
YUCH-002	7	0	2.47	1.02	--	--	--	2.26
YUCH-003	6	0	7.13	--	--	--	--	7.13
YUCH-004	22	0	2.42	3.51*	3.54	4.23	5.55	3.88
YUCH-005	7	0	6.18	3.26*	--		--	5.77
YUCH-006	7	0	1.08	1.06*	--		--	1.08
YUCH-007	7	0	0.47	0.90*	--		--	0.53
YUCH-008	7	0	12.43	4.27*	--		--	11.27
YUCH-009	6	0	7.97	--	--		--	7.97
YUCH-010	11	0	--	1.49	1.26	19.07	--	6.16
YUCH-011	10	0	--	1.93	1.42	2.67	--	1.77
YUCH-012	11	2	--	1.75	0.38	3.00	--	1.53
YUCH-013	11	5	--	1.34	0.20*	3.01	--	1.98
YUCH-014	2	0	--	1.1	--		--	1.1
YUCH-015	2	0	--	1.52	--		--	1.52
YUCH-016	11	3	--	1.32	0.46	0.44	--	0.67
YUCH-017	11	0	--	1.5	1.14	10.33	--	3.71
YUCH-018	0	0	--	--	--	--	--	No data
YUCH-019	2	0	--	4.73	--	--	--	4.73

MRL = Minimum reporting level, * = single sample above MRL

Macroinvertebrate Taxa Richness

Taxa richness was determined for the lakes sampled in June and August of 2003 and 2004. The total number of taxa per lake ranged from 22 to 54 with a mean of 41.3 (Table 21; Larsen 2011c). Taxa from the insect order Ephemeroptera, often considered indicators of good water quality (EPA 2010b), were found in all 17 of the lakes sampled (Larsen 2011c). Taxa richness in lakes sampled by O'Brien and Huggins (1976) ranged from 5 to 34 with a mean of 14.1 (

Appendix **10**). However, these differences could be due to differences in lake size, time of sampling or sampling effort rather than change over time. All the classes and insect orders found by O’Brien and Huggins (1976) were also recorded by Larsen (2011c); however, O’Brien and Huggins only found ephemeropterans in two of the eight lakes they sampled (Appendix 28).

Table 21. Results of macroinvertebrate sampling in YUCH (Larsen 2011c).

Lake	Samples taken				Total taxa
	June 2003	Aug. 2003	June 2004	Aug. 2004	
YUCH-001	x	x	x	x	52
YUCH-002	x	x	x	x	44
YUCH-003	x	x	--	--	39
YUCH-004	x	x	X	X	54
YUCH-005	x	x	X	X	54
YUCH-006	x	x	X	X	48
YUCH-007	x	x	X	X	51
YUCH-008	x	x	X	X	53
YUCH-009	x	x	--	--	43
YUCH-010	--	--	--	X	38
YUCH-011	--	--	--	X	30
YUCH-012	--	--	--	X	36
YUCH-013	--	--	--	X	37
YUCH-014	--	--	--	X	36
YUCH-015	--	--	--	--	No data
YUCH-016	--	--	--	X	32
YUCH-017	--	--	--	X	33
YUCH-018	--	--	--	--	No data
YUCH-019	--	--	--	x	22

Figure 16 shows the number of families found in several macroinvertebrate orders by season in 2003-2004. For two orders (Hemiptera and Ephemeroptera), a higher number of families were observed during summer sampling in both years. Further information on macroinvertebrate sampling results can be found in Larsen (2005).

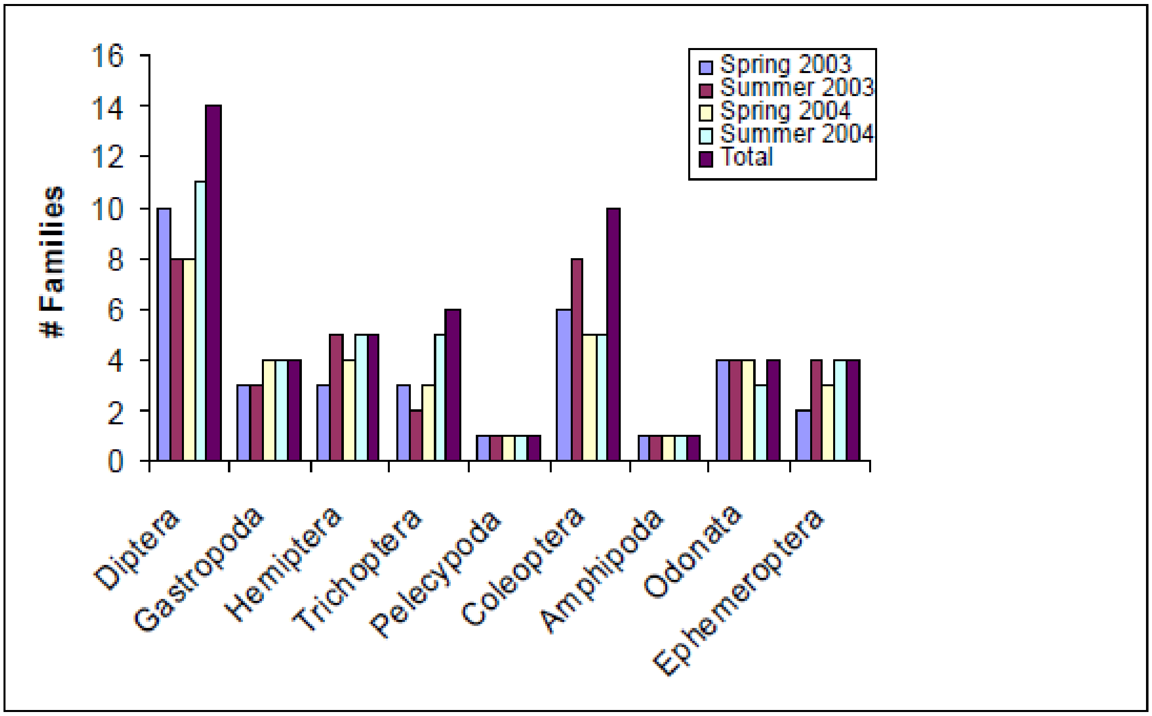


Figure 16. The number of families in major invertebrate orders found during 2003-2004 lake sampling (Reproduced from Larsen 2005).

<u>Threats and Stressor Factors</u>

Non-native Aquatic Species
Non-native species in lakes have the potential to alter the hydrology, biogeochemical cycling, and biotic composition of the aquatic ecosystem (Strayer 2010). While no non-native aquatic species have been found in the preserve to date, regular flooding of the Yukon River makes floodplain lakes and wetlands vulnerable to the introduction of these species. Strayer (2010, p. 160) warns that, "the establishment of even a single alien plant species can radically transform the entire character of an aquatic ecosystem, affecting nearly every aspect of ecosystem structure and function, and having effects that reach far beyond the boundaries of the plant bed itself."

Climate Change
Many of the stressors to YUCH's lake ecosystems can be attributed to climate change. The preserve is expected to become warmer and drier during the next century (SNAP et al. 2009). Although precipitation is expected to increase, warmer temperatures and increased evapotranspiration due to a longer growing season will likely cause a decrease in water levels (SNAP et al. 2009). Water temperatures are also likely to increase, affecting the biological composition of lakes and even their water chemistry. Other factors affecting lakes that will likely be influenced by climate change include length of growing season, ice duration and thickness, seasonal precipitation patterns, and flood dynamics.

Permafrost Degradation and Catastrophic Lake Drainage
Lakes have been observed to be shrinking or disappearing across interior Alaska (Riordan 2005, CAKN 2008) (Photo 10). However, researchers have noted that not all lakes are affected equally,

suggesting that increasing temperatures and evapotranspiration were not the only factors contributing to lake drying (Naranjo 2009). Subsurface drainage appears to be playing a key role in lake drying in Alaska.

Photo 10. The bare area in the center of this photo was a lake that drained suddenly in 2003 (NPS photo, in Larsen 2005).

Subsurface drainage can increase greatly as permafrost thaws with increasing temperatures (Naranjo 2009). When permafrost is present under a lake, the frozen soils provide a "protective ring", preventing water from draining out through the soil (Naranjo 2009, p. 40). Permafrost is sometimes protected from thawing by surface layers of peat moss and organic matter that insulate it from solar radiation. As the climate warms, conditions may become less favorable for peat moss and the permafrost could lose its protective insulation as well (Naranjo 2009). Other threats to permafrost include wildfires and talik expansion. Taliks are areas of unfrozen soil under lakes where the soils do not freeze. As climate warms and water temperatures rise, these taliks will likely grow and further increase subsurface drainage of lakes (Riordan 2005). Refer to Plate 7 for an illustration of the lake drainage in the area depicted in Photo 10.

Permafrost degradation can also strongly influence the water chemistry of lakes. Increases in total nitrogen, base cations, and turbidity are often seen when permafrost is lost around lakes (Larsen, pers. comm., 2012).

Airborne Contaminants
Air quality is generally considered to be good in Alaska, due to the state's low population density and relatively low levels of industrial activity (MacCluskie and Oakley 2005). However, airborne contaminants have begun reaching Alaska national parks from regional and global industrial sources. Although no data has been gathered in YUCH, a study of fish from two lakes at Denali National Park and Preserve found elevated levels of dieldrin (a banned insecticide) and mercury (Landers et al. 2008). Fish from one lake had mercury concentration levels above the contaminant health threshold for both fish-eating birds and fish-eating mammals (Landers et al. 2008). Several other metals, including lead, were elevated in both fish and lake sediments at Denali (Landers et al. 2008). Dieldrin and mercury levels were also higher than expected in fish from Gates of the Arctic National Park and Preserve (Landers et al. 2008).

Flood Dynamics of the Yukon River
The relationship between lakes (e.g., water levels, nutrient dynamics) in the Yukon River floodplain and the river's flood dynamics has not been studied. This is a concern, considering that flood frequency and magnitude could be impacted by climate change (McGowan et al. 2011). Lakes within active floodplains often rely on periodic flooding to maintain wetland

biodiversity and functioning (McGowan et al. 2011). However, a recent study of a floodplain lake system in Canada found that algal production and, in some cases, emergent plant growth was elevated in lakes that received flood waters less frequently (McGowan et al. 2011). Researchers in Europe also found that flood duration had a direct impact on the physico-chemistry and biological composition of floodplain lakes (Van den Brink et al. 1993). Therefore, it is possible that any changes in the Yukon River's flood dynamics will impact YUCH's floodplain lakes.

<u>Data Needs/Gaps</u>

Despite their ecological importance, very little is known about the physical, chemical or biological structure of lake ecosystems in YUCH (Larsen et al. 2004). No research has been done into the presence of contaminants in YUCH lakes, or how changes in lake ecosystems may affect wildlife that rely on them for habitat or forage (Larsen, pers. comm., 2011). The CAKN monitoring program has begun to address these needs, and as data is gathered, will better allow resource managers to evaluate the condition of YUCH's lakes and any changes that may be occurring. Further investigation of changes in lake area and numbers using the existing datasets and possibly future imagery could characterize landscape-level ecological changes such as lake drying and new thermokarst lake formation. A consistent mapping protocol for lakes across all available image dates (1950s, 1980s, and 2007) and an assessment of LandSat water surface area will help reduce some of the possible variables (e.g., mapping differences and hydrologic conditions at time of photography) affecting lake area and number estimates.

<u>Overall Condition</u>

Total Acres of Lake Surface Area and Number of Lakes Over One Acre

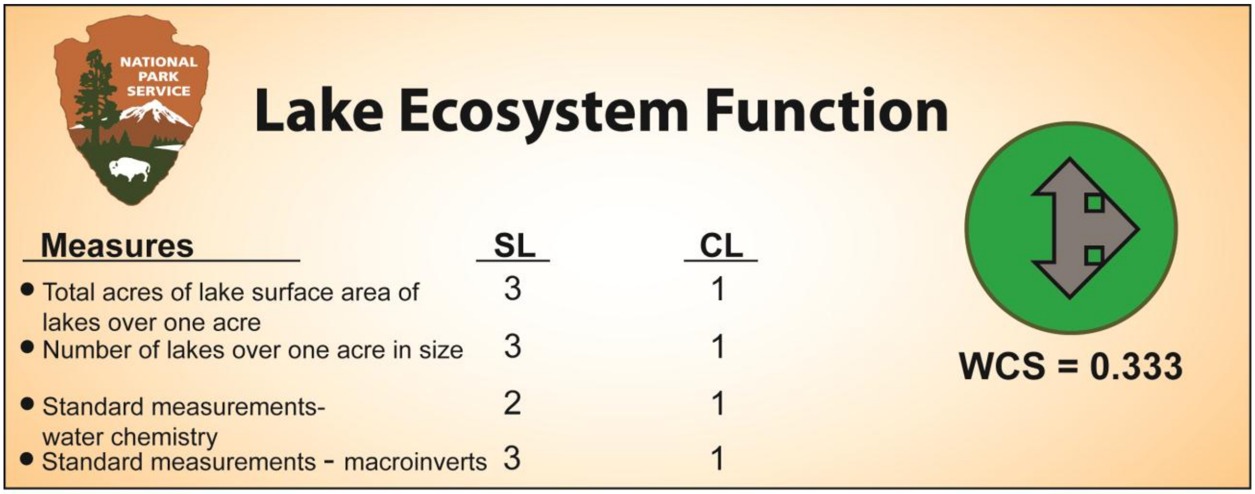
NPS staff assigned these measures a *Significance Level* of 3. While the USGS and 2007 lake data may contain some variation due to mapping differences, some areas have experienced lake drying and initial evidences suggests there are more small water bodies than in the 1980s. At this time a *Condition Level* of 1 (low concern) is assigned for the area and number of lakes. This is due to some preliminary evidence that lakes that appear in older GIS datasets such as USGS lakes data no longer are present in recent aerial imagery. However, to confidently state that lake drying is occurring, a well-developed mapping protocol and detailed statistical analysis across multiple imagery dates is needed. In addition, more research is needed to understand causes of lake drying and other lake dynamics.

Selected Standard Measurements of Limnological Ecosystem Function

For the purpose of scoring, YUCH staff divided this measure in two: water chemistry measurements and macroinvertebrate taxa richness. Water chemistry measurements were assigned a *Significance Level* of 2 while macroinvertebrate taxa richness was assigned a *Significance Level* of 3. Both aspects of this measure received a *Condition Level* of 1. There is no evidence that current nutrient levels are harmfully elevated and macroinvertebrates that are considered indicators of good water quality were found in all lakes sampled. However, comparisons to data from O'Brien and Huggins (1976) suggest that total nitrogen levels may have increased since the 1970s; this potential change is worth further investigation.

Weighted Condition Score

The Weighted Condition Score (WCS) for lake ecosystem function in YUCH is 0.333. This represents an overall condition of low concern with an unknown trend. Lake water quality in Interior Alaska is generally considered good and standard measurements of limnological ecosystem function in YUCH are of low concern. However, lake drying and sudden draining is a concern across interior Alaska and may warrant further attention in YUCH.



Sources of Expertise

Amy Larsen, aquatic ecologist, YUGA.

Literature Cited

Central Alaska Network Inventory and Monitoring Program (CAKN). 2008. Denali's disappearing lakes: Shallow lake monitoring in the Central Alaska Network. National Park Service, Fairbanks, Alaska.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Fish and Wildlife Service, Washington, D.C.

Environmental Protection Agency (EPA). 2010a. Biological indicators of watershed health: invertebrates as indicators. Online. (http://www.epa.gov/bioindicators/html/invertebrate.html). Accessed 13 December 2010.

Environmental Protection Agency (EPA). 2010b. Biological indicators of watershed health: Mayflies. Online. (http://www.epa.gov/bioindicators/html/mayflies.html). Accessed 13 December 2010.

Environmental Protection Agency (EPA). 2010c. Biological indicators of watershed health: aquatic biodiversity. Online. (http://www.epa.gov/bioiweb1/aquatic/airpoll.html) Accessed 13 December 2011.

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, Western Ecology Division, Corvallis, Oregon.

Larsen, A. 2005. Annual report on Vital Signs monitoring of shallow lakes in Yukon-Charley Rivers National Preserve. National Park Service, Central Alaska Network, Fairbanks, Alaska.

Larsen, A. 2006. Annual report on Vital Signs monitoring of shallow lakes in Denali National Park & Preserve. National Park Service, Central Alaska Network, Fairbanks, Alaska.

Larsen, A. 2010. WaterChemistryDENA.xls. Microsoft Excel Spreadsheet.

Larsen, A. 2011a. WaterProfilesYUCH.xls. Microsoft Excel Spreadsheet.

Larsen, A. 2011b. WaterChemistryYUCH.xls. Microsoft Excel Spreadsheet.

Larsen, A. 2011c. InvertebratesYUCH.xls. Microsoft Excel Spreadsheet.

Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, and R. McGinnis. 2004. Shallow lake limnology monitoring protocol: Central Alaska Network national parks and preserves, Alaska. National Park Service, Fairbanks, Alaska.

Larsen, A. S., and D. Verbyla. 2007. Interpreting the spatial heterogeneity of lake drying in the Minchumina Basin, Central Alaska. EOS. Trans. AGU 88(52), Fall Meet. Suppl., Abstract B21-0048.

Lillie, R. A., and J. W. Mason. 1983. Limnological characteristics of Wisconsin lakes. Online. (http://digital.library.wisc.edu/1711.dl/EcoNatRes.DNRBull138). Accessed 10 December 2010.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Fairbanks, Alaska.

McGowan, S., P. Leavitt, R. Hall, B. Wolfe, T. Edwards, T. Karst-Riddoch, and S. Vardy. 2011. Interdecadal declines in flood frequency increase primary production in lakes of a northern river delta. Global Change Biology 17:1212-1224.

Mitsch, W., and J. Gosselink. 1986. Wetlands. Van Nostrand Reinhold, New York, New York.

Naranjo, L. 2009. Drying in Denali. Pages 38-41 *in* Sensing our planet: NASA earth science research features 2009. National Aeronautics and Space Administration. Online. (http://nasadaacs.eos.nasa.gov/articles/2009/2009_lakes.html). Accessed 11 March 2011.

Necsoiu, D. M., D. M. Hooper, C. L. Dinwiddie, R. N. McGinnis, and G. R. Walter. 2009. Preliminary ALOS data analysis of thaw lakes and polygonal soils in the Kobuk River Valley, Northwestern Alaska. Paper presented at the 3rd ALOS Joint PI Symposium, Kona, Hawaii, November 9–13, 2009.

National Park Service (NPS). 2010. Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska.

O'Brien, W. J., and D. G. Huggins. 1976. A limnological investigation of the lakes and streams of the Charley River area. Pages 282-321 *in* The environment of the Yukon-Charley Rivers area, Alaska. S. B. Young, editor. The Center for Northern Studies, Wolcott, Vermont.

Riordan, B. A. 2005. Using remote sensing to examine changes of closed-basin surface water area in interior Alaska from 1950-2002. Thesis. University of Alaska, Fairbanks, Alaska.

Riordan, B. A., D. Verbyla, and A.D. McGuire. 2006. Shrinking ponds in subarctic Alaska based on 1950-2002 remotely sensed images. Journal of Geophysical Research 111, G04002, doi:1029/2005JG000150.

Scenarios Network for Alaska Planning (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 23 February 2011.

Shaw, B., C. Mechenich, and L. Klessig. 2004. Understanding lake data. Online. (http://learningstore.uwex.edu/Assets/pdfs/G3582.pdf). Accessed 10 December 2010.

Strayer, D. 2010. Alien species in fresh waters: ecological effects, interactions with other stressors, and prospects for the future. Freshwater Biology 55 (Suppl. 1):152-174.

Swanson, D.K. 2001. Ecological subsections of Yukon-Charley Rivers Nation Preserve. National Park Service, Alaska Region Inventory and Monitoring Program, Anchorage, Alaska.

Van den Brink, F., J. De Leeuw, G. Van der Velde, and G. Verheggen. 1993. Impact of hydrology on the chemistry and phytoplankton development in floodplain lakes along the Lower Rhine and Meuse. Biogeochemistry 19:103-12.

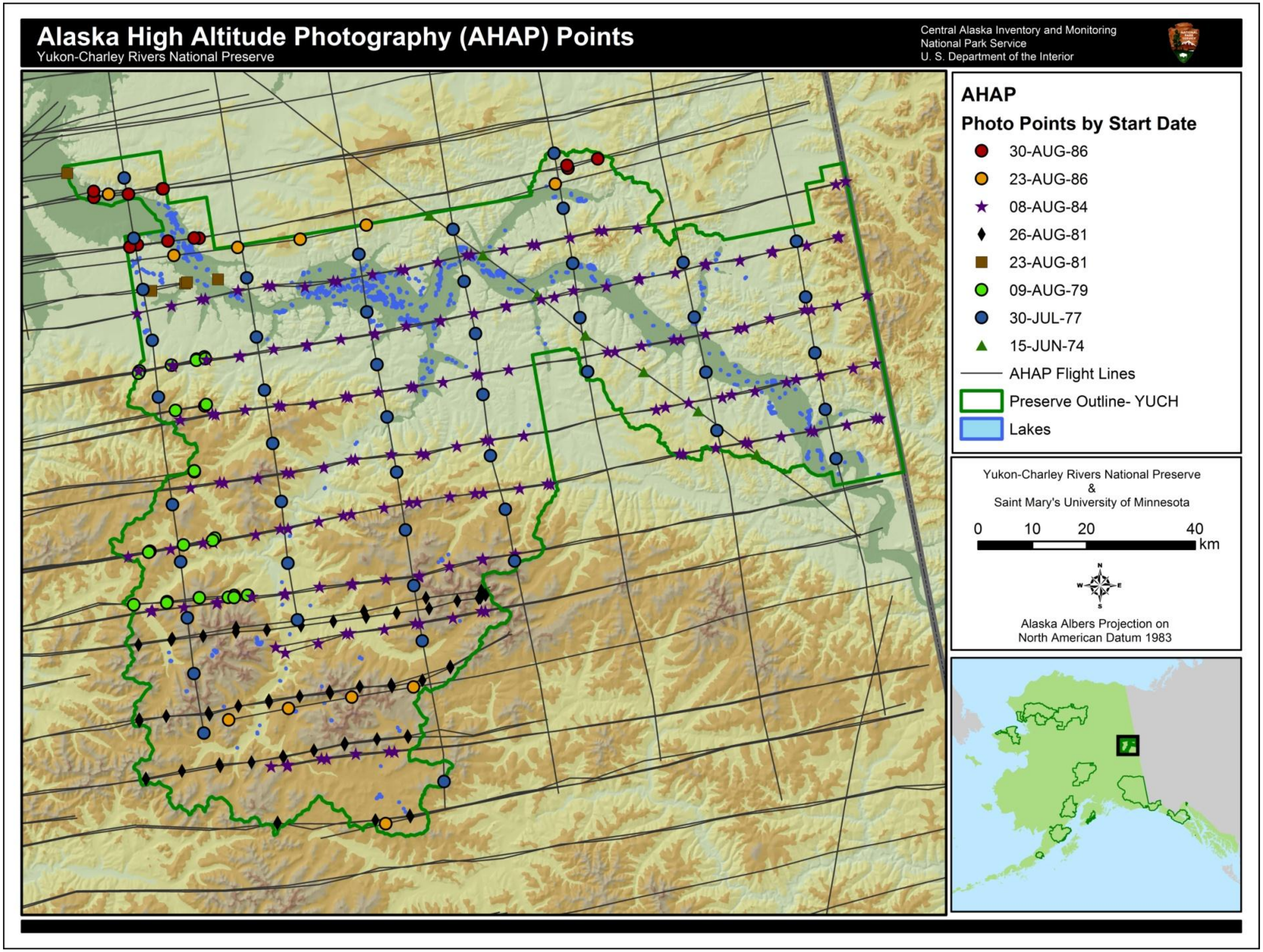


Plate 6. Dates and locations of Alaska High Altitude Photography (AHAP) points (NPS 2010).

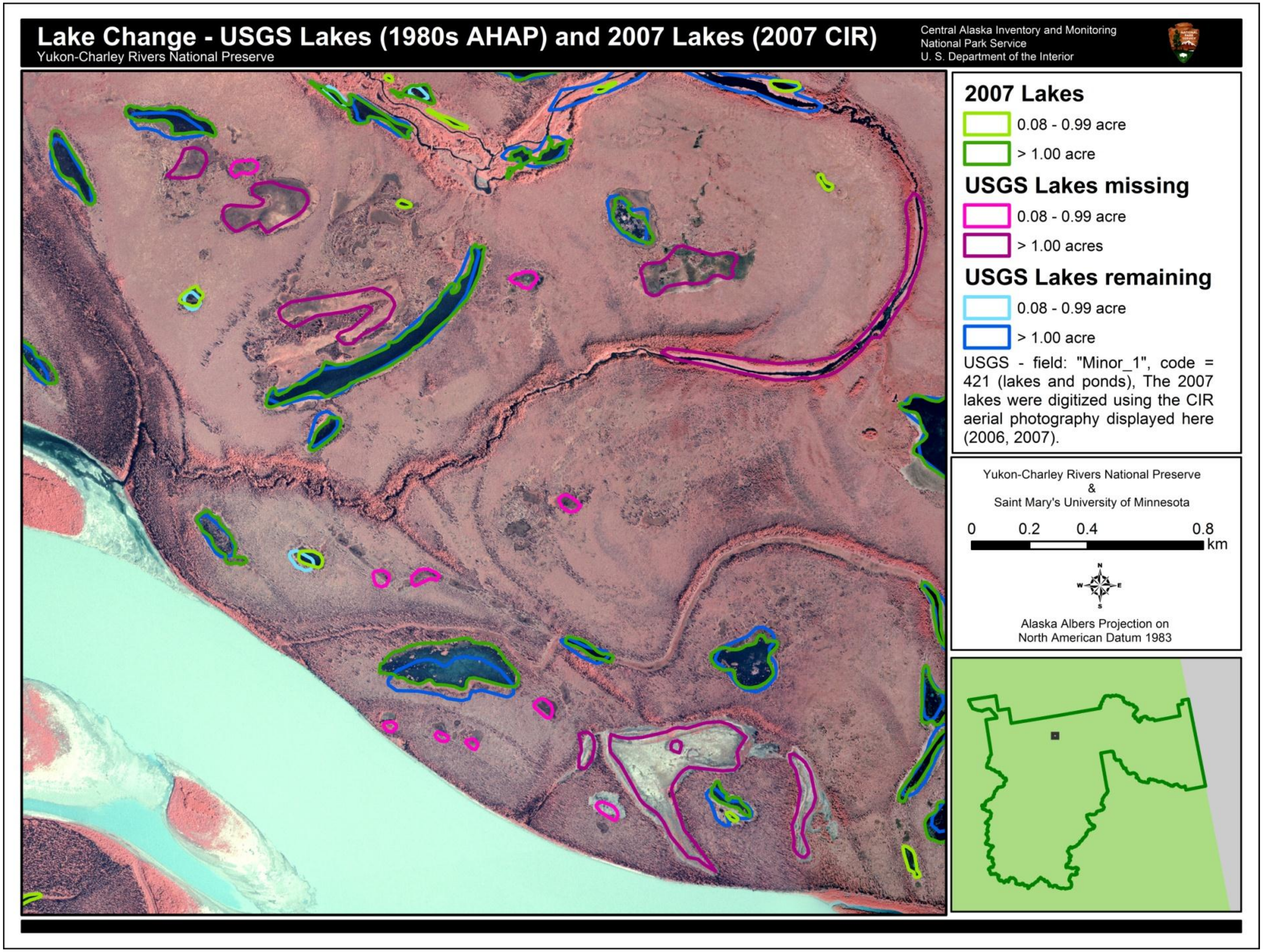


Plate 7. Lake change example with USGS lakes and 2007 lakes overlaid on 2007 CIR aerial photography.

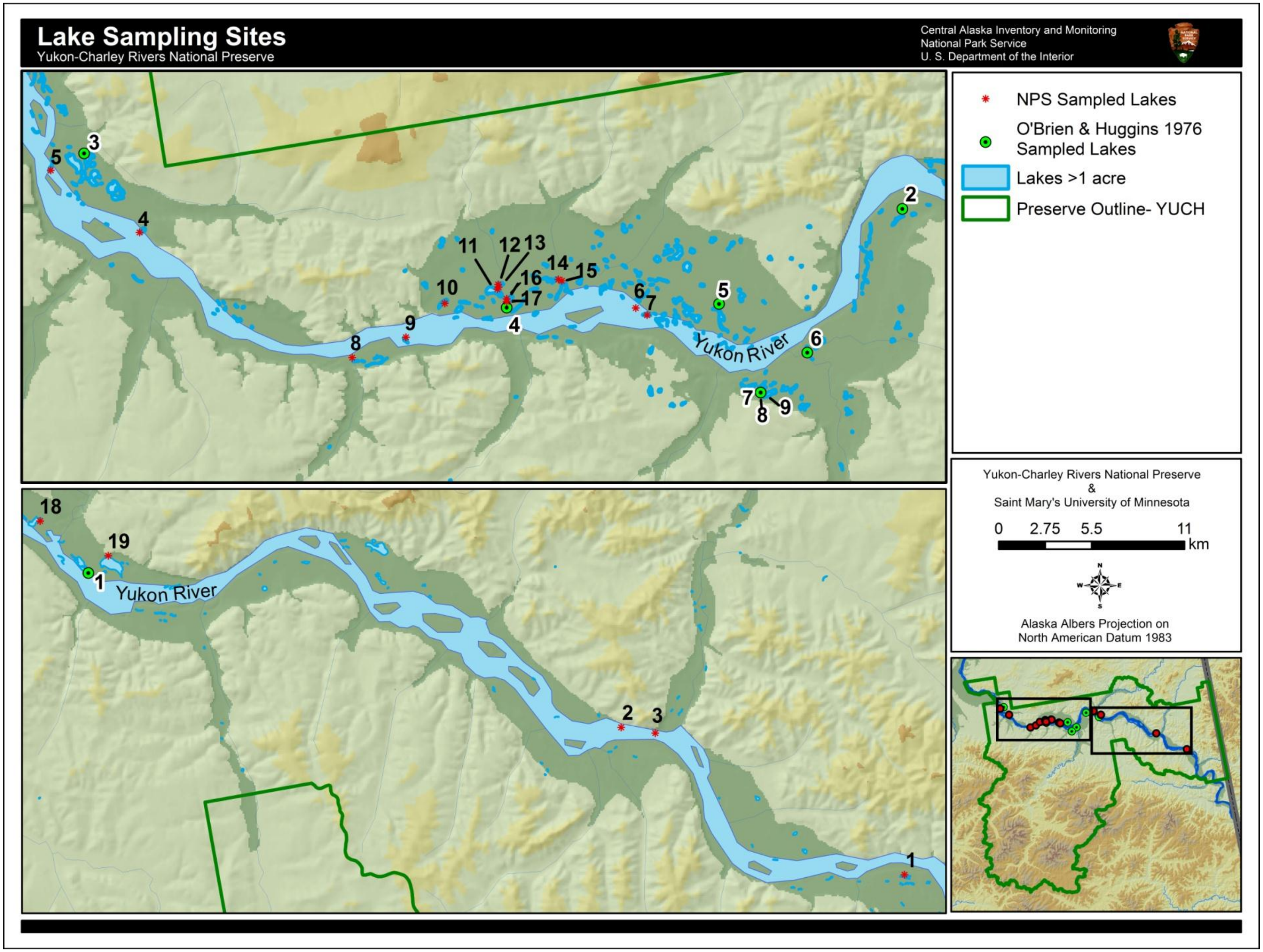


Plate 8. Location of lakes sampled by Larsen (2005) for the CAKN I&M program and by O'Brien and Huggins (1976).

4.3 Permafrost

* Permafrost is included in this NRCA in recognition of its ecological importance within YUCH. At this time there is not enough data available for a full assessment of condition for permafrost within the preserve. This assessment will focus instead on providing an overview of the status of what is known of permafrost in YUCH and report preliminary information from the NRCS soil/ecological unit mapping efforts.

Description

Permafrost is defined as soil or rock "that remain at or below 0°C for at least two consecutive years" (Osterkamp 2005, p. 4), and the overlying ground surface layer that freezes and thaws each year is called the "active layer". The entire region in which YUCH lies is underlain primarily by discontinuous permafrost, particularly in valley bottoms and on north-facing slopes (Larsen et al. 2004, Jorgenson et al. 2008). Its presence affects, either directly or indirectly, many other ecosystem components including hydrology, vegetation patterns, and wildlife communities (NPS 2006a). Permafrost soils also serve as important carbon reservoirs, sequestering carbon gas from the atmosphere (Ping et al. 2008) Permafrost is particularly important within YUCH due to its ability to hold the little precipitation that falls in the preserve near the surface, making it available for use by plants and animals (Larsen et al. 2004). The distribution of permafrost is impacted not only by climate but also by soil type, snow cover, vegetative cover, and fire history (Burn 1998). A soil's ability to retain moisture and form permafrost is affected by soil grain size and organic matter content. Permafrost is extensive in loamy soils with a thick surface layer of organic matter but is rarely seen in gravelly soils (NPS 2006a). Snow cover insulates soils from the cold winter temperatures necessary for permafrost development while vegetative cover protects permafrost from warm summer temperatures (Osterkamp 2007a). Wildfires disturb this protective ground layer, leading to warmer soil temperatures and localized thawing of permafrost (Viereck 1982).

When permafrost thaws, the ground often sinks by several meters because the ice-rich soils become a "mud slurry" that can no longer support the weight of the overlying soil and vegetation (Osterkamp 2005, p. 6). This process, called thermokarsting, can dramatically affect the ground surface, hydrologic systems, and plant distribution and productivity, sometimes resulting in the conversion from one ecosystem to another (e.g., terrestrial system to an aquatic or wetland system) (Osterkamp 2005, Jorgenson and Osterkamp 2005). Thermokarsting also has important implications for fluxes in energy, moisture, and gases across the ground surface-air interface (Osterkamp 2005).

Photo 11. Thermokarst features in the Toklat Basin of Denali National Park and Preserve from the ground (left) and from the air (right) (NPS photos).

Measures

- Permafrost extent
- Number and area of thermokarst features
- Carbon balance
- Soil temperature
- Acreage of human-initiated erosion and soil degradation (including sensitive soils)

Reference Conditions/Values

The reference condition for acres of thermokarst, carbon balance, and soil temperature is within the range of natural variation. For acreage of human-initiated erosion and soil degradation, the reference condition is to remain at or below 2007 levels. Little long term information exists that would define what the range of natural variation is for these measures, therefore the specifics of what can be used as reference conditions are undetermined.

Data and Methods

Several journal articles and reports were provided by NPS staff. Additional literature was found online or obtained through the SMU library.

The NRCS is in the process of finalizing a soil and ecological survey of YUCH. The fieldwork covered a total of 922 vegetation and soil field sites across YUCH over three field seasons from 2008 to 2010. Draft soil survey data (NRCS 2011c) was provided by the NRCS for this assessment. Various data and research are available from the National Snow and Ice Data Center (NSIDC) regarding permafrost; however, these data typically cover large geographic extents, useful at a regional scale, but typically do not provide any information specific to YUCH. An example of permafrost extent information available from NSIDC is the Circum-Arctic Map of Permafrost and Ground-Ice Conditions by Brown et al. (2001). This information is a very coarse resolution, a map scale of 1:10,000,000, compared with the NRCS data, which is intended for a scale of 1:63,000.

Through inference from aerial photos, Swanson (2001) characterized soils and general physiographic areas or landscape positions containing permafrost for each of the ecological subsections within YUCH. However, this information does not lend itself directly to map creation (i.e., the descriptions are specific to each ecoregion, but not specific in geographic location to indicate permafrost extent or thermokarst terrain without significant interpretation and GIS data development).

Current Condition and Trend

Permafrost Extent

Recent draft NRCS soil data provides a rough indication of permafrost extent. The data categorize the prevalence of permafrost across the preserve using preliminary NRCS GIS data. NRCS soil scientists sampled 922 field sites in the preserve and created soil map-unit polygons. Among many other site descriptions, the depth to permafrost within 2 meters of the surface was recorded. This allowed for a categorization of the percent gelisols (permafrost) within a map-unit. Permafrost categories include continuous (>85%), discontinuous (15-85%), sporadic (0-15%), none, and not rated (e.g., mountain peaks). Permafrost in YUCH is primarily discontinuous permafrost. However, some higher elevation areas contain sporadic permafrost and lower elevations along the Yukon River and other isolated areas contain continuous permafrost (NRCS 2011c) (Plate 9). It is important to note that the map in Plate 9 may under-represent the extent of permafrost. Dave Swanson, YUGA Ecologist (pers. comm., 2011), suggests that using only the percentage of gelisols in a map unit would underrepresent the extent of permafrost because other soils may also contain permafrost. For example, many higher elevation areas in the preserve are likely to contain inceptisols with permafrost (Swanson, pers. comm., 2011).

Number and Area of Thermokarst Features

The CAKN I&M Program has selected the presence and distribution of thermokarst features as one component of their permafrost monitoring protocol (Schuur et al. 2008). Thermokarst features can be described together as thermokarst terrain (irregular topography resulting from thawing soil containing ice-rich permafrost or excess ground ice and subsequent thaw settlement) (Osterkamp and Jorgensen 2009). This terrain can consist of channels, pits, troughs, potholes, ponds, lakes, and “drunken forests” (trees leaning in multiple directions after subsidence) (Osterkamp and Jorgensen 2009). Thermokarst terrain forms when ice-rich permafrost thaws due to natural causes or anthropogenic causes and the ground subsides into the voids left by the thawed ice (Brown and Grave 1979, Hinzman et al. 1997). Given the threat of climate warming in Alaska, the current thermokarst terrain extent in YUCH could provide baseline information to detect climate change related effects.

Karle and Jorgenson (2004) conducted a study comparing permafrost mapping methodologies using a sample site in each CAKN national park unit. The 10 x 10 km YUCH test site was located on the right bank of the Yukon River within the North Ogilvie Mountains ecoregion (centered at approximately 65°22’00” N, 142°51’24” W) (Karle and Jorgenson 2004). Thermokarst features were delineated on 1984 color aerial photos of the test site based on manual photo interpretation. These features were identified based on their shape (typically round), landscape position (lowland depressions or basins), topographic relief around the margins (banks), contextual position of water, and spectral characteristics diagnostic of various vegetation types associated with thermokarst (e.g., dwarf birch-ericaceous shrub bogs, wet meadows, etc.) (Karle and Jorgenson 2004). Thermokarst features were then classified according to degradation stage based on degree of vegetation establishment (Table 22). Only a small percentage of the YUCH study area was actively degrading (showing substantial thaw settlement and die-off of original vegetation), with a larger percentage of area in the stabilization stage (Karle and Jorgenson 2004). During initial stabilization, the ground thaws entirely and re-vegetation begins but water is often still present. In advanced stabilization, vegetation is re-established and water is generally absent.

Table 22. Extent of permafrost degradation within the YUCH test site. Degradation stages were classified as degradation-moraine (DM), degradation-active (DA), stabilization-initial (SI) and stabilization-advanced (SA) (adapted from Table 5 in Karle and Jorgenson 2004).

Year	Image Type	Analysis	Percent Area of Degradation Stage				
			DM	DA	SI	SA	Total
1980	CIR Photo	PI		0.7	1.0	5.1	6.9

Color aerial photos from 1984 were also compared to 1954 black and white aerial photos for a qualitative analysis of change in thermokarst features over time. This comparison showed that the thermokarst features visible in 1984 were also present in 1954, with only minor changes over the 30-year period (Karle and Jorgenson 2004). Active thermokarst was noted at only one lake, which showed 7-11 meters of bank erosion on one side in 30 years (Karle and Jorgenson 2004).

Clark (2010) used NRCS soil-ecological site inventory data from Denali National Park and Preserve to indicate the sensitivity of permafrost to thawing from disturbances; however, the sensitivity to permafrost thawing after fires does not indicate which areas may experience subsidence and the formation of thermokarst features. The NRCS soil-ecological site survey data, due from the NRCS in spring/summer 2012, can be used to create a map of susceptibility to thermokarsting. Identifying the total area and number of thermokarst features in the preserve is the subject of further research. D. Swanson (pers. comm., 2011) suggests that the 2006/2007 color-infrared aerial photography could be used to identify some thermokarst features. Swanson identified some initial sites to visit as part of an NPS permafrost project scheduled to conduct field work in summer 2012. An area initially identified in the preserve contains ice-wedge polygons that show some initial degradation (Plate 10). Although not technically a thermokarst feature, some slopes in the park appear to be experiencing permafrost related subsidence (i.e., active layer detachment) (Plate 11). Other primary features likely distinguishable in aerial photography are black spruce forest areas that experienced subsidence and converted to wet-sedge meadows or shallow water bodies. The thermokarst features in YUCH are primarily located in low-lying and undulating topography areas of YUCH (e.g., areas in the Yukon River Valley (YV) subsection containing many thermokarst lakes).

Carbon Balance

While an increase in active layer depth due to permafrost reduction leads to increased plant growth (which sequesters carbon from the atmosphere), permafrost thaw from warming can also stimulate microbial decomposition of soil organic matter, causing an increase in CO_2 emissions (NPS 2009). Studies of the relationship between permafrost thawing and carbon balance in the Denali area suggest that moderate permafrost thaw causes increased carbon sequestration while extensive permafrost thawing leads to a net release of carbon into the atmosphere (Figure 17; NPS 2009). Sampling methods and preliminary results for this study are discussed in Schuur and Vogel (2010).

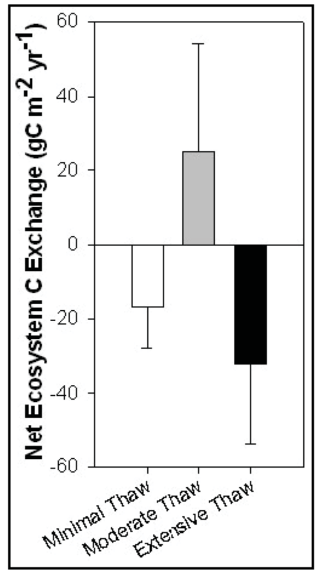


Figure 17. Carbon exchange as a result of permafrost thaw in Denali (NPS 2009).

No data has been gathered on carbon balance within YUCH, but Schuur and Vogel (2010) have prepared a report detailing monitoring techniques for carbon cycling in relation to thermokarst that may be included in the CAKN monitoring protocol currently in development.

Soil Temperature

Soil temperature (particularly the average annual soil temperature) is a pivotal measurement in understanding changes in permafrost, most importantly permafrost thawing. A borehole was established in the early 1980s near Eagle, just south of YUCH, as part of a statewide study (Osterkamp 2005). At this site, mean permafrost surface temperatures were near 3°C and did not show any significant change during measurements taken every three years from 1985 through 1994 (Figure 18; Osterkamp 2005).

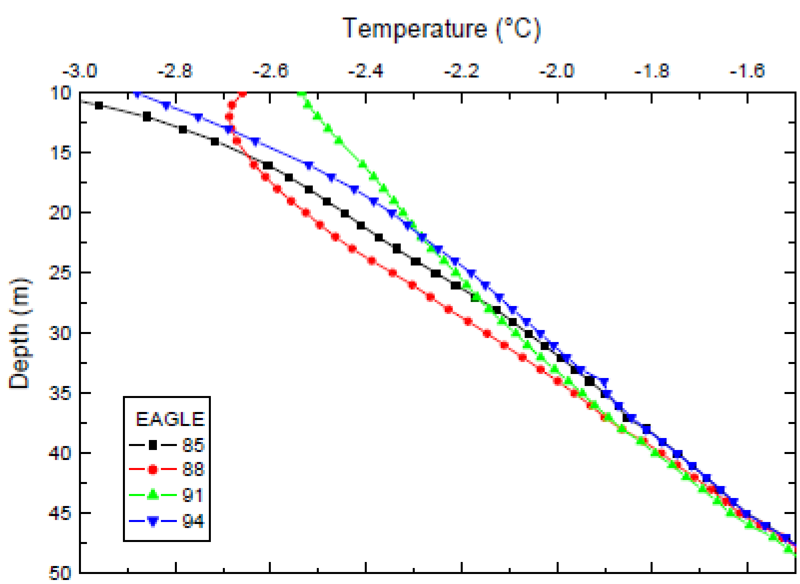


Figure 18. Temperature profiles at the Eagle borehole over time (Osterkamp 2005).

NRCS data-loggers, referred to as HOBOs (trade name by the Onset Corporation), have been recording soil temperatures at various depths (5, 20, and 50 cm) at five locations in YUCH for one full year (July 2009-July 2010). Data collection will continue until the summer of 2012. These sites are described in Table 23 and locations are shown on Plate 9. Refer to Appendix 12 for more detail regarding these soil temperature monitors.

Table 23. NRCS soil temperature data logger sites in YUCH (NRCS 2011a).

Site Name	Elevation (m)	Site Description
FM1 (Mid-floodplain)	231	Mid-floodplain on Yukon River in poplar stand
ES4 (Aspen-graminoid)	259	Steep south-facing bluff along the Yukon in an aspen-graminoid community
SA2 (Three Fingers subalpine)	1097	Three Fingers subalpine basin in a wet white spruce stand
LP1 (PIMA mesic)	401	Low-sloping, loess-capped plain in a black spruce-feathermoss forest
MS2 (Alpine graminoid)	1579	High alpine low-sloping summit

Preliminary data from these sites is presented in Table 24. The results suggest that soil temperatures are favorable for permafrost at the LP1 and MS2 sites, marginal at SA2, and unfavorable at FM1 and ES4 (Swanson, pers. comm., 2011).

Table 24. Mean annual soil temperature (MAST) at various depths for the five study sites in YUCH (NRCS 2011b).

	Mean Annual Soil Temperature (°C)		
Site	at 5 cm	at 20 cm	at 50 cm
FM1 (Mid-floodplain)	0.82	1.01	1.29
ES4 (Aspen-graminoid)	2.91	2.84	2.84
SA2 (Three Fingers)	0.65	NA*	0.28
LP1 (PIMA mesic)	-0.16	-1.27	-1.76
MS2 (Alpine graminoid)	-3.29	-3.27	NA

* An error appears to have occurred at this depth, yielding unrealistic and unusable data.


Photo 12. The LP1 data-logger is located near the bottom center of the photo on the left in a black spruce forest, and the FM1 data-logger is on an island in the Yukon, near the end in the foreground of the photo on the right (NRCS photos).

Soil temperature data have also been gathered at the Coal Creek Remote Automated Weather Station (RAWS) since the winter of 2004; other nearby RAWS stations at Eagle, AK and at Ben Creek (within the preserve) do not monitor soil temperature. Refer to Plate 9 for the general location of the Coal Creek RAWS station in the preserve. Mean annual soil temperatures (MASTs) and maximum monthly summer soil temperatures are stable over the period of record at a depth of approximately 10 cm (4 in). This indicates that the current condition of permafrost, at least in the Coal Creek area, is likely safe from active layer thickening or from permafrost melting for the time being. Areas disturbed by roads or trails may be examples of exceptions to this. Monthly average soil temperatures and MASTs for the Coal Creek station are displayed in Figure 19. It is important to note that in addition to air temperatures, snow cover can play a significant role in increasing permafrost temperatures (Osterkamp 2007a). Osterkamp (2007a) found that during the 1990s snow cover effects were the primary cause of permafrost warming in Healy, AK.

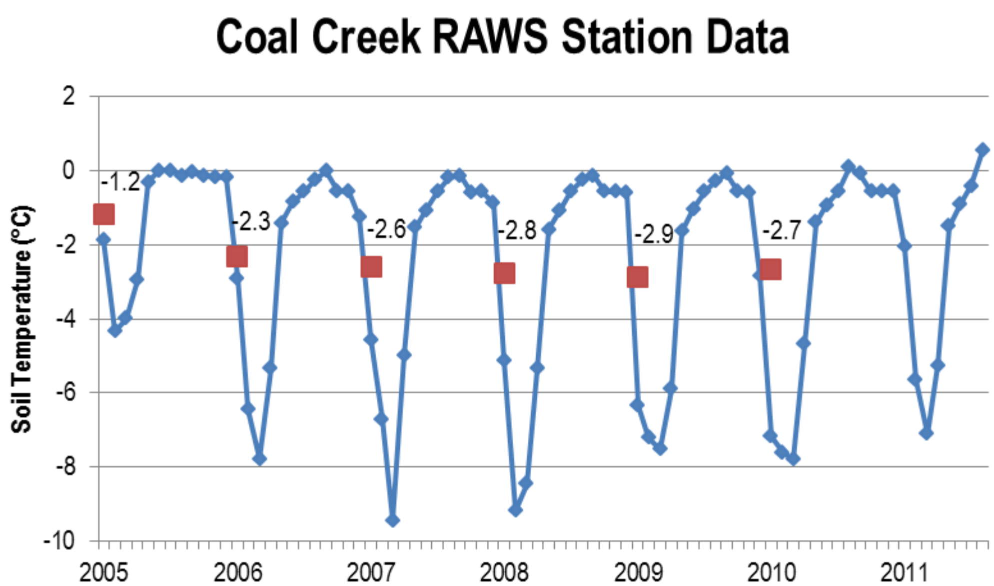


Figure 19. Monthly average soil temperatures (blue line) through August 2011 and mean annual soil temperatures (MASTs) (red squares shown with data labels) for the Coal Creek RAWS in YUCH (WRCC 2011).

Area of Human-initiated Erosion and Soil Degradation (including sensitive soils)

Human-initiated erosion and soil degradation is considered a negative impact or stressor on natural resources or processes including permafrost. The current area of human-initiated erosion and soil degradation is not known in YUCH. Potential sources of human initiated erosion include OHV trail use, social trail development along river take-outs, and hiking trail use in the preserve. The only information available for this assessment that reports areas that may provide an indication of human-initiated erosion and soil degradation is the OHV trail conditions at Coal Creek GIS data.

Threats and Stressor Factors

Management Actions (development, land use pattern)
Development, including features such as buildings, roads, and air-strips, could alter soil conditions such that permafrost thawing can occur. This is an issue throughout many areas of Alaska and therefore can require careful considerations in terms of how to build without disturbing permafrost (e.g., changing the active layer depth). Fire suppression could favor permafrost (i.e., protect permafrost from fire and potential thawing); however, suppression activities would only occur in cases where fire protection points (typically historic and private structures such as cabins) were at risk of being damaged by fire, though most structures in the preserve are not likely to have been built on permafrost.

Climate Change
The greatest threat to permafrost in YUCH and across Alaska is climate change. Temperatures at the preserve are projected to increase by an average of 0.6°C (1°F) per decade, resulting in a transition from average annual temperatures below freezing to near or above the freezing point (SNAP et al. 2009). SNAP et al. (2009) predict average annual air temperatures to increase by 2.6°C (4.6°F) by 2040 and 4.7°C (8.4°F) by 2080. Greater increases are predicted in the average winter air temperature, with a 3.4°C (6.2°F) increase by 2040 and a 5.8°C (10.4°F) increase by 2080. Changes in precipitation, particularly the timing and amount of snow, will also affect permafrost (Osterkamp 2007a). During the 1990s, mean air temperatures decreased slightly in the Healy area (near Denali in central Alaska) yet the temperature of permafrost 10 m deep at the nearby borehole continued to increase (Osterkamp 2007b). Annual snow depths were often above average during this same period, leading researchers to conclude that increased temperatures and ground instability (thermokarst formation) "cannot be attributed solely to increases in air temperatures. Snow cover effects have played a significant role" (Osterkamp 2007b, p. 523). SNAP et al. (2009) predicts an overall increase in annual precipitation for YUCH: a 23% increase in winter precipitation by 2040 and a 40% increase by 2080, with 14% and 20% respective increases in summer precipitation for 2040 and 2080. However, evapotranspiration is predicted to exceed the increases in precipitation, creating a warmer and drier climate over the next century, with drier summer and fall seasons and possibly icier winters.

Wildfires cause soils to warm, as a result of decreased insulation by organic matter. This is a natural process that temporarily reduces permafrost and increases the active layer depth, leading to an increase in ecosystem productivity (Larsen et al. 2004). However, any increase in the frequency or intensity of fires as a result of climate change may affect the ability of permafrost to recover from this disturbance.

Increasing Visitation and OHV Use
Research in other parts of Alaska has shown that OHV use can have significant negative impacts on permafrost. When surface vegetation and organic soils are compressed or disturbed by OHV traffic, the insulative properties of these materials are changed, which can lead to an increase in permafrost thaw depth (Racine and Ahlstrand 1991). This in turn could lead to an increase in thermokarst feature development.

The NPS conducted an assessment of the Coal Creek OHV trail conditions during the summer of 2006. Table 25 summarizes the length and estimates the area of trail by condition class. The condition class was determined by the mapping methods employed during the 2006 GPS field survey and are contained in the data dictionary (NPS 2006b). According to this classification, the majority of the Coal Creek OHV trails mapped were in fair or good condition. The length of these condition classes act as an initial indicator of OHV-related erosion issues until conditions are large enough to report total area. The fieldwork also identified trail features (e.g., culverts, signs, stream crossings). The NPS personnel found a total of 13 "erosion or water problem areas". These included features such as dams, aquatic problems, deposition zones, structure failures, and wash-outs. Outside of the detailed field measurements and condition characterizations during the summer of 2006 in the Coal Creek region OHV trails, the present status of OHV trail use in YUCH is not documented. Additional trails distinguishable in recent aerial photography (CIR 2006/2007) in the preserve are not mapped or assessed.

Table 25. Trail condition class by length in the Coal Creek region off-highway vehicle (OHV) trails (NPS 2006b).

Condition[a]	Length (m)	Area (ha)[b]	% of total
Not rated (-8 to 7)	22,030	65.11	17
Good (8-10)	30,646	144.10	24
Fair (11-26)	74,193	364.94	58
Degraded (27-52)	1,307	0.94	1
Very Degraded (53-77)	41	0.01	0
Total Length	12,8217	575.1	100

[a] According to the data dictionary of NPS (2006b), the trail condition is based on several field characterizations and measurements. Primary factors contributing to degraded trail conditions (high scores) in this trail assessment were areas with a combination of a wide trail, poorly drained surface, muddy conditions, heavily rutted, and heavy impacts to vegetation including trail segments stripped of vegetation.

[b] Area was calculated by using the median of the range of trail width estimates for double wheeled and wide-track segments and multiplied by the trail segment length. For single track width estimates, the median of the range of values were doubled and multiplied by the trial segment length.

Data Needs/Gaps

According to Osterkamp (2005, p. 29), "current knowledge of permafrost conditions within YUCH is poor, almost nonexistent." Information is needed on the condition of permafrost (soil temperatures, active layer depths, carbon balance) and thermokarst features throughout the preserve, as well as how any changes in permafrost are affecting other ecosystem components. Karle and Jorgenson (2004) recommended using remote sensing to monitor changes in the abundance and distribution of thermokarst features. Osterkamp (2005, p. 9) warns that permafrost thawing in boreal forest ecosystems "is not just a slight shift in the nature of the ecosystem but rather partial or total destruction of the ecosystem and its replacement by a new ecosystem." The NRCS soils/ecological unit mapping will provide some of this baseline information once it is published (scheduled for late winter of 2012). CAKN is currently finalizing a permafrost monitoring protocol that will address many of these data needs. The first phase is scheduled for implementation during 2012, pending funding (NPS, Guy Adema, Alaska Region Natural Resource Team Manager, pers. comm., 2011).

Overall Condition

Due to a lack of long-term research, the overall condition of permafrost is unknown at this time. Primary concerns regarding permafrost are related to potential effects of climate warming. According to average annual soil temperatures at Coal Creek, permafrost has likely remained stable in the preserve. However, all of the MASTs measured in YUCH are above -3.5°C, with some very close to 0°C. SNAP et al. (2009) predicts an increase of 2.6°C (4.6°F) in average annual air temperature by 2040 and a 3.4°C (8.4°F) increase by 2080. Greater increases are predicted in the average winter air temperature, a 3.4°C (6.2°F) increase in 2040 and a 5.7°C (10.4°F) increase in 2080. If the predicted increases in temperatures occur, it could cause essentially all of YUCH's permafrost to be unstable and begin to thaw over the next century, resulting in widespread ecological consequences (Swanson, pers. comm., 2011). Winter snowfall and average snow depth is another important climate-weather factor that will affect permafrost temperatures and depth of permafrost. Broad climatic changes resulting in increased soil temperatures can result in the formation of thermokarst terrain; however, so can disturbances from fires (Swanson 1996), floods, humans, and animals (Osterkamp and Jorgensen 2009).

Sources of Expertise

Dave Swanson, NPS Ecologist, Yukon-Charley Rivers/Gates of the Arctic (YUGA).

Literature Cited

Brown, J., and N. Grave. 1979. Physical and thermal disturbance and protection of permafrost. Special Report 79-5. U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire.

Brown, J., O. J. Ferrians Jr., J. A. Heginbottom, and E. S. Melnikov. 1998 (revised February 2001). Circum-Arctic map of permafrost and ground-ice conditions. Digital Media. National Snow and Ice Data Center/World Data Center for Glaciology, Boulder, Colorado.

Burn, C. R. 1998. The response (1958-1997) of permafrost and near-surface ground temperatures to forest fire, Takhini River valley, southern Yukon Territory. Canadian Journal of Earth Sciences 35(2):184-199.

Clark, M. 2010. A model of permafrost distribution and disturbance sensitivity for Denali National park using soil-ecological site inventory information. Natural Resources Conservation Service, Palmer, Alaska.

Hinzman L., D. Goering, S. Li, and T. Kinney. 1997. Numeric simulation of thermokarst formation during disturbance. Disturbance and recovery in Arctic lands: an ecological perspective. Crawford, R. M., ed. Springer-Verlag Publishing, New York, New York.

Jorgenson, T., and T. Osterkamp. 2005. Response of boreal ecosystems to varying modes of permafrost degradation. Canadian Journal of Forest Research 35:2100-2111.

Jorgenson, T., K. Yoshikawa, M. Kanevskiy, Y. Shur, V. Romanovsky, S. Marchenko, G. Grosse, J. Brown, and B. Jones. 2008. Permafrost characteristics of Alaska. Proceedings of the Ninth International Conference on Permafrost. University of Alaska Fairbanks, Institute of Northern Engineering, Fairbanks, Alaska.

Karle, K., and T. Jorgenson. 2004. Review of existing permafrost monitoring projects, with application and recommendations for the Central Alaska Network ecological monitoring program. Prepared for the National Park Service, Denali National Park and Preserve, Alaska.

Larsen, A., C. Rector, C. Roland, and M. Cook. 2004. Results of an inventory of the vascular plants of Yukon-Charley National Preserve. National Park Service Inventory and Monitoring Program, Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). 2006a. Permafrost Landscapes - Denali National Park and Preserve. DENA-FS-009-2006. National Park Service, Denali Park, Alaska.

National Park Service (NPS). 2006b. Condition of OHV trails in the Coal Creek region of Yukon-Charley Rivers National Preserve Creek OHV trail mapping – GIS data (line). NPS OHV Technical Assistance Team, Alaska Region. National Park Service, Anchorage, Alaska.

National Park Service (NPS). 2009. Permafrost thaw and carbon balance - Denali National Park and Preserve. DENA-FS-031-2009. National Park Service, Denali Park, Alaska.

Natural Resources Conservation Service (NRCS). 2011a. HOBO_SiteInformation.xls. Excel spreadsheet containing site information of soil/air temperature data loggers in YUCH. Received from Mark Clark (NRCS), August 2011.

Natural Resources Conservation Service (NRCS). 2011b. 2009_2010 Hobo_graphs.xls. Excel spreadsheet containing soil/air temperature form data loggers in YUCH. Received from Mark Clark (NRCS), August 2011.

Natural Resource Conservation Service (NRCS). 2011c. 2011 draft soil GIS data. Received from Mark Clark (NRCS Soil Scientist), June 2011.

Osterkamp, T. E. 2005. Applications of measurements at permafrost monitoring sites for documenting long-term change in Denali, Wrangell-St. Elias, and Yukon-Charley Rivers National Parks and Preserves. University of Alaska, Fairbanks, Alaska.

Osterkamp, T. E. 2007a. Characteristics of the recent warming of permafrost in Alaska. Journal of Geophysical Research 112: F02S02, doi: 10.1029/2006JF000578

Osterkamp, T. E. 2007b. Causes of warming and thawing permafrost in Alaska. Eos 88(48):522-523.

Osterkamp, T. E., and M. T. Jorgenson. 2009. Permafrost conditions and processes. The Geological Society of America, Boulder, Colorado.

Ping, C., G. J. Michaelson, M. T. Jorgenson, J. M. Kimble, H. Epstein, V. E. Romanovsky, and D. A. Walker. 2008. High stocks of soil organic carbon in the North American Arctic region. Nature Geoscience 1(9):615-619.

Racine, C., and G. Ahlstrand. 1991. Thaw response of tussock-shrub tundra to experimental all-terrain vehicle disturbances in south-central Alaska. Arctic 44(1):31-37.

Scenarios Network for Alaska Planning (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 23 February 2011.

Schuur, E., and J. Vogel. 2010 . Development of monitoring techniques to detect change in carbon cycling in relation to thermokarst in national parks and preserves. Natural Resource Technical Report NPS/CAKN/NRTR—2010/383. National Park Service, Fort Collins, Colorado.

Schuur, E., T. Osterkamp, T. Jorgenson, J. Sickman, G. Adema, and L. Yocum. 2008. Permafrost monitoring protocol: Central Alaska Network National Parks and Preserves, Alaska. DRAFT. National Park Service, Fairbanks, Alaska.

Swanson, D. K. 1996. Susceptibility of permafrost soils to deep thaw after forest fires in interior Alaska, U.S.A., and some ecologic implications. Arctic and Alpine Research 28(2):217-227.

Swanson, D. 2001. Ecological subsections of Yukon-Charley Rivers National Preserve. National Park Service, Alaska Region Inventory and Monitoring Program, Anchorage, Alaska.

Viereck, L. 1982. Effects of fire and firelines on active layer thickness and soil temperature in interior Alaska. Proceedings of the Fourth Canadian Permafrost Conference:123-135.

Western Regional Climate Center (WRCC). 2011. Coal Creek Alaska monthly summary data. Online. (http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?akACOA). Accessed 12 September 2011.

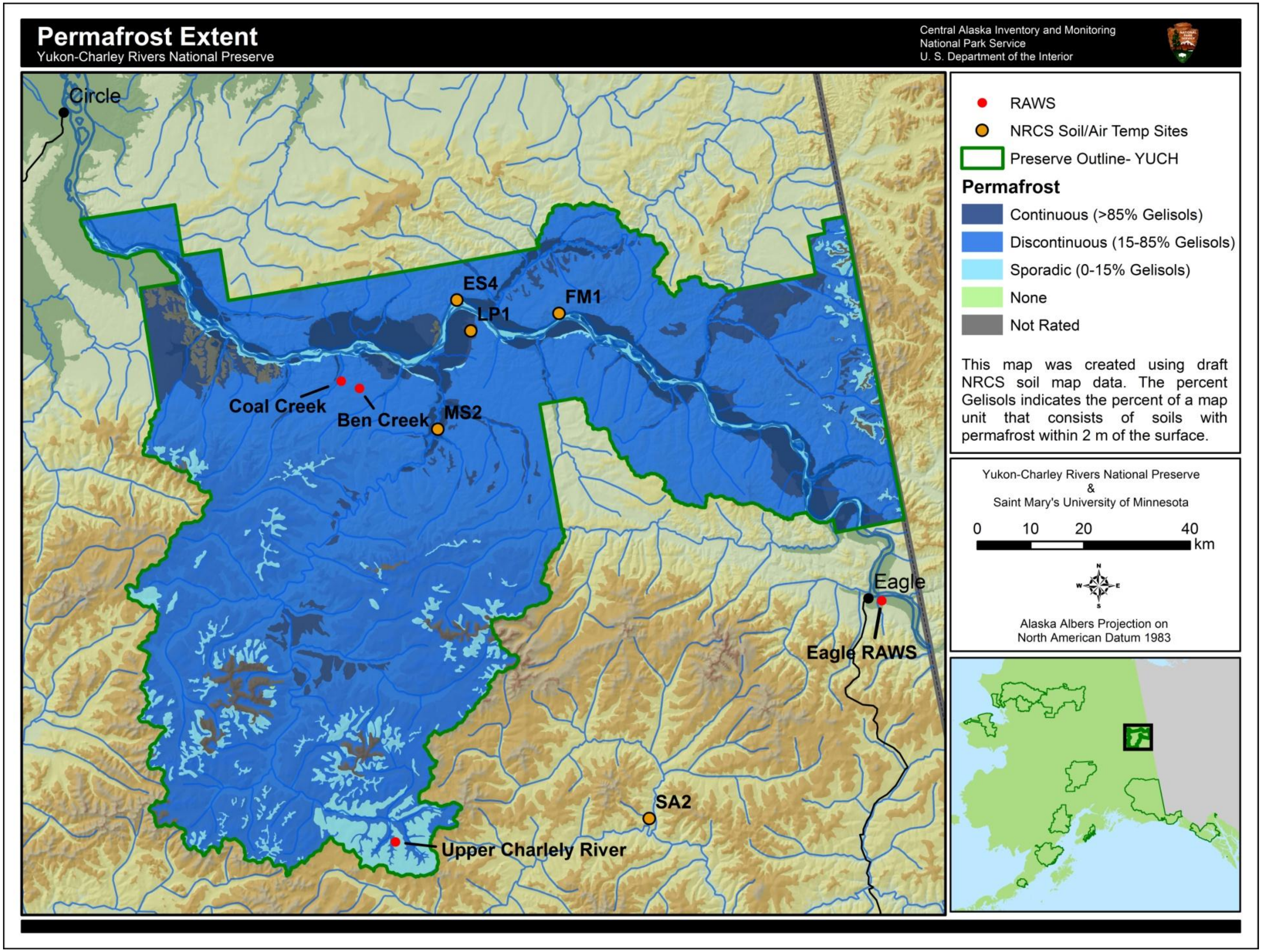


Plate 9. Permafrost extent in YUCH (NRCS 2011c).

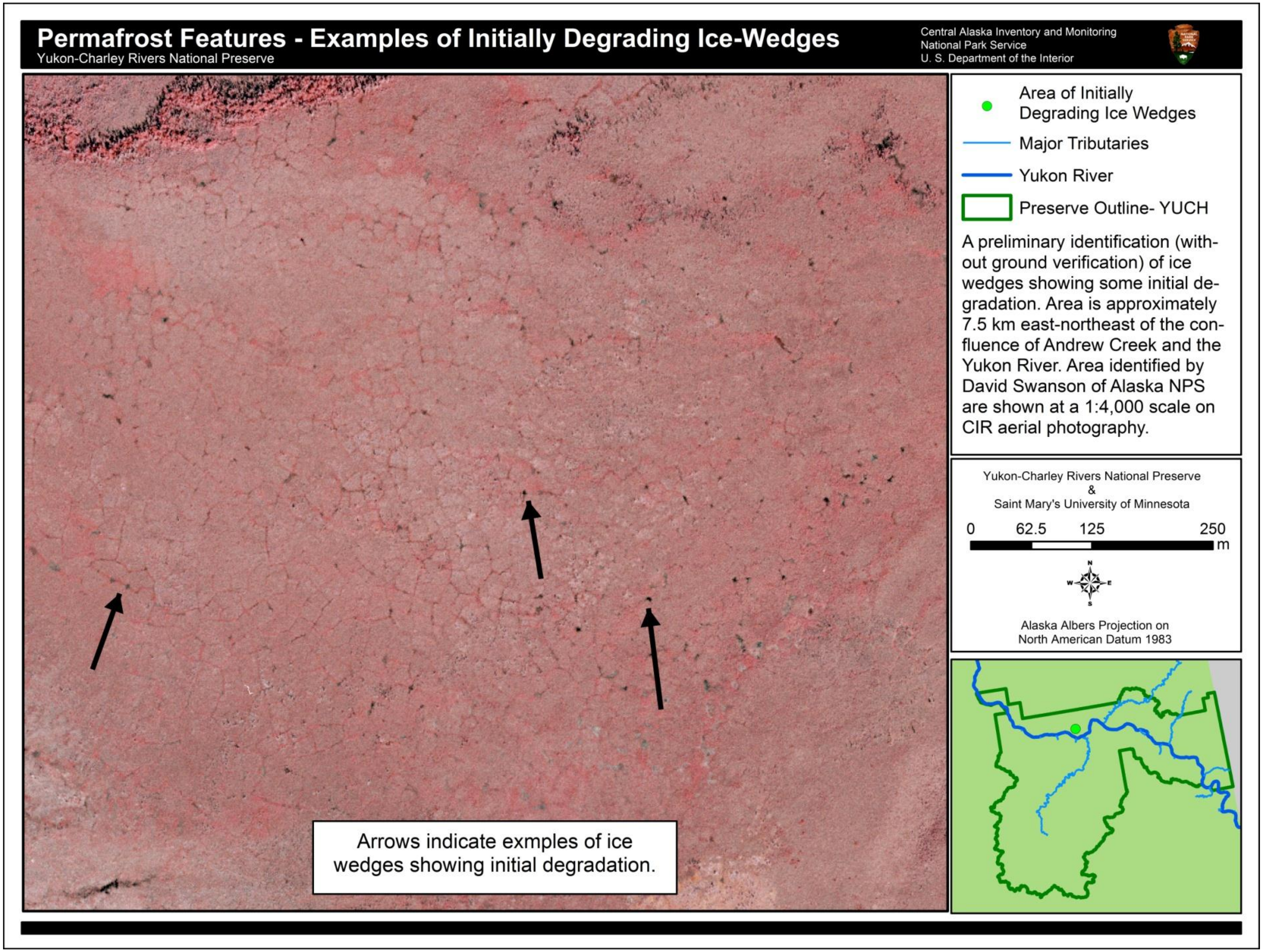


Plate 10. Ice-wedge polygons showing initial degradation.

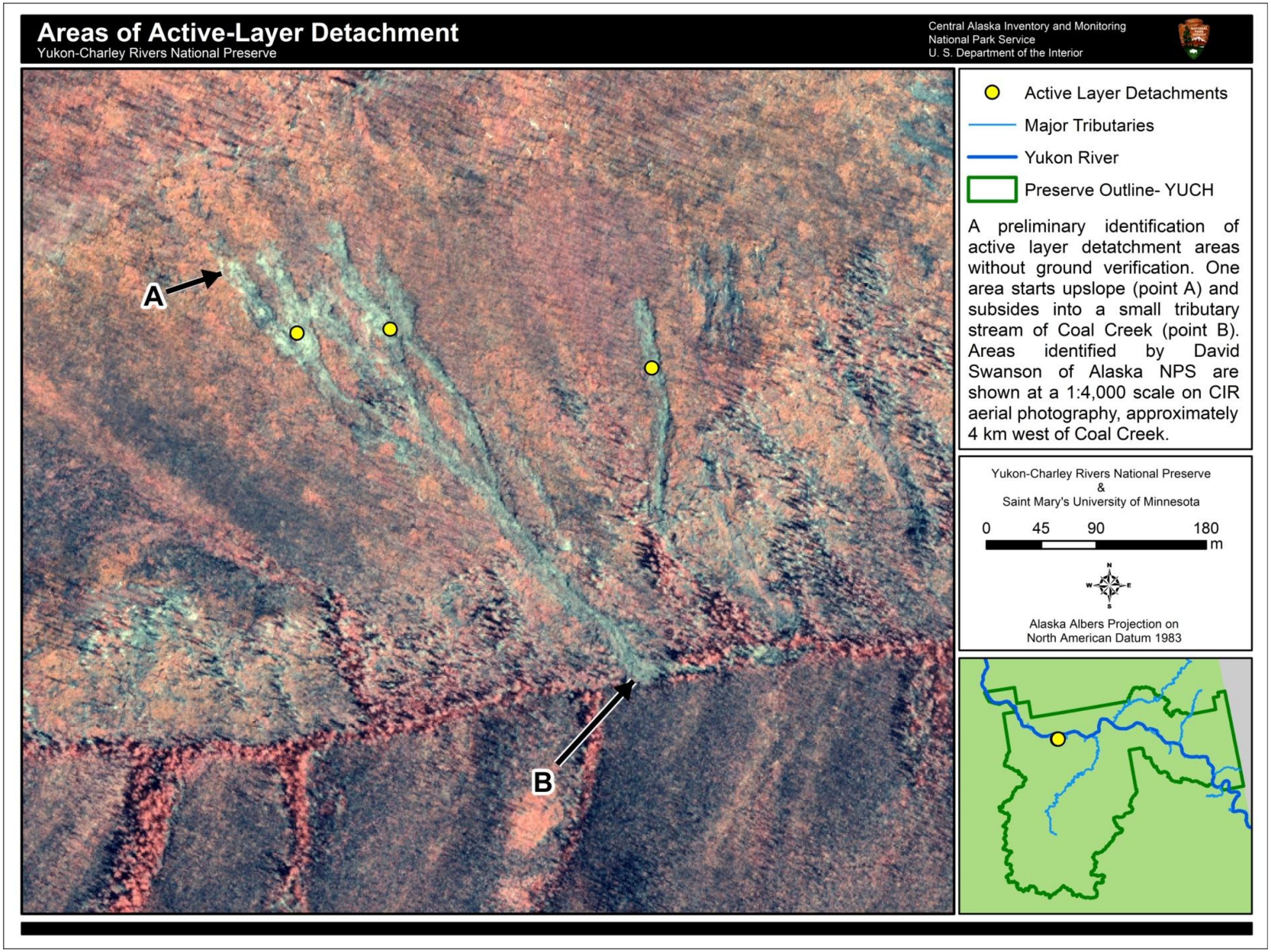


Plate 11. Active layer detachment visible in CIR aerial photography.

4.4 Fire Regime

Description

Fire regime is a combination of fire frequency, predictability, intensity, seasonality, and size characteristics of a given ecosystem (NPS 2010). Fire plays a major role on the ecological process of YUCH's landscape (NPS 2011a). The climate in the area, with its high summer temperatures, low precipitation, and high occurrence of lightning, produces favorable conditions for wildfires. An average of 13,049 ha (32,245 ac) burns each year at YUCH, with 91 percent of all fires started by natural sources (AICC 2011, NPS 2011b). Fire is a Vital Sign of the CAKN Inventory and Monitoring Program.

Photo 13. Fire mosaic resulting from varied burn severity of the Witch (B242) fire of 1999 in YUCH (Photo from Sorbel and Allen 2005).

Fires can have a landscape-level influence on vegetation structure and composition, permafrost dynamics, water quality, air quality, nutrient cycling, primary productivity for herbivores, and biodiversity (Allen 2005). In the absence of fire in boreal forests, organic matter accumulates and insulates the ground, causing the permafrost table to rise. Fires usually remove portions of the accumulated organic layer, which can warm the soils and increase the active layer (Van Cleve and Viereck 1981). These changes in soil temperature can influence nutrient availability (Smithwick et al. 2005) and permafrost depths which can relate to ecosystem productivity (Van Cleve and Viereck 1981). Changes in fire regime can cause nutrient cycling, trophic dynamics, and species regeneration that may be completely different from the original system (Johnstone and Chapin 2006a). Short fire return intervals encourage the growth of resprouting, woody deciduous species (Johnstone 2006).

In Alaska's boreal forest and tundra ecosystems, burn severity strongly impacts post-fire vegetation patterns and succession (Sorbel and Allen 2005). If burn severity is low or moderate, the aboveground plant materials will be damaged, but much of the vegetation will be able to regenerate quickly from roots and stems. However, severe fires burn deeper into the organic soils, which may kill off the underground root structure of some shrubs and herbaceous plants. Therefore, plant reproduction may be more dependent on seed establishment or deep rooted plants, which may slow or alter the successional changes after a fire (Sorbel and Allen 2005, Johnstone and Chapin 2006b, Bernhardt et al. 2011). Changes in vegetation due to fires, in turn, affect wildlife distribution and habitat use. Patchy fires create a mosaic of habitats frequently used by snowshoe hares and martens, while moose often browse on resprouting willow and other shrubs (Sorbel and Allen 2005). Small mammals such as voles often thrive in recently burned areas, creating large colonies in the remaining duff and feeding on new vegetation. Caribou avoid recently burned areas (<35 years ago), as they lack sufficient amounts of lichen for winter forage (Joly et al. 2003).

The occurrence, extent, and severity of fires in Alaska are strongly influenced by climate, terrain, and vegetation (Allen 2005). The fire regime will also likely be affected by local and global climate change (Allen 2005). Due to record high temperatures and low precipitation, the summer of 2004 was the largest fire season in Alaska's recorded history with over six million acres burned (Sorbel and Allen 2005).

Measures

- Annualized burn area
- Number of natural fire starts per year
- Annual fire season duration
- Percentage of burns by severity class annually

Reference Conditions/Values

Number of acres burned and natural fire starts per year and total duration of fire incidents - remain within range of natural variability (1952-current); Fire season duration and timing - remain within range of natural variability (1993-current); Percentage of burns by severity class annually - remain within range of natural variability (1983-current).

Data and Methods

The Alaska Interagency Coordination Center (AICC) provided fire perimeter data from 1942 to present for the state of Alaska. Perimeter data was analyzed in multiple ways to examine burn area trends within YUCH and the associated ecoregions. Fire perimeters were analyzed using GIS for three separate areas; 1) "YUCH boundary" (where fire perimeters extending outside YUCH were clipped at the preserve boundary), 2) "YUCH area" (fire perimeters that extend outside the preserve boundary were included in the analysis), and 3) fires, using entire fire perimeters, that intersect with the North Ogilvie Mountains and Yukon-Tanana Uplands ecoregions (within and overlapping the ecoregional boundaries). In addition, the NPS provided GIS point data for fires that burned in YUCH from 1950 to 2010. These data included fire names, dates, origin, and acreage burned and were used to assess the number of natural starts within the preserve and the annual fire season duration. Burn severity data from the Monitoring Trends in Burn Severity (MTBS) website provided burn severity data to assess the percentage of burns by severity class annually in YUCH. The techniques employed by the MTBS program to collect and analyze data are presented in the percentage of burns by severity class annually section.

It is important to note that the perimeter and point GIS data representing the fires that took place in the 1960s are likely incomplete due to lost or damaged data. Prior to the 1980s, fire suppression techniques were widely used in Alaska, resulting in a more heavily managed fire regime in areas such as YUCH compared with today. The heavily managed fire regime may have resulted in a lower number of acres burned and shorter individual fire durations and annual fire season duration, than what may have occurred without suppression efforts. After the 1980s, fire suppression activities were reduced, resulting in a more natural fire regime. Today fire management is determined by the land manager/owner. They are authorized to make decisions regarding the management of a specific land area, selecting from four different wildfire management options. These include critical, full, modified, and limited, with critical being the most aggressive suppression option and limited meaning periodic surveillance. Nearly all (96%) of the land area within the preserve is currently under the "limited" fire management option. This keeps the natural disturbance of fire largely uninterrupted on the landscape of the preserve today.

Current Condition and Trend

Annualized Burn Area

For a state-wide perspective, Kasischke et al. (2002) characterize a high fire year in the entire state of Alaska as one year with an average of 66 fires > 400 ha (988 ac) and an average fire size of 20,300 ha (50,162 ac), whereas a small fire year is an average of 17 fires > 400 ha (988 ac) and an average fire size of 7,800 ha (19,274 ac). Kasischke et al. (2002) found that in high fire years, 65% of the total area burned in Alaska resulted from fires > 50,000 ha (123,552 ac) in size. During smaller fire years, 73% of the total area burned occurred from fires < 50,000 ha (123,552 ac) in size (Kasischke et al. 2002). Duffy and Rupp (2007) found only a few fires comprised the majority of the total burned area in high fire years. During smaller fire years, 9% of the total area burned was the result of fires > 100,000 ha (247,104 ac) in size while in high fire years, 33% of total area burned resulted from fires > 100,000 ha (247,104 ac) in size (Kasischke et al. 2002).

From 1950 to 2010, the total area burned for the "YUCH boundary" (where fire perimeters extending outside YUCH were clipped at the preserve boundary) is 398,007 ha. However, in examining the total acreage of all fires within the "YUCH area", a total of 664,204 ha burned. Approximately 54% of the total acreage burned from the fires in the "YUCH area" occurred in the years 1969 and 2004 (Figure 20). In 15 of the 24 years with recorded fires, fires did not overlap the boundaries (starting within or outside the preserve).

From 1950 to 2010, the "YUCH area" had two fire years with an average burn size greater than 20,300 ha (50,162 ac) and nine fire years with an average greater than 7,800 ha (19,274 ac) (Appendix 13). During this time period, 75% of the fires were greater than 400 ha (988 ac) (Appendix 13). Plate 12 displays the "YUCH area" fire perimeter data and the fire perimeters that burned in the surrounding area but did not affect YUCH from 1950 to 2010.

YUCH is a small area compared to the patterns found in Alaska by Kasischke et al. (2010). Displaying a larger area, fires that burned within the primary ecoregions of YUCH (North Ogilvie Mountains and Yukon-Tanana Uplands) from 1947 to 2010 were analyzed (Plate 12). Within both ecoregions there have been nine fires greater than 100,000 ha (247,104 ac) and five years with an average fire size of 20,300 ha (50,162 ac) or greater. The average annual area burned for the ecoregions is 78,700 ha and the total acreage burned from 1947 to 2011 is 4,013,696 ha (Figure 21). See Appendix 13 for burn area specific to the "YUCH boundary", "YUCH area", and whole fire area for the aforementioned ecoregions.

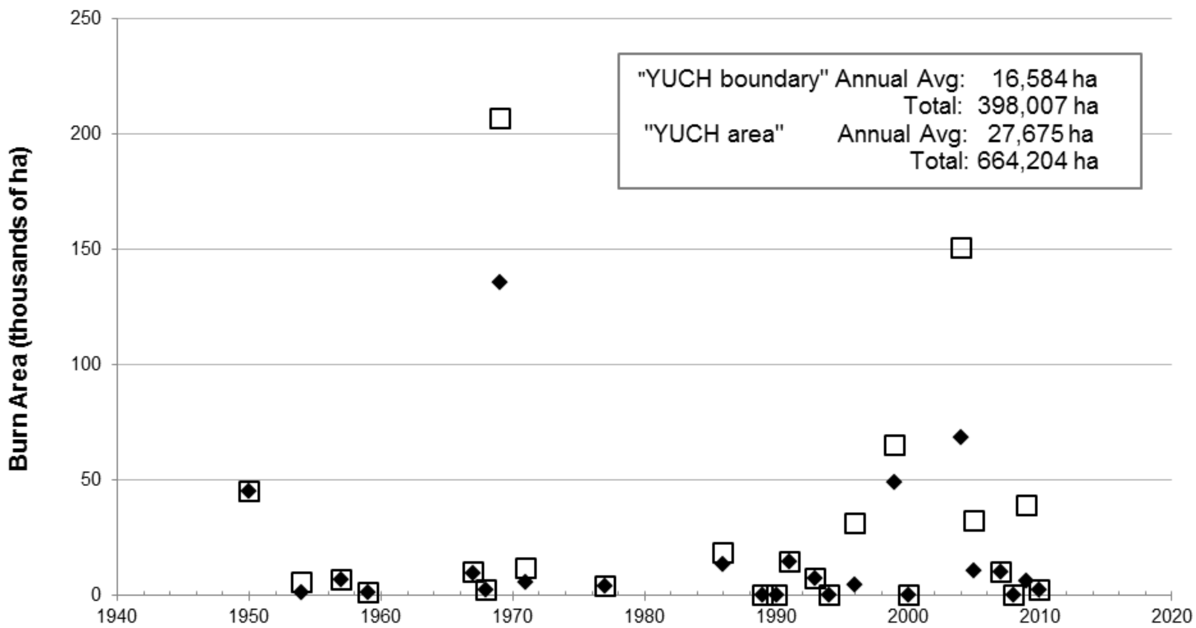


Figure 20. Annual area burned within the YUCH boundary (black diamonds) and annual area burned in the YUCH area (hollow squares) from 1950 to 2010 (AICC 2011).

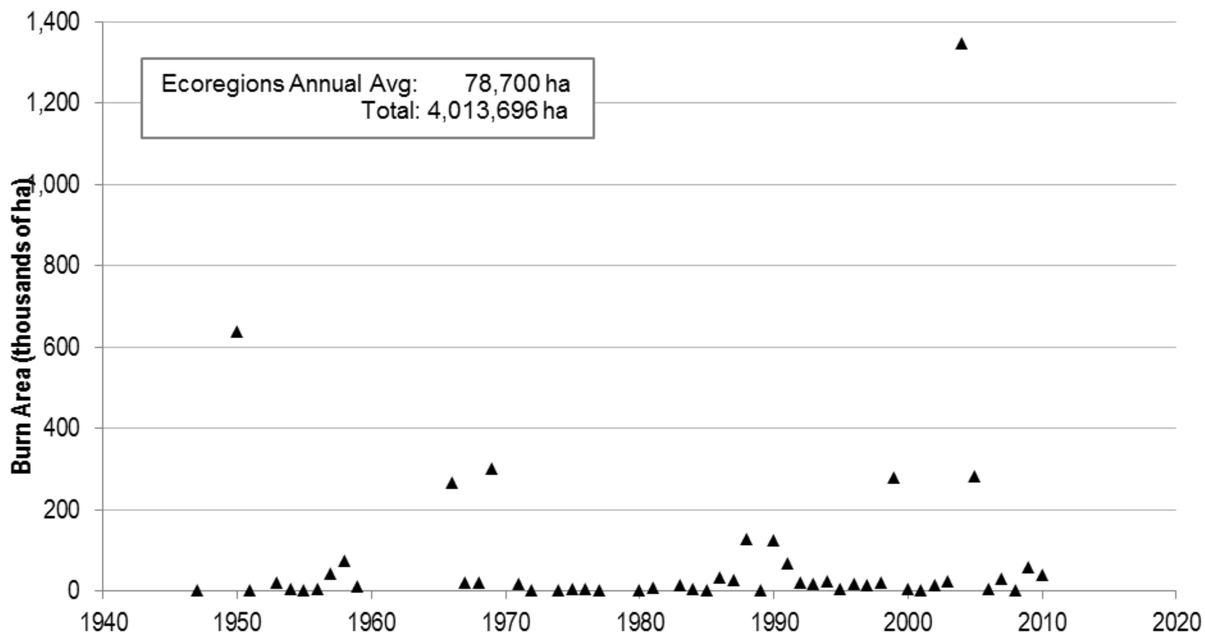


Figure 21. Annual area burned for the fires overlapping the North Ogilvie Mountains and Yukon-Tanana Uplands ecoregions (AICC 2011).

High fire years produce a high quantity of large fires that occur in bigger events and burn longer in the growing season (Kasischke et al. 2002). Patterns of high fire years are directly related to weather patterns (Kasischke et al. 2002). The number of acres burned provides indications of burn severity, length of fire season, and weather to help management during fire events. Duffy and Rupp (2007) found large fires occurring during late-season have increased the average burn severity and can be used as a proxy for weather conditions and seasonality.

<u>Number of Natural Fire Starts per Year</u>

Most Alaskan wildfires ignite by localized air mass thunderstorms; in boreal forest regions of Alaska, 87% of lightning strikes occur in June and July (Kasischke et al. 2010). Kasischke et al. (2010) found the number of lightning-ignited fires in Alaska was highest in the 1970s and decreased every decade since. The authors also noticed a significant correlation between the occurrence of lightning strikes and the number of naturally started fires during the 2000s in Alaska.

Approximately 91% of fires started in YUCH are of natural origin (NPS 2011b). There is no increasing or decreasing trend in the number of natural fire starts from 1950 to 2010 (Figure 22). However, it is important to note that data from the 1960s may be inconclusive as mentioned previously. Over the past 60 years, the preserve has averaged 2.58 fires per year [var 8.12, SD 2.85]. The largest number of fires recorded in the preserve was in 1969, with 14 fires.

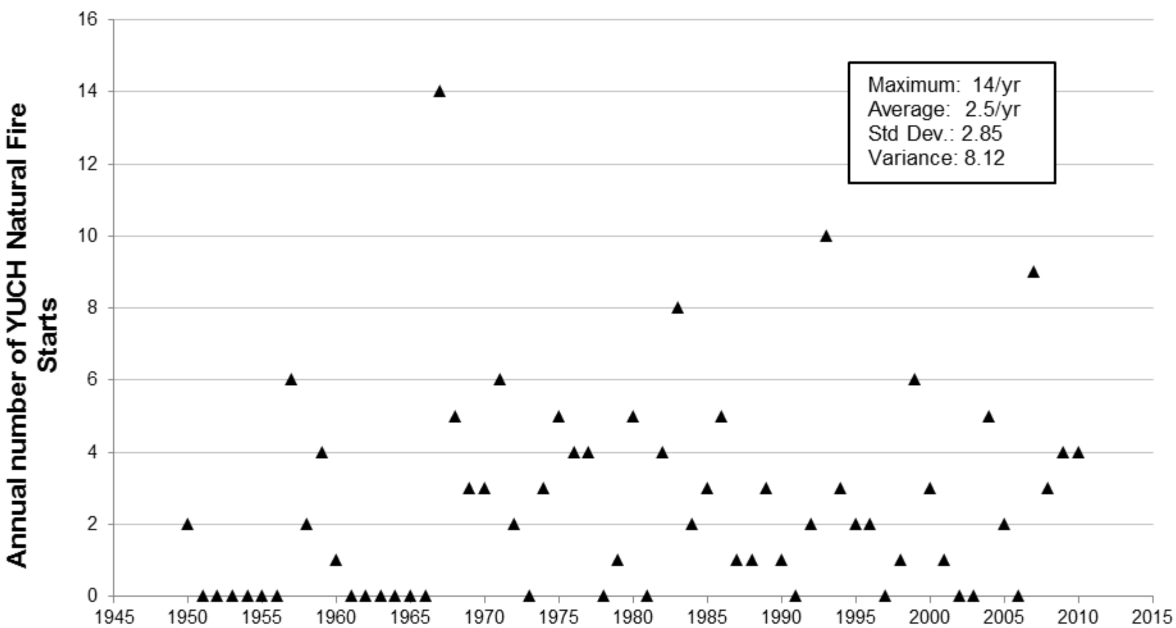


Figure 22. Natural fires started each year within YUCH (NPS 2011b).

Land managers or landowners in Alaska select wildland fire management options for fire suppression on their lands. The options range from “critical” to “limited”, with “critical” being the most aggressive suppression option and “limited” being periodic surveillance. Nearly all of the preserve area (96%) is currently under the “limited” fire management option. This option allows a natural fire regime to occur, while allowing for the protection, maintenance, and enhancement of natural and cultural resources. Suppression techniques in “limited” areas are initiated with a threat to human life or a higher priority wildland fire management option (AWFCG 2010).

Annual Fire Season Length (duration)
The annual fire season duration is the total days of fire incidents from first discovered date to final declared out date for each fire season. Annual fire season length (total days burned, start date to end date) appears to be higher in the 1990s and 2000s for the preserve (Figure 23). Start dates and end dates of fire seasons and individual fires provide indications of climate, burn severity, and fire size. Within the record set, the end dates of fires are not always reliable, as some fires were declared out at the end of the fiscal year or no end dates were unknown (Barnes, pers. comm., 2011).

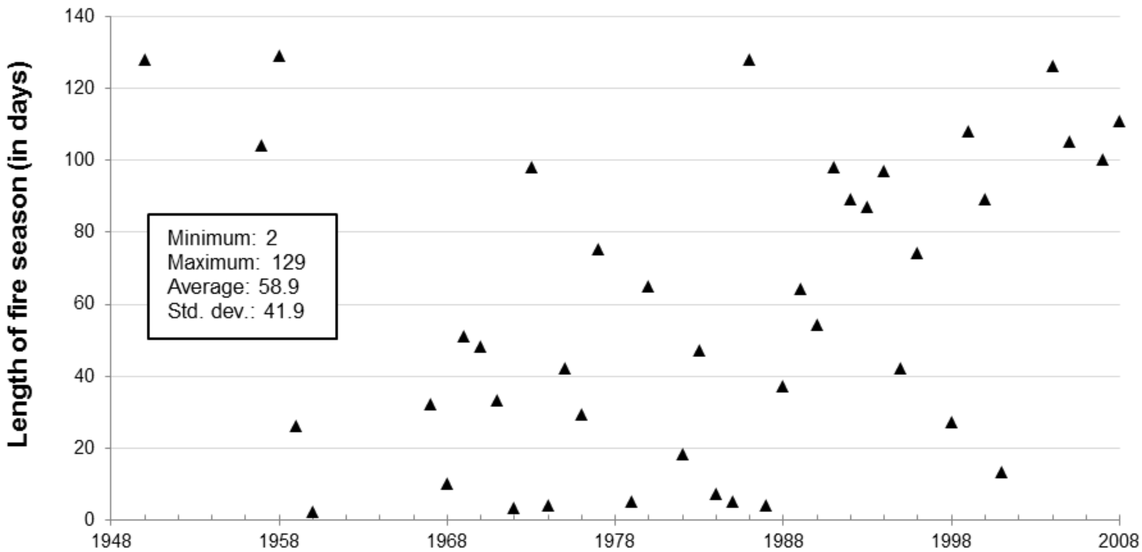


Figure 23. Annual duration of fire season (total days burned) from 1950 to 2010 (NPS 2011b).

The seasonality of fires is another important parameter examined by fire researchers and it is relevant to the total length of fire seasons. Using a fire reconstruction approach, Kasischke et al. (2010) define an early season fire as burning before July and a fire burning after July 31 as a late-season fire. Throughout past decades (1940 to 1999), Alaskan late-season area burned remained stable. In Alaska during the 2000s, late-season area burned increased about four times over any preceding decade (Kasischke et al. 2010).

For the purpose of this assessment, a late season fire is defined as one beginning after July 31. End dates in the dataset are not always reliable because some fires had unknown end dates and some were declared out at the end of the fiscal year (J. Barnes, pers. comm., 2011). According to the AICC fire perimeter data in the "YUCH area" from 1950 to 2010, 55 of the 57 total fires (96%) were early-season and two (3.5%) were late-season. According to the NPS fire point data, from 1950 to 2010, 109 of a total 170 fires (64%) were early season and six of 170 fires were late season. The remaining fire records in the point dataset lacked fire start and end dates (Appendix 14) (NPS 2011b).

Turestsky et al. (2010) found that the depth of burning varied with early-season fire size but late-season burning depth increased for all fire sizes.

Percentage of Burns by Severity Class Annually

Severity impacts current vegetation and the vegetation types associated with re-growth (Duffy and Rupp 2007). One method for measuring burn severity is to compare pre-burn to post-burn LandSat imagery and determining a Differenced Normalized Burn Ratio (dNBR). This method is described in detail in Sorbel and Allen (2005). In Sorbel and Allen (2005), the accuracy of the dNBR method was tested by sampling Composite Burn Index (CBI) plots established on the ground in recently burned areas. CBI methods involve scoring burn severity based on 22 variables including soil cover/color change, duff and litter consumption, percent of colonizers, percent of altered foliage, and percent of canopy mortality (Sorbel and Allen 2005). A comparison of CBI scores and dNBRs for the same areas shows that dNBR is "a suitable measure and predictor of burn severity in Alaska national parks" (Sorbel and Allen 2005).

YUCH individual fire burn severity data is available for certain fires from 1986 to 2010 through the USGS and USFS Monitoring Trends in Burn Severity (MTBS) program (Plate 13). With a limited number of fires and years of collected burn severity data, interpretation of any trends by severity class is difficult. MTBS (2011) provides and classifies burn severity data into six categories: "unburned to low", "low", "moderate", "high", "increased greenness", and "no data". The dNBR data, which is a continuous value, is categorized into these classes. According to information on the MTBS web page, an analyst evaluates the dNBR data range and determines where significant thresholds exist in the data to discriminate between severity classes. Interpretations are conducted on the dNBR data aided by raw prefire and postfire imagery, plot data, and analyst experience with fire behavior and effects in a given ecological setting. Therefore the values are subject to the interpretation of the analyst. The metadata for the acquired fires provides the thresholds used for each fire. After review, the thresholds used by the analysts to establish the categories of severity for each fire were relatively similar from fire to fire.

Utilizing the categorized severity data from MTBS, it was found that throughout the observed period (1986 to 2007) in YUCH, the annual percentage of "unburned to low" and "low" burn severity classes have decreased, whereas the percentage of the "moderate severity" class has increased. The annual percentage of area of high severity was highly variable by fire, ranging from 3.4% to 46.7% (Appendix 15).

Duffy et al. (2007) found that average burn severity typically increases as fire area increases. Severity increases as total area burned, fire size, and late-season burning increase (Turetsky et al. 2010).

Threats and Stressor Factors

During project scoping, NPS staff identified potential threats to current fire conditions. These include climate change, habitat fragmentation, and the occurrence of fires outside the historic range of variability.

Climate Change

Increases in wildfire frequency, severity, duration, and total area burned are possible ecological effects of climate warming in Alaska (Kasischke et al. 2010). Fire frequency will likely increase at high latitudes and may further contribute to climate warming by releasing more carbon into the atmosphere (Goetz et al. 2007). Climate warming trends documented elsewhere have also been noticed in Alaska, such as increased snow and ice melting, permafrost and snowfield thawing, reduced seasons of snowfall and river or lake ice, and decreases in moisture for plant growth (MacCluskie and Oakley 2005).

Large fire years from late-season burning are a product of weather conditions such as warmer springs and drier summers. Under these climatic conditions, when deep ground layer burning occurs in the early season, it is predicted to continue for several months (Turetsky et al. 2010). Kasischke et al. (2010) found climate is the primary reason for the frequency of large fire years and annual area burned, and helps explain the decadal patterns in average annual area burned. As climate, fire size, and severity increase it is predicted that vegetation change from conifer to deciduous will occur more rapidly (Duffy and Rupp 2007).

Habitat Fragmentation

The term "habitat" typically describes where an organism resides. Habitat varies among organisms and relates to the surrounding physical and biological characteristics of a specific species (MacCluskie and Oakley 2005). Landscape characteristics such as soil type, slope, aspect, elevation, and site history are used to describe plant habitats. Various environmental characteristics needed for survival and reproduction are used to describe animal habitats.

NPS (2008) describes changed vegetation results four years after the Woodchopper fire of 2004 in YUCH using collected tree seedling concentration. In deciduous stands, post fire conditions increased the density of paper birch seedlings 23 times greater than plots with unburned conditions. In black spruce plots, spruce seedlings were consistently low (<2 seedlings per m^2) for pre and post burned areas. Post fire deciduous seedlings densities (paper birch and aspen) in conifer plots increased from absent to <2 seedlings per m^2 (NPS 2008).

Joly et al. (2003) found that caribou in eastern Alaska prefer to use mature stands (areas burned >50 years ago) during the winter season and avoided stands burned ≤ 35 years ago. Resident woodland caribou and migratory populations in Canada also avoided recently burned areas (≤50 years) on their wintering range (Shaefer and Pruitt 1991, Thomas et al. 1998, as cited in Joly et al. 2003). Areas burned <50 years ago do not contain sufficient amounts of lichen for caribou forage and vascular forage is limited in these areas as well (Joly et al. 2003). Duffy and Rupp (2007) expect future changes in fire regime and vegetation types to decrease winter caribou habitat (spruce stands > 80 years old) and increase moose habitat (deciduous stands 10 to 31 years old).

Occurrence of Fires Outside the Historic Range of Variability

Given the available data, the range of variability over the entire period of record (1950 to present) may be suspect due to the issues of loss and/or damage to fire records from the 1960s and the fact that fire suppression prior to the 1980s may have altered fire statistics. If these data issues could be statistically corrected for, then the range of variability over the period of record could be compared to decadal or annual fire statistics. If fires were determined to be occurring outside of the historic range, this could present and confirm existing concerns around climate/weather changes to altered fire regimes in the preserve.

Ignition Source

While most fire starts in Alaska are human-caused (>60%), the majority of burn area (over 90%) is from wildfires caused by lightning strikes (Kasischke et al. 2010). Lightning strikes are considered natural factors/causes of fires in Alaska. If climate change alters the frequency and seasonality of lightning strikes, it could be considered a threat to the fire regime in the preserve. Alaska-wide, Kasischke et al. (2010) found a decrease in the number of lightning-ignited fires. However, the authors also found increases in large fire years and late-season burning, and that with warming summer temperatures, more storm activity means more lightning strikes.

Data Needs/Gaps

MacCluskie and Oakley (2005) found dealing with a potential increase in burning cycles in interior Alaska that management actions/responses are unclear. They suggest a need to better understand the relationships between fire and soils, vegetative succession, animal movement patterns, erosion, and tree line movement. Kasischke et al. (2010) claim one of the most important topics to better understand is the impact of the changing fire regime on the services provided by Alaska's boreal forests. Basic fire statistics and data sets need to be improved. For example, accurate end dates of fires should be recorded, and acreages for fire size vary between the AICC fire perimeter data and NPS point data sets for some fires (J. Barnes pers. comm., 2011).

Overall Condition

Trends in fire statistics using both fire perimeter and fire point data for YUCH are inconclusive. Fire records in Alaska from the 1960s may be missing (Kasischke et al. 2002) and the fact that fires were heavily managed through suppression efforts in the 1980s may result in misleading comparisons of recent decades' fire regime (current condition of fire regime) to the past decades. That is, the burned area, number of fires, and duration of fires and length of fire seasons in the datasets may be lower than what actually took place because of the missing data and suppression techniques. It is clear the early 2000s were some of the largest fire years on record, but what is unclear, according to Kasischke et al. (2010), is whether the feedbacks between forest and climate will be positive or negative in the future.

Annualized Burn Area

The project team defined the *Significance Level* for annualized burn area as a 3. The area burned of the "YUCH area" (those within or partially overlapping the boundaries of YUCH) from 2001 to 2010 remains within the observed data trend (1950 to 2000), with the highest area burned in 1969 and 2004. The *Condition Level* for annualized burn area is a 0, meaning the condition is of no concern.

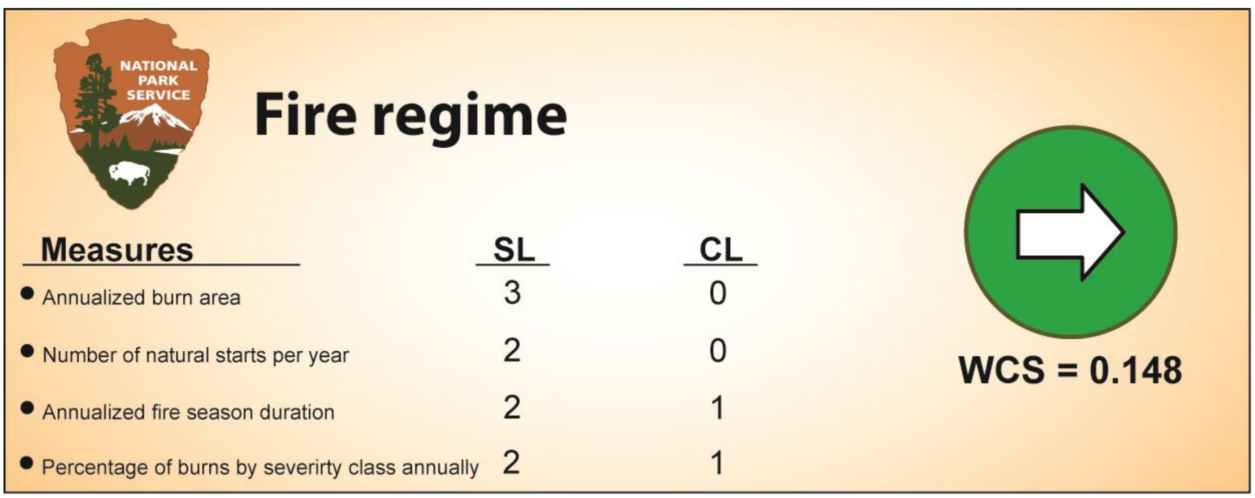
Number of Natural Fire Starts per Year

The project team defined the *Significance Level* for number of natural fire starts per year as a 2. The number of natural fire starts within YUCH from 2001 to 2010 has not increased or decreased when compared to the trend observed from 1950 to 2000 when analyzed by decade. The *Condition Level* for number of natural fire starts per year is a 0, meaning the condition is of no concern.

Annualized Fire Season Duration
The project team defined the *Significance Level* for annualized fire season duration as a 2. Annualized fire season duration (total days of fire season) has increased from 2001 to 2010 when compared to the trend observed from 1950 to 2000 when analyzed by decade. However, a determination of which fires in the dataset were suppressed and more accurate/consistent recording of fire end dates would provide a clearer understanding of fire season duration. At this time the *Condition Level* for annualized fire season is a 1, meaning the condition is of low concern.

Percentage of Burns by Severity Class Annually
The project team defined the *Significance Level* for percentage of burns by severity class annually is a 2. YUCH "unburned to low" and "low" burn severity classes have decreased while "moderate" severity has increased and "high severity" has remained stable from 1986 to 2010. The *Condition Level* for percentage of burns by severity class annually is a 1, meaning the condition is of low concern. Individual burn severity data for YUCH is limited and may misrepresent the actual percentage class trend.

Weighted Condition Score
Given the significance levels and condition levels for fire regime, the overall weighted condition score is 0.148, meaning the component is of low concern.



Sources of Expertise
Jennifer Barnes, NPS Alaska Regional Fire Ecologist, Fairbanks, Alaska.

Literature Cited

Alaska Interagency Coordination Center (AICC). 2011. Fire perimeter GIS data since 1942. Online. (http://afsmaps.blm.gov/?site=fire). Accessed 24 May 2011.

Alaska Wildland Fire Coordinating Group (AWFCP). 2010. Alaska Interagency Wildland Fire Management Plan 2010. Alaska Interagency Coordination Center, Alaska Fire Service, Fort Wainwright, Alaska.

Allen, J. L. 2005. Annual report on vital signs monitoring of the extent, severity and effects of wildland fire in Yukon-Charley Rivers NP, Denali NP/P & Wrangell-St. Elias NP/P. National Park Service, Central Alaska Network, Fairbanks, Alaska.

Bernhardt, E. L., T. N. Hollingsworth, and F. S. Chapin III. 2011. Fire severity mediates climate-driven shifts in understory community composition of black spruce stands of interior Alaska. Journal of Vegetation Science 22:32-44.

Duffy, P., and S. T. Rupp. 2007. Fire and climate change in Alaska. Alaska Center for Climate Assessment and Policy, University of Alaska, Fairbanks, Alaska.

Goetz, S. J., M. C. Mack, K. R. Gurney, J. T. Randerson, and R. A. Houghton. 2007. Ecosystem responses to recent climate change and fire disturbance at northern high latitudes: observations and model results contrasting northern Eurasia and North America. Environmental Research Letters 2:1-9.

Johnstone, J. F. 2006. Response of boreal plant communities to variations in previous fire-free interval. International Journal of Wildland Fire 15:497-508.

Johnstone, J. F., and F. S. Chapin III. 2006a. Fire interval effects on successional trajectory in boreal forests of northwest Canada. Ecosystems 9:268-277.

Johnstone J. F., and F. S. Chapin. 2006b. Effects of soil burn severity on post-fire tree recruitment in boreal forest. Ecosystems 9:14–31

Joly, K., B. W. Dale, W. B. Collins, and L. G. Adams. 2003. Winter habitat use by female caribou in relation to wildland fires in interior Alaska. Canadian Journal of Zoology 81:1192-1201.

Kasischke, E. S., D. W. Williams, and D. Barry. 2002. Analysis of the patterns of large fires in the boreal forest region of Alaska. International Journal of Wildland Fire 11:131-144.

Kasischke, E. S., D. L. Verbyla, S. T. Rupp, D. A. McGuire, K. A. Murphy, R. Jandt, J. L. Barnes, E. E. Hoy, P. A. Duffy, M. Calef, and M. R. Turetsky. 2010. Alaska's changing fire regime-implications for the vulnerability of its boreal forests. The dynamics of change in Alaska's boreal forests: resilience and vulnerability in response to climate warming. Canadian Journal of Forest Research 40:1313-1324.

MacCluskie, M., and K. Oakley. 2005. Vital Signs monitoring plan. Central Alaska Inventory and Monitoring Network, Fairbanks, Alaska.

Monitoring Trends in Burn Severity (MTBS). 2011. Monitoring trends is burn severity data access. Wildland Leadership Council (WFLC). Online. (http://www.mtbs.gov/dataquery/customquery.html). Accessed 30 June 2011.

National Park Service (NPS). 2008. Annual Report 2008. Yukon-Charley Rivers National Preserve. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

National Park Service (NPS). 2010. Wildland fire: Terms and definitions. Online. (http://www.nps.gov/fire/fire/fir_wil_termsdefinitions.cfm). Accessed 3 May 2010.

National Park Service (NPS). 2011a. Environmental factors – Yukon-Charley Rivers National Preserve. Online. (http://www.nps.gov/yuch/naturescience/ environmentalfactors.htm). Accessed 9 March 2011.

National Park Service (NPS). 2011b. Fires- NPS Alaska (point data), Permanent GIS dataset. National Park Service, Alaska Regional Office, Anchorage, Alaska.

Schaefer, J. A., and W. O. Pruitt. 1991. Fire and woodland caribou in southeastern Manitoba. Wildlife Monographs 116.

Smithwick, E. A. H., M. G. Turner, M. C. Mack, and F. S. Chapin. 2005 Postfire soils N cycling in northern conifer forests affected by severe, stand-replacing wildfires. Ecosystems 8:163-181.

Sorbel, B., and J. Allen. 2005. Space-based burn severity mapping in Alaska's national parks. Alaska Park Science 4(1):4-11.

Turetsky, M. R., E. S Kane, J. W. Harden, R. D. Ottmar, K. L. Manies, E. Hoy, and E. S. Kasisschke. 2010. Recent acceleration of biomass burning and carbon losses in Alaskan forests and peatlands. Letters, Nature Geoscience. Vol. 4. Macmillan Publishers Limited.

Thomas, D. C., H. P. Kiliaan, and T. W. Trottier. 1998. Fire-caribou relationships. (III) Movement patterns of the Beverly Herd in relation to burns and snow. Canadian Wildlife Service, Prairie and Northern Region, Edmonton, Alberta.

Van Cleve, K., and L. A. Viereck. 1981. Forest succession in relation to nutrient cycling in boreal forest of Alaska. Pages 185-211 *in* Forest succession: Concepts and application. D. C. West, D. B. Botkin, and H. H. Shugart, eds. Springer-Verlag Publishing, New York, New York.

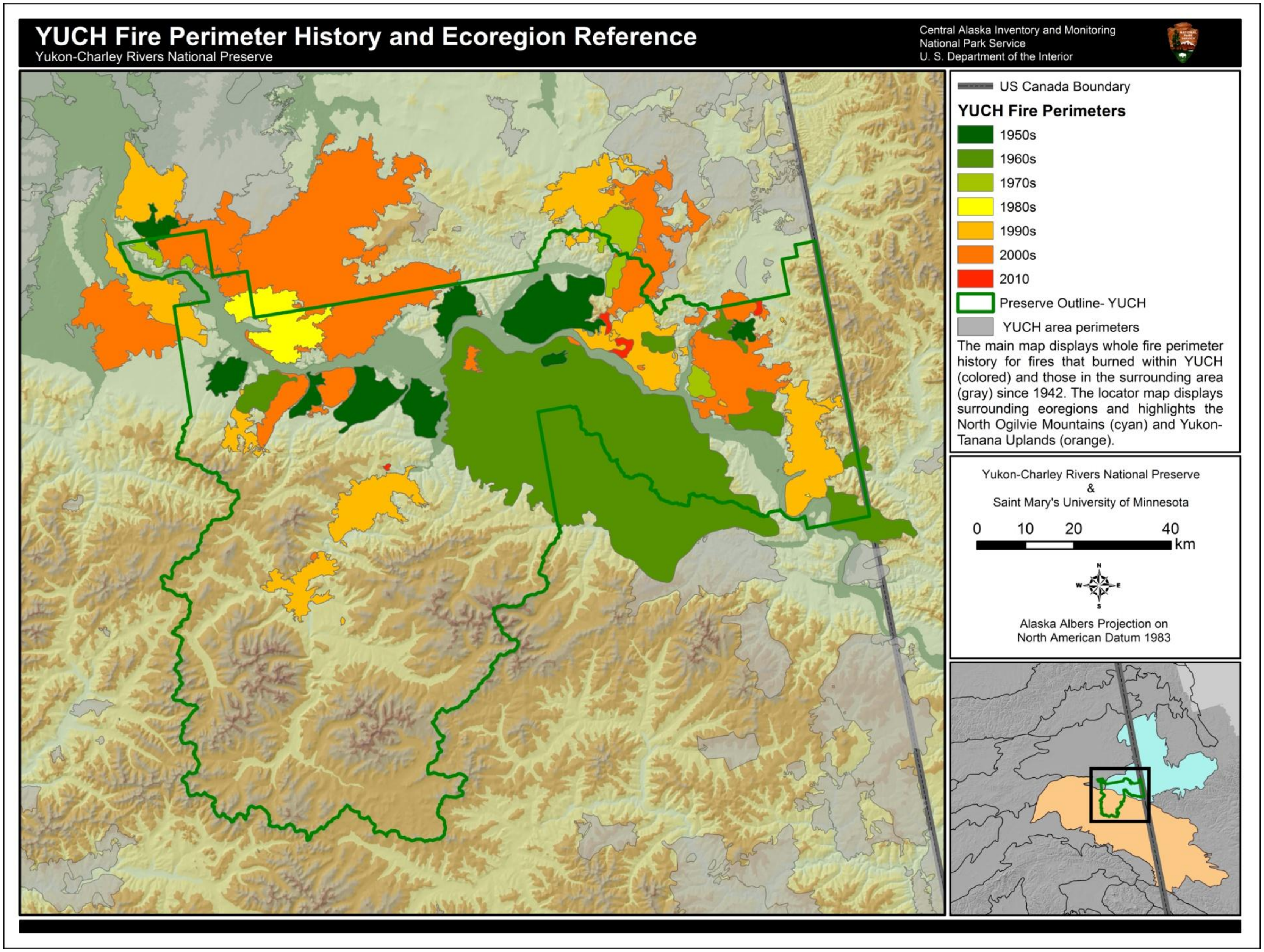


Plate 12. Fire perimeter history and North Ogilvie Mountains and Yukon-Tanana Uplands ecoregions.

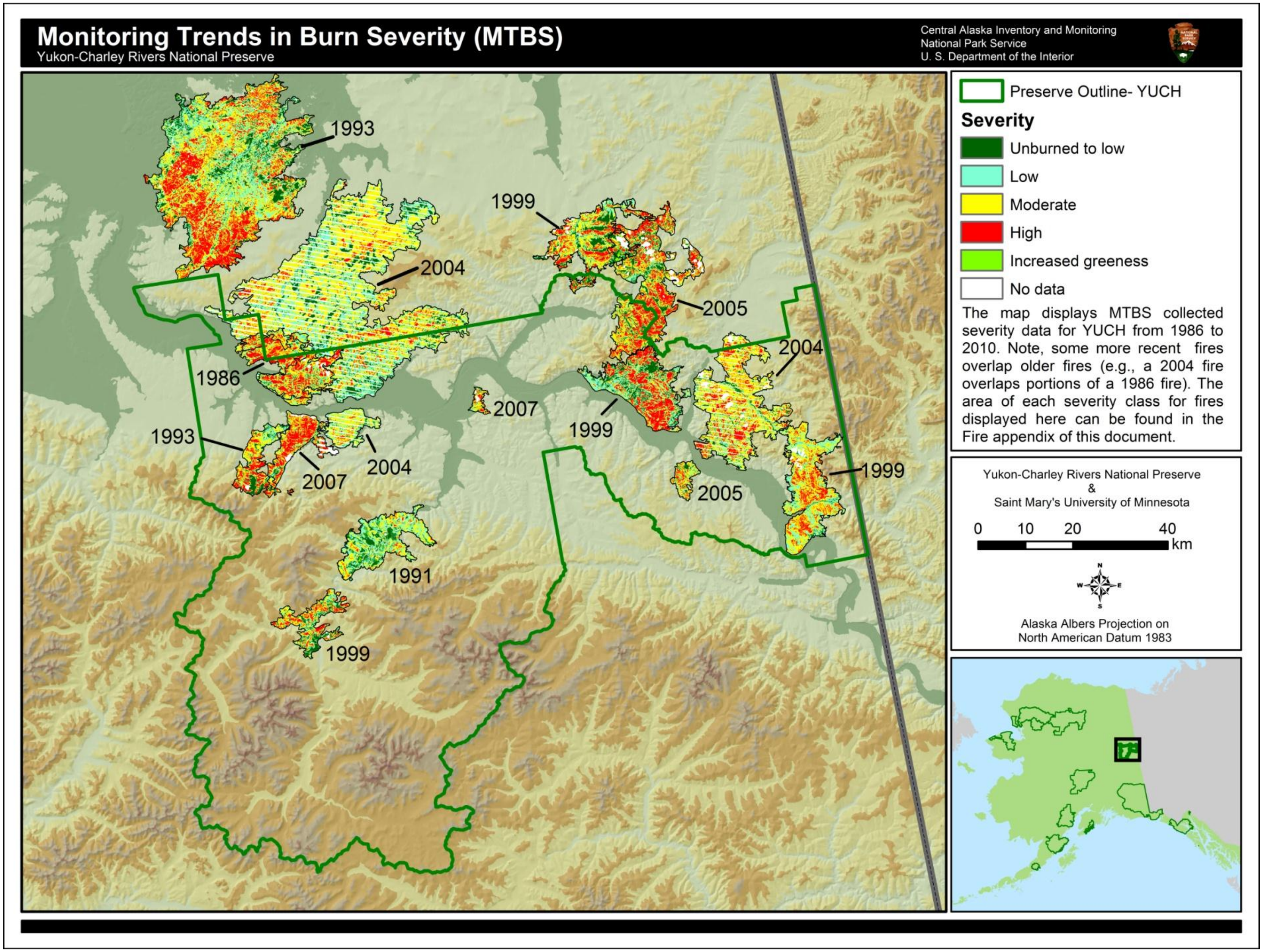


Plate 13. YUCH fire severity data for individual fires from 1986 to 2010. Map lables indicate fire year (MTBS 2010).

4.5 Fortymile Caribou Herd

Description

Caribou (*Rangifer tarandus*) is listed as one of six keystone large mammal species in interior Alaska due to their importance to the ecosystem as a whole (MacCluskie and Oakley 2005). The ADF&G is currently monitoring the FCH. While ADF&G monitoring objectives currently align with those of the CAKN, if these objectives change the CAKN may reevaluate the possibility of collaboratively or independently monitoring caribou (MacCluskie and Oakley 2005).

Caribou have been an important source of food and raw materials for humans across thousands of years in Alaska (NPS 2008). From the late 1800s until World War I, the herd was impacted by heavy market hunting (ADF&G 2007). In addition to meeting the needs of humans for food and raw materials, today the FCH provides excellent wildlife viewing opportunities (Advisory Committee Coalition 2000).

Measures

- Population size estimates
- Composition (bull: cow, calf: cow, spring and fall ratios)
- Nutritional state (fall calf weights)
- Range/distribution
- Harvest rates

Reference Conditions/Values

Although Dr. Olaus J. Murie estimated a large number of caribou in the late 1920s by extrapolating counts of caribou crossing a river (Murie 1935), the reference condition for this component is historic population estimates from Skoog (1956, 1964) and Valkenburg et al. (1994).

Data and Methods

To build a reference condition for this assessment, data from Skoog (1956, 1964, and 1968), Valkenburg et al. (1994), and Gross (2009) were used. Boertje and Gardner (1998, 2000) data were used to build the trend through the 1990s for most measures. Various authors from the ADF&G and NPS provided data for the current condition of the FCH. Pam Sousanes (NPS) provided the average end of month snow on the ground from October-April at Eagle, AK every year from 1972-2009. The percent of caribou population change from one year to the next was calculated (1994-2009) and compared with the average end of month snow on the ground to show the effect of snow on the caribou population. The only data manipulation that occurred was in the creation of figures, where multiple author estimates from the same year were averaged to generate a single point for each year.

Current Condition and Trend

<u>Population Size Estimates</u>

In the 1940s, the herd was estimated at 10,000-20,000 caribou (Skoog 1956, as cited in Valkenburg et al. 1994). Then, during the early 1950s, the herd was estimated at 50,000 individuals (Skoog 1956, as cited in Valkenburg et al. 1994). During the late 1950s, the herd reportedly declined to 40,000 (Valkenburg et al. 1994). Estimates of the herd's size from 1960-1963 were approximately 50,000 (Valkenburg et al. 1994). Then, from 1968 to 1972, a major decline was reported, with estimates ranging from less than 6,000 to 20,000 individuals (Valkenburg et al. 1994). In 1975, the herd was estimated at 5,740-8,610 individuals (Valkenburg et al. 1994). During the 1980s, the herd steadily increased each year until reaching a reported 22,766 in 1990 (Valkenburg et al. 1994) (Figure 24, Appendix 18). From 1990-1995 the herd's population was relatively stable, with approximately 22,000-23,000 individuals (Boertje and Gardner 2000). The herd then increased to 34,640 by June of 2000 (Boertje and Gardner 2000). The herd further increased to 43,375 in 2003 and then declined to an estimated 40,000 by 2005 (ADF&G 2006). The timeline of population estimates is displayed in Figure 24.

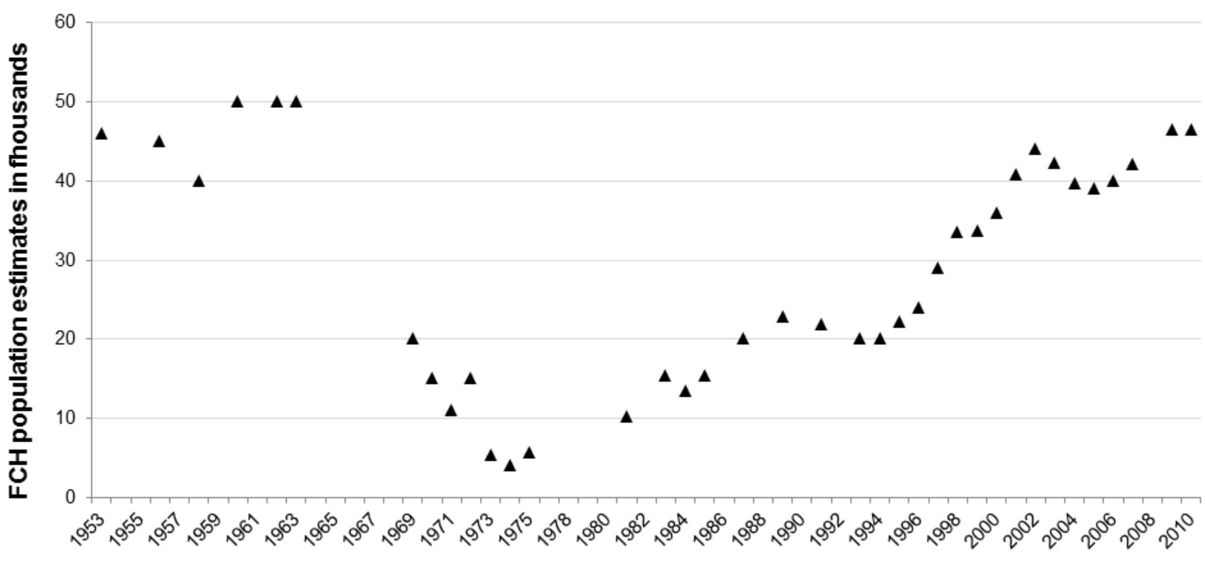


Figure 24. FCH population estimates 1953 to 2010. 1950-1984 (Valkenburg et al. 1995) 1985 to 2009 (Gross 2009) 2010 (Gross, pers. comm.).

On 5 July 2009, the ADF&G completed a photo-census of the Fortymile Caribou Herd. They used seven aircraft to find and photograph 46,509 caribou. Five spotter planes were used to locate caribou not associated with known radiocollared animals. The majority of the herd was located at the headwaters of the Salcha River. Small groups were counted from the air or photographed and counted later (ADF&G 2010).

Composition (bull: cow, calf: cow, spring and fall ratios)

Calf to cow ratios are important for understanding recruitment between different time periods, and is the only data available for some years (Valkenburg et al. 1994). In periods of observed herd growth, calves averaged 18.1 to 20.7 percent of the herd's population. Calf to cow ratios in 2009 and 2010 were 34 and 32 calves to 100 cows (Gross 2011). From 1992 to 2010 the average calf to cow ratio was 32:100. From 2004-2006, the bull to cow ratio was greater than 43 bulls to 100 cows. In 2009, the bull to cow ratio was 37:100. From 1992 to 2010 the average bull to cow ratio was 45:100 (Figure 25). Previous years' data is presented in Appendix 17.

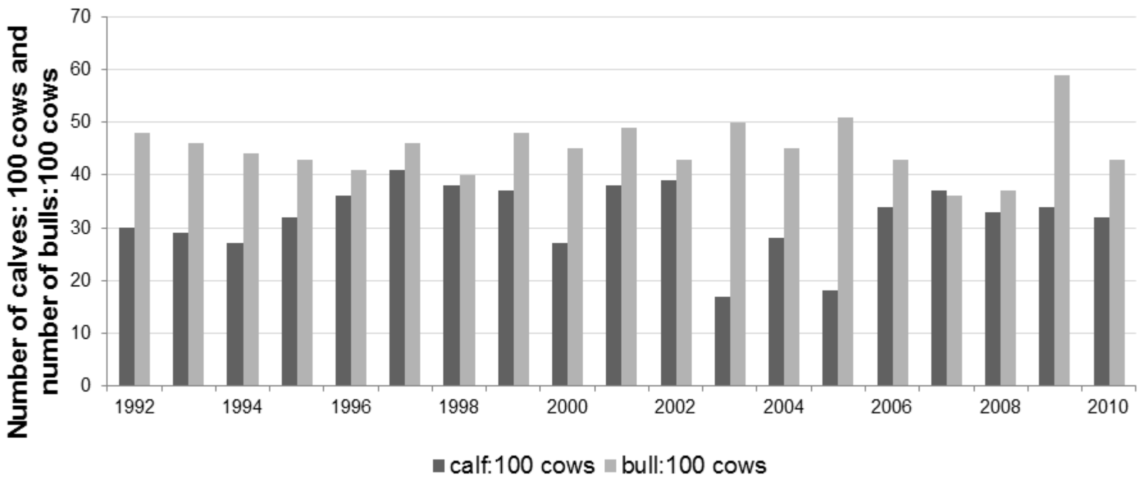


Figure 25. Calf to cow and bull to cow ratios from 1992 to 2010 (1992-2002 Gardner 2002), (03-08 Gross 2008), and (09 & 10 Gross 2011).

Nutritional State (fall calf weights)

Fall calf weights can provide insight into the previous spring/summer conditions. Fall calf weights may also be a predictor of pregnancy rates for the following year. For example, high fall calf weights in 1995 and 1997 were associated with to high pregnancy rates in 1996 and 1998, respectively (Boertje and Gardner 2000). Fall calf weights from 1990 to 2010 are presented in Figure 26 (Boertje and Gardner 2000, Gross 2011).

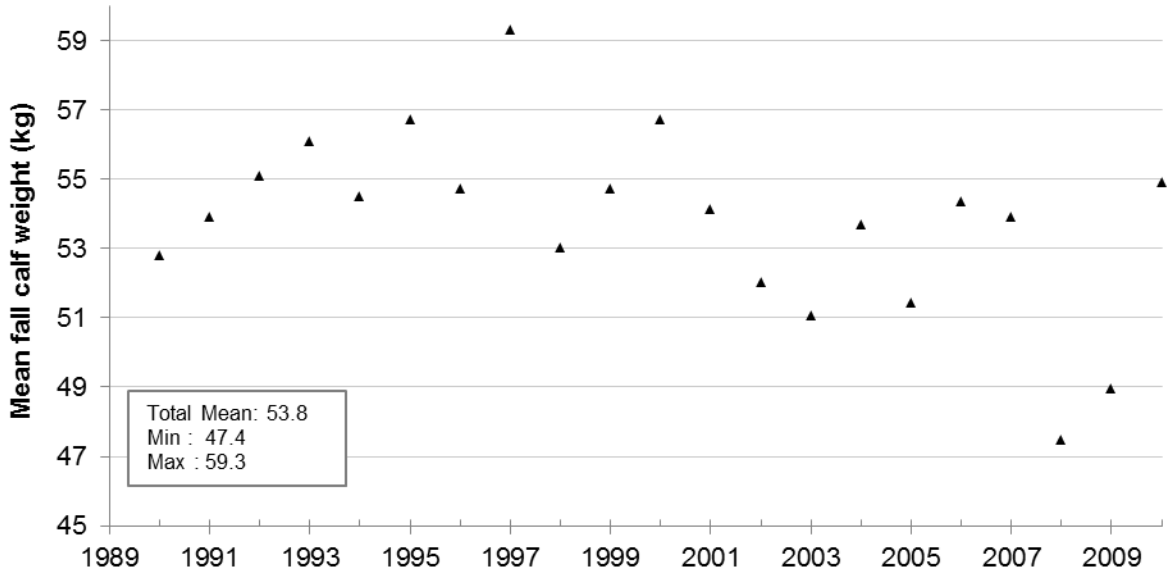


Figure 26. Mean fall calf weight from 1990 to 2010 (Boertje and Gardner 2000, Gross 2011). Sample sizes from 1992-2000 ranged 14-17 female calves and sample sizes not provided from 2001 to 2010.

<u>Range/Distribution</u>

The FCH occupies relatively small area (no area estimates are available) in east central Alaska, overlapping the U.S.-Canada border into the adjacent Yukon Territory to the east (Valkenburg et al. 1994). Boertje and Gardner (2000) offer one of the most recent representation of the herd's range from 1984 to 1999 (Figure 27). More recent representations of the FCH range were not identified in literature searches.

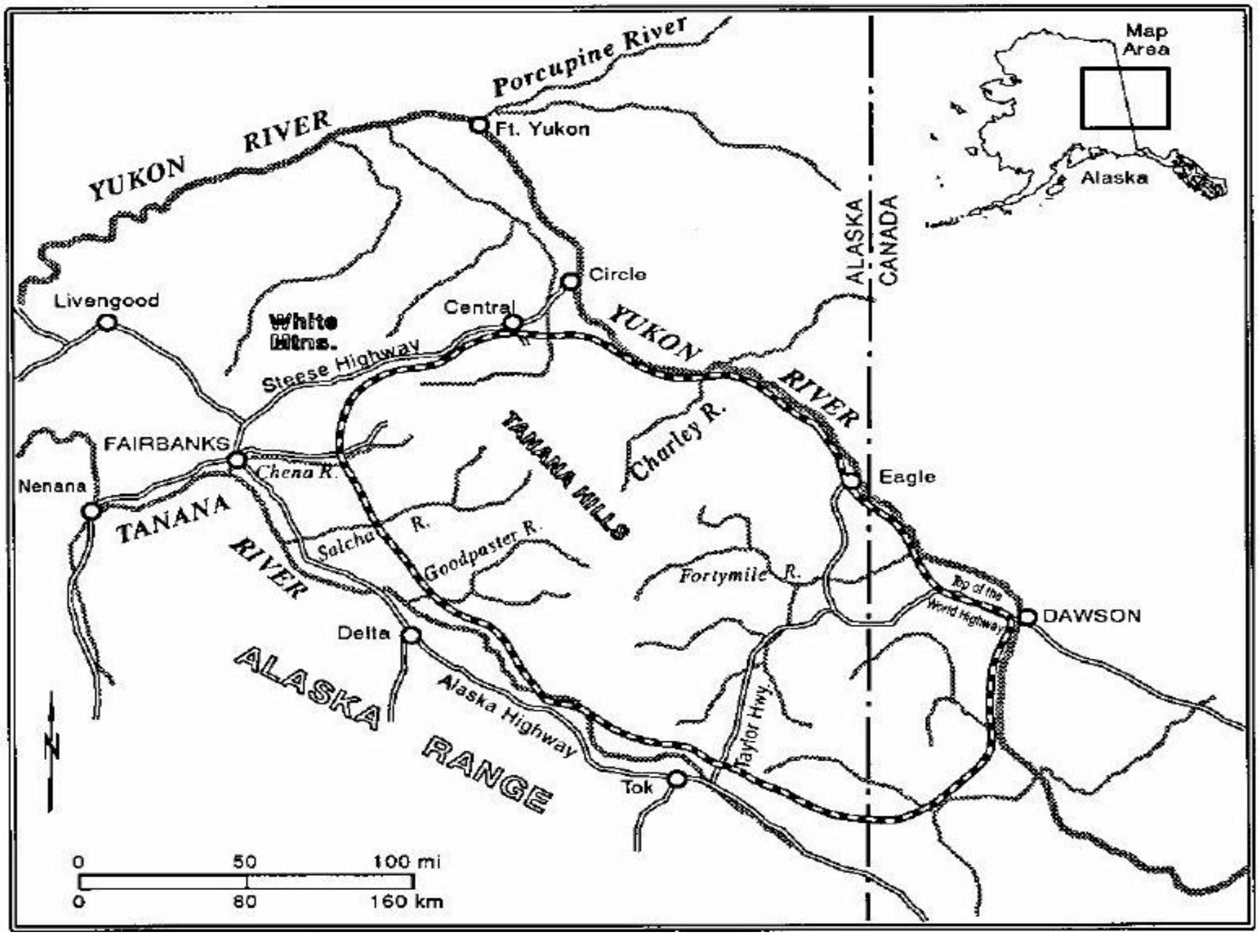


Figure 27. Range of the Fortymile Caribou Herd, 1984 to 1999 (Boertje and Gardner 2000).

Valkenburg et al. (1994) note that the FCH is more dispersed in the winter than at other times of the year, primarily located among spruce forest and subalpine ridges. The herd is more concentrated during the months of June and July (Valkenburg et al. 1994). Depictions of historic FCH ranges are available from the other agencies, however, Joly (pers. comm., 2012) asserts that caribou from a different herd may be represented in historic range estimates for the FCH, and data identifying which herd caribou were from are not available. Therefore, the historic range of the FCH is not clear.

Harvest Rates

In 1935, an enforcement agent reported that at least 10,000 caribou were harvested and each trapper took 30 to 60 caribou for dog feed each year in this region (Alaska Game Commission 1934, 1935; as cited in Skoog 1956). Prior to the 1950s Taylor Highway construction, the majority of hunting occurred along the Steese Highway and the Yukon River above Dawson (ADF&G 2006). Valkenburg et al. (1994) suggested that high rates of harvest occurred from 1964 to 1967, but were unreported. In 1965, only 90 caribou were actually reported at harvest check stations; however, the estimated total harvest was 800 animals. The inconsistency in reporting may have resulted in overharvest and a population decline of the FCH. Harvest reports were not made mandatory until 1968.

Until 1973, the bag limit was three caribou and the competition for harvest among hunters was great (Valkenburg et al. 1994). The herd crashed and reached an all-time low population level of < 10,000 caribou. From the mid 1970s through the 1980s, hunting regulations prevented harvesting from limiting herd growth (ADF&G 2006). The FCH planning team decided to reduce the annual harvest of bulls to 150 for five years starting in 1996. After the five-year reduction in annual bull harvest, there was no increase detected in bull to cow ratios (INSERT cross reference for Calf:Cow and Bull:Cow ratios); Appendix 18). The 2001 to 2006 Harvest Plan proposed an annual harvest rate of about 2-3%, with 65% of the total annual caribou harvest from 2001 to 2006 assigned to Alaska and 35% assigned to Yukon (ADF&G 2006). The T'rondek Hwechin First Nations gave up their hunting opportunity and the Yukon Department of Environment had no seasons for the FCH during this period to promote herd growth (ADF&G 2006). The Alaska harvest plan, developed by the FCH planning team, presents fall and winter caribou harvest quotas, total quotas, number of permits issued and total harvest for caribou in the Steese/Chena Hot Springs Area, Taylor Highway Area, and the Salcha-Goodpaster Roadless Area (Appendix 19).

Threats and Stressor Factors

Possible Loss of Forage Quality and Quantity Due to Climate and Vegetation (specifically lichen) Change

Changes in irradiance, temperature, and precipitation affect nutrient concentrations, anti-herbivore defenses of plants, and forage availability for caribou (Lenart et al. 2002). Summer conditions from 2002 to 2004 were drier than average and deep snow conditions were prevalent during the winter of 2004-2005. These conditions may have reduced nutritional status in 2003 and 2005, resulting in lower birthrates observed in those years (Gross 2007). According to Gross (2007), the winters of 1991-92, 92-93, 95-96, 96-97, and 99-00 produced excellent conditions for access to forage, though conditions were not specified. During these years, fecal samples of the FCH contained high proportions of lichen fragments (72-81%) and a low proportion of mosses (8%) (Gross 2007). Preliminary data collected between the years 2000-2004 also showed high proportions of lichen in fecal samples. The preliminary data suggested that forage conditions in the FCH's range were excellent during those winters (Gross 2007). While this means caribou were able to find areas with high lichen content, in the absence of detailed information regarding caribou distribution, no inference about range condition should be made (Joly, pers. comm., 2012).

Fire and Climatic Effects on Forage Quantity and Quality

Fire increases vegetative diversity and productivity, but may reduce the availability of winter forage (lichens) for decades (Joly et al. 2002). Climate change is a factor that influences the frequency of fire and likely influences the quantity of forage on the caribou's winter range (Joly et al. 2002). Caribou tend to avoid areas that have been burned within the past 50 years (Joly et al. 2002). Wildfires during the summers of 2004 and 2005 burned about 15% of the FCH's winter habitat (Gross 2007).

Overflights (soundscape)

The negative impacts of human-generated noise on caribou have been a concern for a considerable amount of time (Harrington 2003). Lawler et al. (2005) studied the response of caribou to military overflights; they found that caribou often exhibited startled reactions and running for up to 15 seconds following an overflight. During observations of the FCH by Lawler et al. (2005), four out of 65 calves died within 24 hours of being exposed to an overflight (Lawler et al. 2005). However, the source of the four deaths was predation; two were killed by wolves, one by a black bear, and the other by a grizzly bear (Lawler et al. 2005). The more directly over the caribou the flights occurred, the larger the animals' reactions were (Lawler et al. 2005). Higher level responses occurred more frequently at flight levels below 305 meters and with faster flight speeds (Lawler et al. 2005). The slower flying A-10 provoked fewer reactions than the faster F-15 and F-16 (Lawler et al. 2005). The authors also found that caribou group size had minimal effect on reaction levels (Lawler et al. 2005).

Magoun et al. (2003) found no evidence that caribou calves died as a direct result from military overflights. Approximately six months after birth, 82% of the radiocollared calves that had been overflown by a military jet at a distance of < 2 km were still alive (Magoun et al. 2003). In contrast, woodland caribou calves near Goose Bay and Labrador, Canada, were found to have a high mortality rate when exposed to low-level jet overflights (Harrington 2003).

Predation (wolf and bear)
Skoog (1968, as cited in Curatolo 1975) found wolves and humans to be the primary proximate causes of caribou mortality in Alaska. Boertje and Gardner (2000) claimed the primary proximate sources of FCH mortality came from wolf and grizzly bear predation. From 1994 to 1997, wolves reportedly preyed upon 2,000-3,000 caribou calves and 1,000-2,300 older caribou of the FCH annually (Boertje and Gardner 1998). Predation from grizzly bear was less than 15% in 1998 and 2000 (Boertje and Gardner 2000). Wolves were determined to be the proximate cause of all the FCH radiocollared calf fatalities in the winter of 2004 (Gross 2007). In 2005, four of the 15 radiocollared calves that died in the fall were killed by wolves (Gross 2007).

The 1995 planning team came to the conclusion that wolves were the most influential predator limiting calf survival (Advisory Committee Coalition 2000). The team then developed a plan to limit predators, focusing on wolves. Trappers targeted wolves located in the FCH's winter and summer range. The ADF&G followed with a non-lethal predator control plan, focusing their efforts on wolf packs located within the FCH's calving grounds. The dominant pair of each pack in the calving grounds was sterilized and the remaining wolves were relocated. Sterilization and relocation reduced the wolf population in the FCH's calving grounds by about 80% from 1998 – 2001 and possibly longer (Advisory Committee Coalition 2000).

During observation, caribou generally moved uphill in the presence of predators. Once the predators left, the caribou returned downhill. In one observation, caribou changed their movement pattern after a wolf encounter. Caribou formed either a circular or oval shape when retreating from wolves or bears. Reactions to bears and wolves caused bunching after the initial chase (Curatolo 1975).

Winter Snowfall (depth/accumulation)
Valkenburg et al. (1994) found that snow index (sum of monthly maximum snow depths for Nov. – April at Eagle, AK) was negatively correlated with herd calf percentage. Wolves, which sometimes can easily travel on top of snow, benefit from deep snow because caribou get bogged down and tire easily, making them more susceptible to predation (Gross 2007). Under other deep snow conditions, the long legs and wide hooves of caribou provide an advantage over wolves.

Snow is believed to play an important factor in caribou population ecology and behavior during the winter. Deep snow may have contributed to the FCH decline from 1963 to 1973. Winters were above the 39-year median snow index in 1963, 1966-67, 1970-71, and 1972-73 (Valkenburg et al. 1994). Figure 28 displays the average amount of snow on the ground from October to April from 1972 to 2009 (NPS 2011).

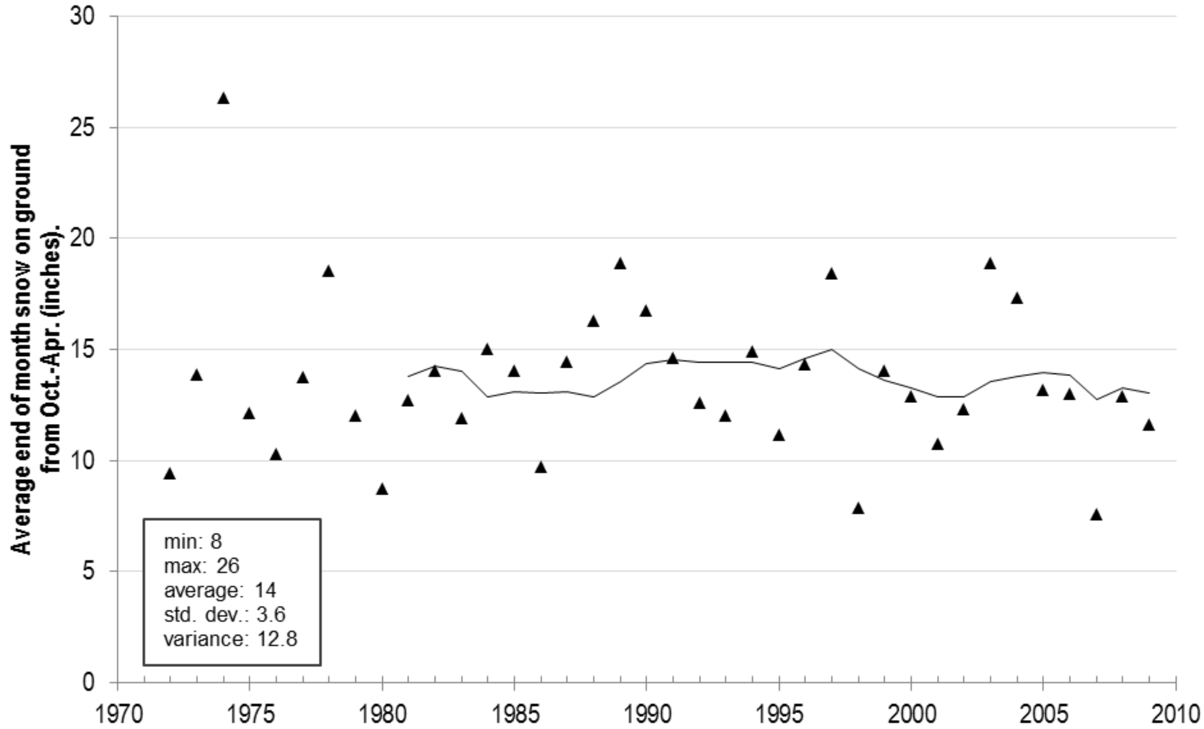


Figure 28. The average end of the month snow depth (inches) October through April for each year from 1972-2009 at Eagle, Alaska (NPS 2011). Shown with a 10-year moving average line.

Visual inspection of data appears to show that years following deeper snows relate to reductions in subsequent year caribou populations. However, the percent population change from one year to the next was calculated and regressed against the average end of month snowfall from October-November for each year (Figure 29). The relationship was not significant ($F = 0.2305$, $p = 0.6405$, $\alpha = 0.05$).

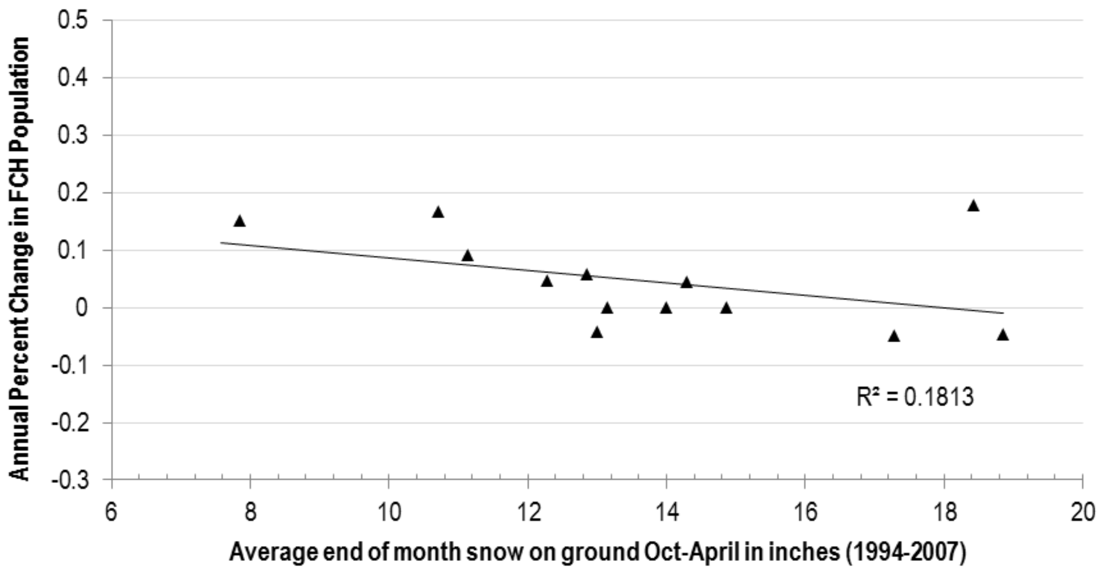


Figure 29. Corresponding yearly percent of population change and average snow depth at end of month from October – November for each year 1994 to 2007.

Summer Temperatures and Precipitation
ADF&G (2006) observed a low birthrate (69%) in 2003 and speculated it was the result of adverse summer weather conditions in 2002. However, the weather conditions were not specified in ADF&G (2006). The 2002 summer weather likely caused poor body condition in cows and a subsequent decrease in the 2003 pregnancy rate (ADF&G 2006). Warmer temperatures may cause caribou to overheat and seek snow banks for relief (Curatolo 1975). Summer temperatures regulate the abundance of insects, which can be a nuisance and put stress on caribou. Summer drought conditions may cause a decline in caribou health, which could contribute to high winter mortality and low birth rates in the following year (ADF&G 2007). Cool, cloudy summers can extend the season for which plants are the most nutritious for caribou and be beneficial to caribou (Lenart et al. 2002).

Insect Harassment
Curatolo (1975) states that mosquitoes are the most problematic insect pest to caribou in the Tanana Hills, and that high densities of these pests influence caribou activity patterns. During high insect harassment, caribou decrease the amount of time spent grazing and lying, and their speed increases when travelling. Faster movement may minimize insect harassment. Caribou also form larger groups when harassed by insects (White et al. 1975, as cited in Curatolo 1975). Another notable insect that harasses caribou are oestrid flies (nasal bots and warble flies). Their harassment causes wild, sporadic running and rigid, prolonged standing in caribou. Curatolo (1975) noted that when wind speeds increase, the density of flying insects decreases.

<u>Data Needs/Gaps</u>

Additional range condition data, including both summer and winter, should be collected. Despite conducting a regression of snow depth and caribou population change, the impact of snowfall depth on the FCH is still uncertain and could benefit from additional and more robust statistical analyses. Burch (2009) suggested that low snowfall from 2005-2007 may have helped caribou avoid predation. Snowfall may also have been a factor in the population decline from 1963-1974. In terms of caribou mortality, little research has been done into the amount of predation from bears. Boertje and Gardner (2000) found that in 1998 and 2000, bear predation on caribou was less than 15%, suggesting that bear predation may be of low concern for those in charge of FCH management.

<u>Overall Condition</u>

Population Estimates
The project team defined the *Significance Level* for population estimates as a 3. The 2010 FCH population was 51,675 animals, representing the highest estimate since Murie's estimate in the 1920s. The current FCH population estimate is the highest in 70 years, and, according to R. Boertje (pers. comm., 2012 via Joly, pers. comm., 2012) the current population would be of low concern if not for early signs of range overgrazing (e.g., low fall calf weights, lower calving rates for young cows and slowing rates of herd growth. That is, an increasing population size in not equivalent to improving conditions in this case. For this assessment, the *Condition Level* for population estimates is 1, indicating a low concern for this measure.

Herd Composition
The project team defined the *Significance Level* for herd composition as a 3. The FCH herd composition has a *Condition Level* of 0, based on current calf to cow and bull to cow ratios falling within the range observed from 1972 to 2009.

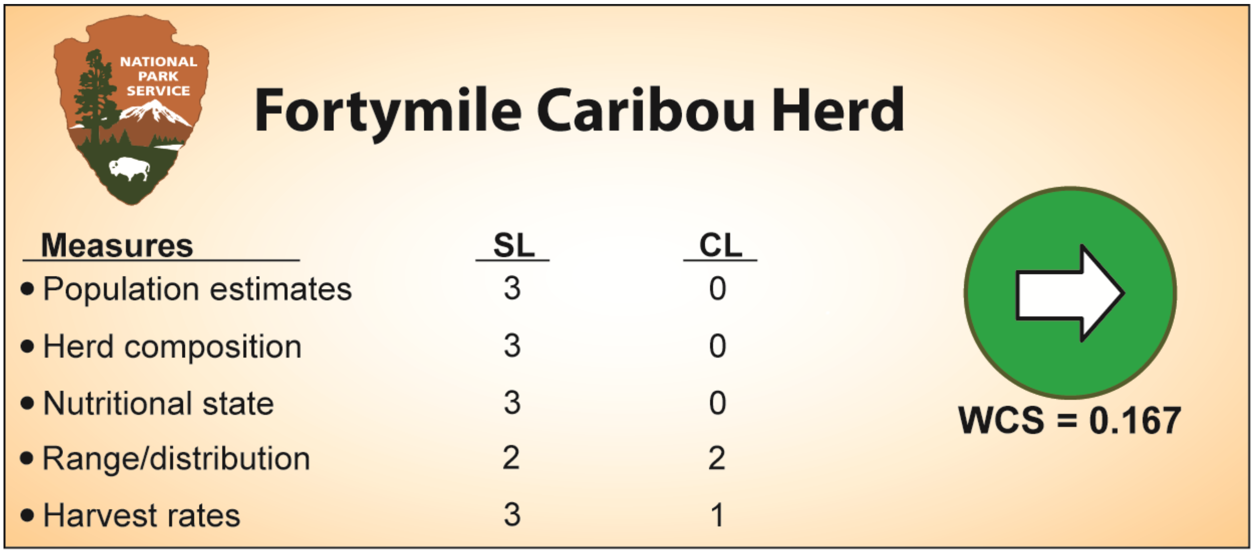
Nutritional State
The project team defined the *Significance Level* for nutritional state as a 3. According to Gross (2007) fecal samples showing a high percentage of lichen to moss from 2000 to 2004 indicate forage quality for the FCH was excellent at that time. However, it is not known if caribou had good access to lichen, possibly due to ideal winter precipitation conditions (e.g., snow depth or hardness) or if the overall range conditions were good. From 1990-2010, fall mean calf weights appear to be declining slightly. *Condition Level* for nutritional state is currently of low concern (*Condition Level* = 1).

Range/Distribution
The project team defined the *Significance Level* for range/distribution as a 2. The *Condition Level* is not determined (N/A) due to estimates of historic ranges being speculative in nature and a lack of information relates herd distribution with detailed range conditions.

Harvest Rates
The project team defined the *Significance Level* for harvest rates as a 2. Harvest rates of the FCH are currently of some concern (*Condition Level* = 1, or low concern). In the past, overharvest has been assumed to cause decreases in population. While, the herd has been heavily managed and harvest has been steadily controlled over the past fifteen years, harvest of cows coincided with a slowing of population growth and therefore, harvest is of some concern (Joly, pers. comm., 2012).

Weighted Condition Score

The Weight Condition Score (WCS) for the Fortymile Caribou Herd is 0.250, indicating the component is of low concern. Examining all measures included in this assessment, the overall condition of the FCH is of low concern and the trend in condition appears to be stable in recent years.



Sources of Expertise

John Burch, YUGA Wildlife Biologist, CAKN; Kyle Joly, YUGA Wildlife Biologist, and Jeff Gross, ADF&G Wildlife Biologist were consulted in the writing of this assessment.

Literature Cited

Advisory Committee Coalition. 2000. Fortymile Caribou Herd harvest plan, 2001-2006. Online. (https://secure.wildlife.alaska.gov/management/planning/planning_pdfs/fortymile_harvest_plan_2001_2006.pdf). Accessed 7 December 2010.

Alaska Department of Fish and Game (ADF&G). 2006. The Fortymile Caribou Herd harvest plan 2006-2012. Online. (http://www.wc.adfg.state.ak.us/management/planning/planning_pdfs/fortymile_harvest_plan.pdf). Accessed 7 December 2010.

Alaska Department of Fish and Game (ADF&G). 2007. Caribou management report of survey-inventory activities, 1 July 2004 – 30 June 2006. P. Harper, editor. Alaska Department of Fish and Game, Juneau, Alaska.

Alaska Department of Fish and Game (ADF&G). 2010. The comeback trail. News of the Fortymile Caribou Herd. Division of Wildlife Conservation, Tok, Alaska.

Alaska Game Commission. 1934a. The ninth report of the executive officer to the Alaska Game Commission.

Alaska Game Commission. 1935a. The tenth report of the executive officer to the Alaska Game Commission.

Boertje, R. D., and C. L. Gardner. 1998. Factors limiting the Fortymile Caribou Herd. Federal aid in wildlife restoration final research report, July 1992-June 1997. Alaska Department of Fish and Game, Juneau, Alaska.

Boertje, R. D., and C. L. Gardner. 2000. Reducing mortality on the Fortymile Caribou Herd, 1 July 1999-30 June 2000. Federal aid in wildlife restoration performance report. Alaska Department of Fish and Game, Juneau, Alaska.

Burch, J. 2009. Annual report on vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Yukon-Charley Rivers National Preserve, Central Alaska Network: 2009 report. Natural Resource Technical Report NPS/CAKN/NRTR—2009/228. National Park Service, Fort Collins, Colorado.

Curatolo, J. A. 1975. Factors influencing local movements and behavior of barren-ground caribou (*Rangifer tarandus granti*). Thesis. University of Alaska, Fairbanks, Alaska.

Gardner, C. L. 2002. Fall sex and age composition of the Fortymile Caribou Herd, 1953-2001. Memo to John Burch, NPS.

Gross, J. A. 2007. Units 20B, 20C, 20D, 20E, and 25C caribou. Pages 135-157 *in* P.Harper, editor. Caribou management report of survey and inventory activities 1 July 2004-30 June 2006. Alaska Department of Fish and Game, Juneau, Alaska.

Gross, J. A. 2008. Fortymile fall composition survey. ADF&G Memorandum. Division of Wildlife Conservation, Tok, Alaska.

Gross, J. A., 2009. Units 20B, 20C, 20D, 20E, and 25C caribou. Pages 136-158 in P. Harper, editor. Caribou management report of survey and inventory activities 1 July 2006-30 June 2008. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska.

Gross, J. A., 2011. 2011. Unpublished data. Received from Jeff Gross of the Alaska Department of Fish and Game (ADF&G), 3 March 2011.

Harington, F. H. 2003. Caribou, military jets and noise: the interplay of behavioural ecology and evolutionary psychology. Rangifer, Special Issue No.14:73-80.

Joly, K., B. W. Dale, W. B. Collins, and L. G. Adams. 2002. Evaluating the impacts of wildland fires on caribou in Interior Alaska. Arctic Research of the United States 16:63-67.

Lenart, E. A., T. R. Bowyer, J. Ver Hoef, and R. W. Ruess 2002. Climate change and caribou: effects of summer weather on forage. Canadian Journal of Zoology 80:664-678.

Lawler, J. P., A. J. Magoun, C. T. Seaton, C. L. Gardner, R. D. Boertje, J. M Ver Hoef, and P. A. Del Vecchio. 2005. Short-term impacts of military overflights on caribou during calving season. Journal of Wildlife Management 69:1133-1146.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Fairbanks, Alaska.

Magoun, A. J., J. P. Lawler, C. L. Gardner, R. D. Boertje, and J. M. Ver Hoef. 2003. Short-term impacts of military jet overflights on the Fortymile Caribou Herd during the calving season. Alaska Department of Fish and Game, Fairbanks, Alaska.

Murie, O. J. 1935. Alaska-Yukon caribou. U.S. Department of Agriculture, North American Fauna No. 54.

National Park Service (NPS). 2008. Chisana caribou herd stable, slightly growing in 2007. Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). 2011. Unpublished data. Snow on ground at Eagle, AK. Received from Pam Sousanes 13 January 2011.

Skoog, R. O. 1956. Range, movements, population, and food habits of the Steese-Fortymile Caribou Herd. Thesis. University of Alaska, Fairbanks, Alaska.

Skoog, R. O. 1964. Caribou report, 1963. Federal Aid in Wildlife Restoration Progress Report Project W-6-R-5. Alaska Department of Fish and Game, Juneau, Alaska.

Skoog, R. O. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Dissertation. University of California, Berkeley, California.

Valkenburg, P., D. Kelleyhouse, J. Davis, and J. Ver Hoef. 1994. Case history of the Fortymile caribou herd, 1920-1990. Rangifer 14(1):11-22.

Valkenburg, P., J. L. Davis, J. M. Ver Hoef, R. D. Boertje, M. E. McNay, R. M. Eagan, D. J. Reed, C. L. Gardner, and R. W. Tobey. 1996. Population decline in the Delta Caribou Herd with reference to other Alaskan herds. Rangifer Special Issue 9:53-62.

White, R. G., B. R. Thompson, T. Skogland, S. J. Pearson, D. E. Russell, D. F. Holleman and J. R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. *In* Ecological investigations of the tundra biome in the Prudhoe Bay Region, Alaska. J. Brown (ed.). Biological Papers of the University of Alaska, Fairbanks, Alaska.

4.6 Dall’s Sheep/Fannin Sheep

Description

Dall’s sheep (*Ovis dalli*) are considered one of the six keystone large mammal species of Interior Alaska and are specifically included in the YUCH enabling legislation (Photo 15). Since Dall’s sheep live at high altitudes and have very specific habitat needs, changes in sheep population and distribution are considered to be indicative of changes in climate and vegetation. Because of this, CAKN has chosen Dall’s sheep as a Vital Sign for their monitoring program (MacCluskie and Oakley 2005).

Photo 15. Dall’s sheep in YUCH (NPS photo by C. Stapler).

There are two distinct Dall’s sheep populations within the YUCH preserve. The most studied population can be found in the southwestern mountains, along the Charley and Seventymile Rivers and upper Woodchopper Creek. There is also a smaller population in the Ogilvie Mountains in the northeastern part of the preserve. Some members of the Ogilvie Mountains population exhibit a darker coloration and are sometimes referred to as “fannin” sheep. The fannin phase is “a color cline between the all white Dall sheep of Alaska and the northern Yukon and the grey-brown Stone sheep of the southern Yukon and northern British Columbia” (Ulvi 1984, p. 2). According to Ulvi (1984, p. 3), “it seems that more than 50% of the sheep exhibit some coloration ranging from black tails or a few grey hairs to striking dark grey-brown body coloration sometimes extending to the face… Less than 50% of the ewes show some coloration but they tend to be lighter and not as extensively colored as the rams.” The Ogilvie Mountains sheep population was surveyed twice in the early 1980s and again in 1991. The terrain of the region makes surveying relatively expensive and hazardous for staff (NPS 1991). At that time the Ogilvie population was determined to be “not presently of management concern” and, given the difficulty of surveying the area, it was recommended “that surveys in the Ogilvie unit be discontinued entirely unless changing circumstances dictate more frequent surveys” (NPS 1991, p. 4). These sheep appear to be part of a larger Canadian population in the Tatonduk River region near the border that is regularly surveyed by the Canadian government (NPS 1991).

The southern population in the Charley River area has been surveyed regularly since the early 1980s. Studies have found that these sheep move extensively between suitable habitat areas with no discernible patterns. “While some general movement of sheep from mountains to bluffs along the Charley River occurred during late April and May, movements were not ubiquitous or predictable. Sheep moved back and forth between mountains and river bluffs throughout the year and this was true for sheep of all sex and age classes studied” (Burch and Lawler 2001, p. 1).

Movement to the river bluffs in early summer may be attributed to the earlier "green up" of vegetation there. Researchers also did not find any areas of concentrated seasonal use, such as lambing or rutting grounds. Lambing and rutting have been observed in nearly all suitable habitat areas in the preserve. The average home range of Dall's sheep in the Charley River drainage is estimated at 157 km^2 (127 km^2 for ewes and 339 km^2 for young rams) (Burch and Lawler 2001).

There has been some concern about the impacts of military overflights on the Dall's sheep population at YUCH. Up to 50,000 military overflights take place above YUCH each year, with jets allowed to fly as low as 30 m (100 ft) above the ground. However, a study of the effects of overflights during 2000-2001 found no evidence that military overflights (at current levels) were negatively impacting sheep within the preserve (Lawler et al 2004). It is possible that after 20 years of exposure to overflights, the sheep have become acclimated to the disturbance.

Measures

- Population size estimates (plus confidence intervals)
- Composition (lamb:ewe, ram:ewe ratios)
- Nutritional state (body condition)
- Harvest rates

Reference Conditions/Values

The reference condition for Dall's sheep is within the range of natural variability; early summer estimates from census data starts in the early 1980s, with results comparable from 1997 on.

Data and Methods

Survey reports and additional literature were provided by NPS staff. The ADF&G Dall's sheep management report was obtained from their website.

Current Condition and Trend

<u>Population Size Estimates</u>

Aerial surveys of the YUCH Dall's sheep population have taken place since the early 1980s, but it was not until the late 1990s that all areas of suitable sheep habitat within the Charley River drainage were flown during every survey. Due to the frequent movement of sheep between survey units, this is considered essential to obtaining an accurate picture of the population's status (Burch 2010). Therefore any surveys prior to 1997 are not directly comparable to more recent surveys. The Ogilvie Mountains sheep population is not included in these regular surveys.

Photo 16. Capturing and radio collaring Dall's sheep in YUCH (Burch and Lawler 2001).

During the most recent aerial survey in 2009, 333 Dall's sheep were observed (Plate 14). This is slightly higher than the average of 313 sheep observed for the six comparable surveys dating back to 1997. With the incorporation of a sightability correction factor, the 2009 sheep population was estimated at 366 sheep. This also is slightly higher than earlier estimates. According to a study that incorporated survey reports from 1997-2002 (with the exclusion of one year, 1998, when survey effort was significantly lower, which skewed sightability and resulted in an unlikely population estimate over 500), the average population during that time was estimated at 360 (± 11.0) individuals (Lawler et al. 2004). These results suggest that the population is stable with good lamb survival and yearling recruitment (Burch 2010). This conclusion is further supported by an observation from the mid-1970s that "the best estimate of Dall's sheep population in the Yukon-Charley region is about 350 animals" (Clough 1976).

<u>Composition (lamb:ewe, ram:ewe ratios)</u>

During the 2009 survey, the estimated age and sex ratios of the population were 48 lambs:100 ewes and 44 rams:100 ewes (Figure 30). The number of lambs is slightly higher than the average of 46 lambs:100 ewes from the previous six surveys. The number of rams is below the average from previous surveys of 51 rams:100 ewes. The ram:ewe ratio has been more variable than the lamb:ewe ratio over time, perhaps due to movement in and out of the study areas or changes in human harvest (Burch 2010). Since rams generally have larger home ranges than ewes, they may even leave the preserve for periods of time.

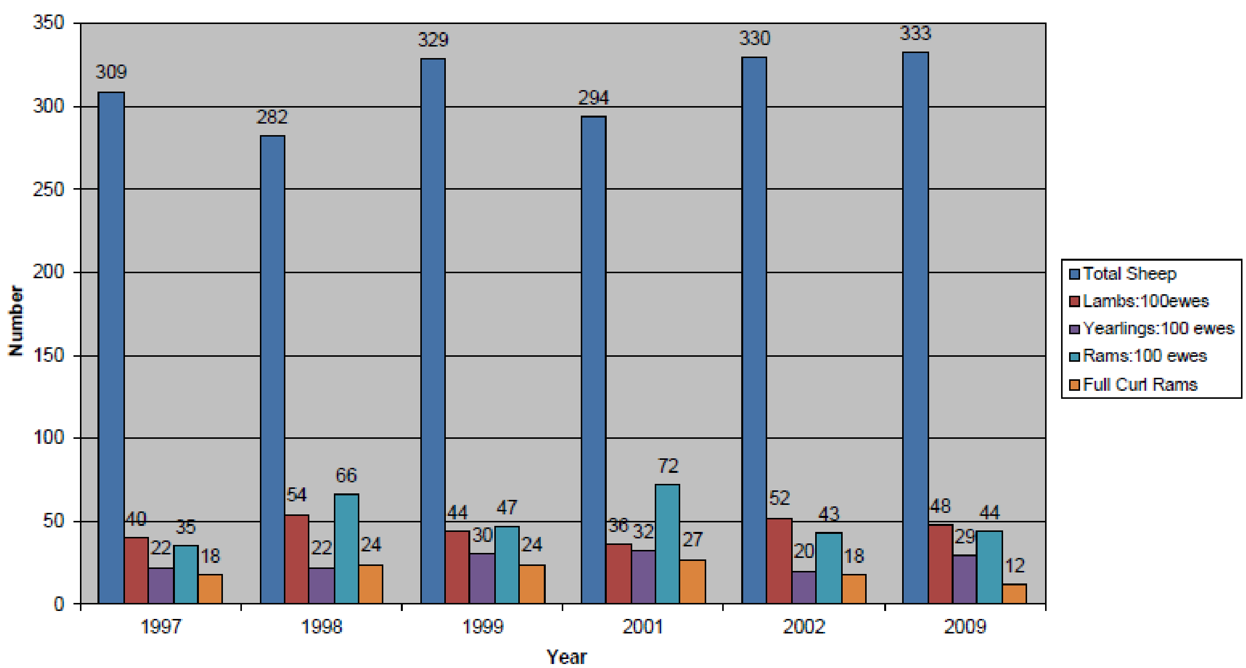


Figure 30. Total sheep observed, age and sex ratios, and full curl ram numbers in YUCH aerial surveys over time (Burch 2010).

<u>Nutritional State (body condition)</u>

Lawler et al. (2004) found that the probability of survival in ewes increases as their body weight increases (Figure 31). The average body weight of ewes captured in the spring for radio collaring in YUCH between 1997 and 2002 was 53.8 kg (Burch and Lawler 2001, Lawler et al. 2004).

This is higher than averages from similar studies of Dall's sheep ewes in the Alaska Range (47.2 kg, Heimer 1972) and in the Central Brooks Range (50.0 kg, Lawler 2004) but lower than the average in the Upper Salcha River area just west of YUCH (57.8 kg, Lawler et al. 2004).

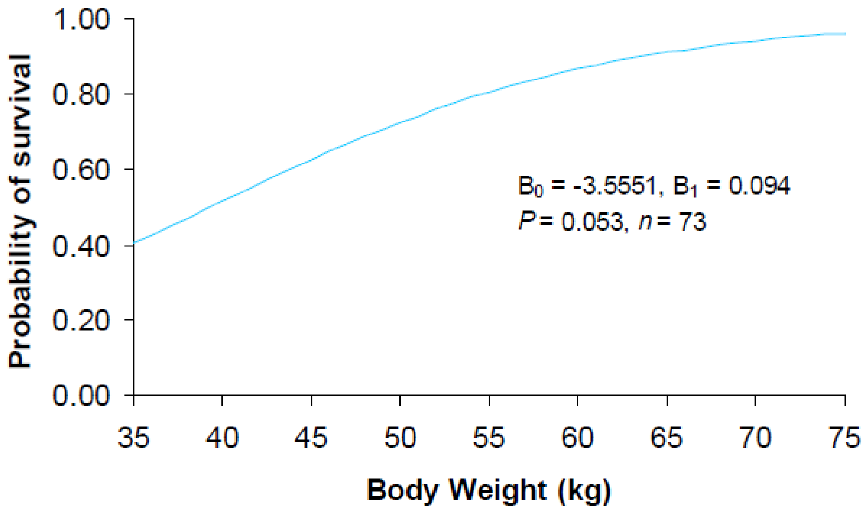


Figure 31. The relationship between the probability of survival and body weight for adult ewes captured in the Yukon-Tanana Uplands. Reproduced from Lawler et al. (2004).

<u>Harvest Rates</u>

An average of four Dall's sheep have been harvested each year within YUCH over the last 25 years, although numbers have varied greatly over time. Harvest numbers were low throughout the 1980s and early 1990s with no sheep taken from 1988 to 1990. In 1993, a restriction of 4 drawing permits per year was removed and sheep were subject to an open hunt. The season runs from mid-August to mid-September with a bag limit of one full curl ram (ADF&G 2008). Since 1995, the average harvest has risen to 6.6 rams a year. Harvest numbers over the last decade have been up and down, reaching a high of 11 in 2005 and falling to a low of three during 2006 and 2007, the most recent years for which data was available (Figure 32, Burch 2010). Hunter effort increased dramatically with the 1993 regulations change. From 1983 to 1994, hunter effort averaged just 15.6 hunter days per year. Between 1995 and 1999, hunter effort rose to an average of 71.8 hunter days per year (Burch and Lawler 2001). The sheep population appears to have remained stable despite this increase in hunting, although the number of full curl rams has seemingly declined.

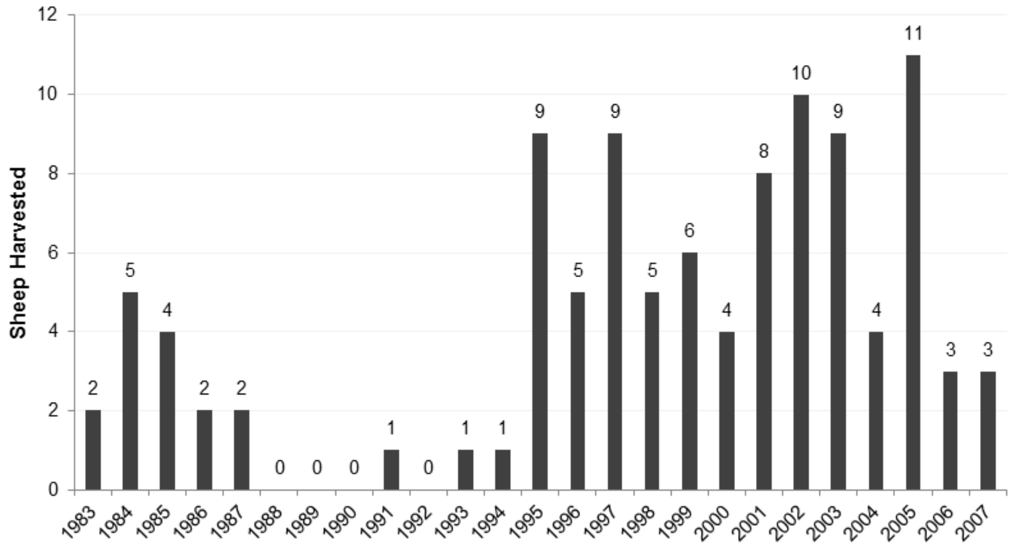


Figure 32. Number of sheep harvested from Yukon-Charley National Preserve, Alaska, 1983-2007. Reproduced from Burch (2010).

<u>Threats and Stressor Factors</u>

Forage Quality and Availability

Fecal pellet analysis by Lawler et al. (2004) showed that the composition of Dall’s sheep diets changes throughout the year (Figure 33). In late winter, sheep consume nearly equal amounts of sedges/rushes, grasses, and moss. During the summer, the majority of their diet is sedges/rushes. Forbs and shrubs comprise a minor portion of the Dall’s sheep’s diet throughout the year, but increases slightly in spring when new leaves and shoots emerge. The nitrogen content of fecal pellets also fluctuated with the seasons, suggesting that forage nutrient quality varies throughout the year. Percent nitrogen was higher in the summer (2.6%) than in late winter (1.7%) or spring (1.4%) (Lawler et al. 2004).

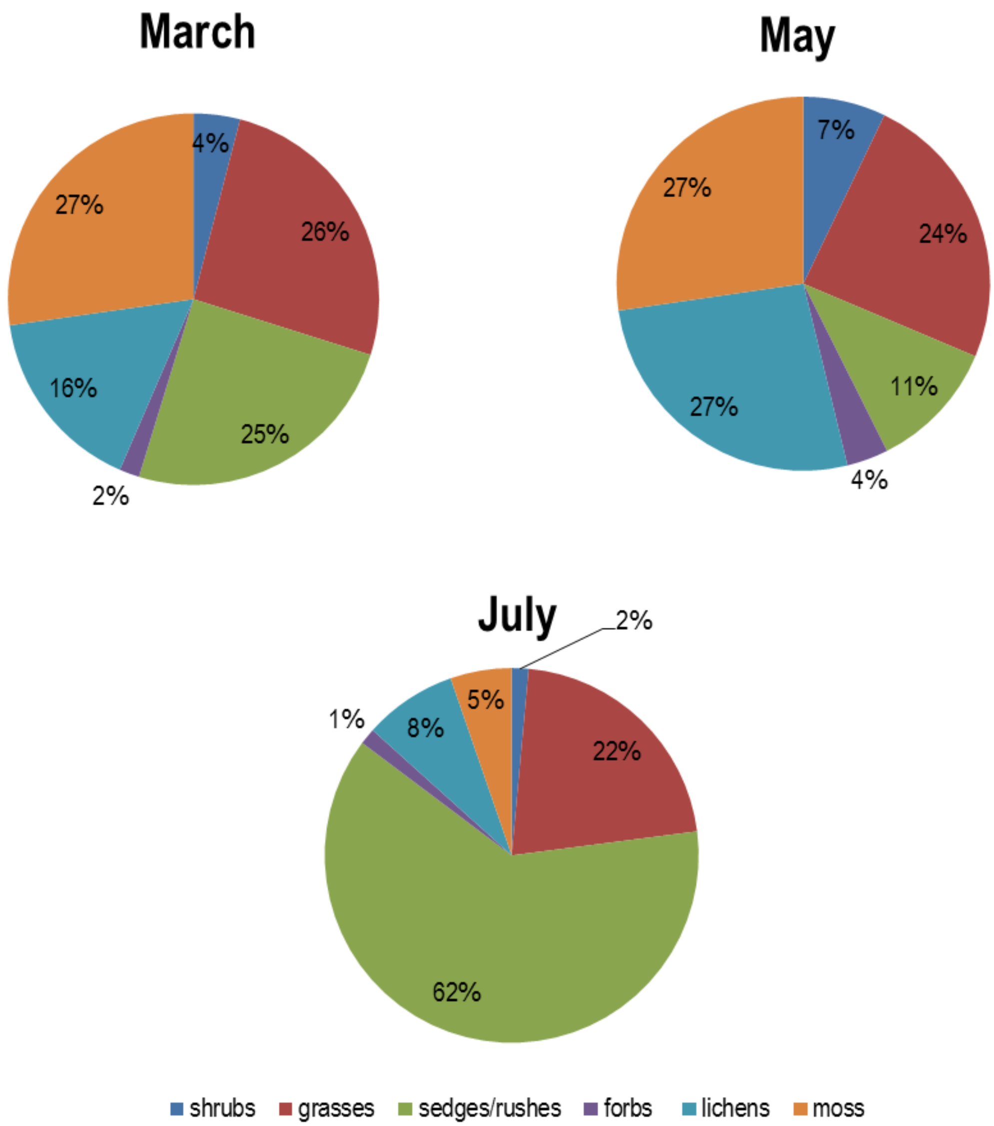


Figure 33. Dall's sheep fecal pellet composition by vegetation type during late winter (March), spring (May), and summer (July) in the Cirque Lakes area of YUCH, 2000-2001 (Lawler et al. 2004).

Studies have shown that changes in irradiance, temperature, and precipitation affect nutrient concentrations, anti-herbivore defenses of plants, and forage availability (Lenart et al. 2002). Therefore wildlife managers are concerned that climate change may affect sheep forage quality and availability and, in turn, the overall health of YUCH's Dall's sheep population.

Snow Depth/Ice Coverage

Snow depth and ice coverage likely affect Dall's sheep by reducing forage availability and increasing their vulnerability to predators. According to the ADF&G, "it seems probable that winter range availability may limit population growth. Inconsistent winter winds and snowpacks combine to produce variable winter foraging conditions" (ADF&G 2008, p. 141).

Evidence from the 1997-2000 study of the YUCH sheep population suggests that adverse weather currently has more of an influence on the preserve's sheep than predation, harvest, or human disturbance (Burch and Lawler 2001). After the above average snowfall and icy conditions during the winter of 1999-2000, the pregnancy rate among YUCH ewes dropped from an average of 88% in the three previous years to just 44% in 2000. Lamb survival and production were also lower during and after the winter of 1999-2000.

Sport Harvest
In a 2001 report, Burch and Lawler stated that harvest levels at that time were "consistent with managing a healthy sheep population". However, they noted that if average annual harvest increased to 12 rams or if the average number of full curl rams in the population drops to 15 or fewer, "harvest regulations should be re-evaluated" (Burch and Lawler 2001, p. 46). While current harvest levels are still within the recommended range, the number of full curl rams appears to have slipped below the benchmark. Only 12 full curl rams were observed in 2009, down from 18 in 2002 and 27 in 2001 (Figure 30, Burch 2010). The low number of full curl rams in the 2009 survey could be attributed to the movement of rams outside the study areas. Yet if the decrease persists, further study and a reconsideration of hunting regulations may be required.

Disease
No research has been conducted on the presence of disease within the YUCH sheep population. During the 2009 aerial survey, one dead ewe was discovered and a necropsy determined it had died of Contagious Hoof Disease. No other sick or dead sheep were reported that year.

Predation
During the 1997-2000 study of the YUCH sheep population, 12 of the 18 sheep that died were likely killed by predators. Wolf tracks were found at one kill site and bear tracks at another, while the predator was unidentifiable at four of the sites. At the remaining six kill sites, all adult ewes, the only animal signs were from wolverines (*Gulo gulo*). This evidence led researchers to conclude that wolverines were killing adult ewes within the preserve (Burch and Lawler 2001). The close proximity of the wolverine kill sites suggests that one or two individual wolverines may have been responsible for the deaths.

Both sheep and wolf research suggests that wolf predation upon sheep is low within YUCH boundaries. During routine radio-tracking of wolves in YUCH in the late 1990s and early 2000s, 297 wolf kills were located and none of them were sheep (Burch and Lawler 2001). However, wolves can kill and consume a sheep relatively quickly, so some sheep kills likely go undetected.

Insect Harassment
Although no information is currently available on the effects of insect harassment on Dall's sheep, it is likely that the YUCH sheep population's summer movements are influenced by attempts to minimize insect harassment.

<u>Data Needs/Gaps</u>
No research has been conducted on the impacts of disease and insect harassment on the YUCH Dall's sheep population. A better understanding of sheep movements within the preserve and the

reasons behind them would also be useful. These movements are likely related to forage availability and quality, which could be affected by climate change.

<u>Overall Condition</u>

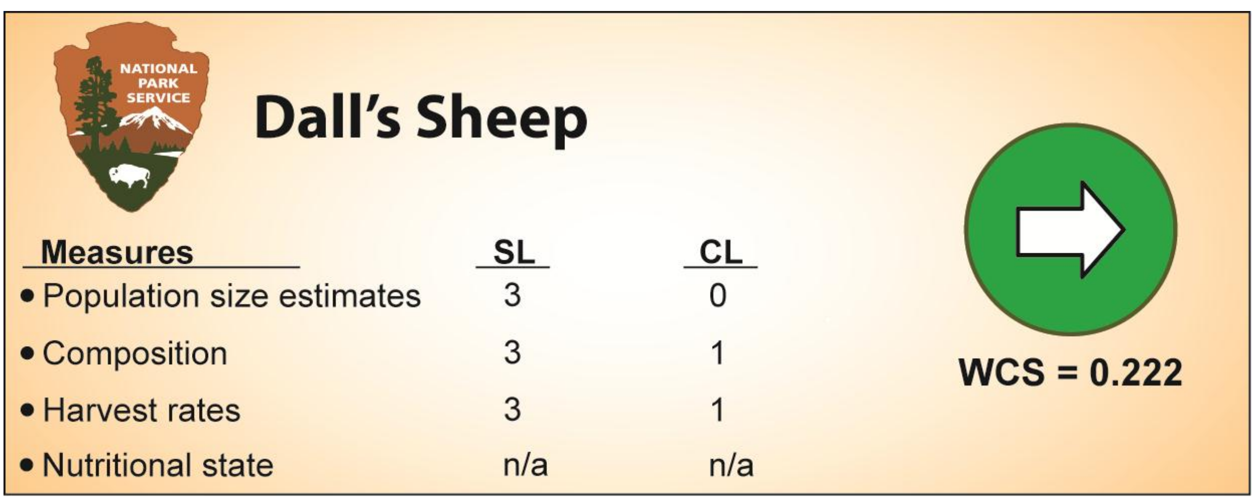
Population Size Estimates
The project team defined the *Significance Level* for population size estimates as a 3. Aerial survey results suggest that the YUCH Dall's sheep population is stable and generally in good condition. Recent population estimates are well within the range of natural variation and therefore are of no concern. With population estimates of no concern, the *Condition Level* is a 0.

Composition
The project team defined the *Significance Level* for composition as a 3. Population composition ratios are also within the range of natural variation, although ewe:ram ratios have fluctuated over time, and overall are of low concern. Because the population composition is of low concern, the *Condition Level* is a 1.

Harvest Rates
The project team defined the *Significance Level* for harvest rates as a 3. Harvest rates are relatively low and therefore also of low concern (*Condition Level* = 1), although the number of full curl rams should be watched closely to determine if their numbers are declining.

Nutritional State
Since little information is available regarding the nutritional state of Dall's sheep in YUCH, this measure was not assigned a *Significance* or *Condition Level* and was not incorporated into the scoring process.

Weighted Condition Score
The Weighted Condition Score (WCS) for Dall's sheep is 0.222 indicating the overall condition is of low concern.



Source of Expertise
John Burch, YUGA Wildlife Biologist, CAKN

Literature Cited

Alaska Department of Fish and Game (ADF&G). 2008. Dall's sheep management report of survey-inventory activities, 1 July 2004 – 30 June 2007. P. Harper, editor. Alaska Department of Fish and Game, Juneau, Alaska.

Burch, J. 2010. 2009 Aerial Dall's sheep survey, Yukon-Charley Rivers National Preserve, Alaska: July 2009 survey report. Natural Resource Technical Report NPS/CAKN/NRTR—2010/367. National Park Service, Fort Collins, Colorado.

Burch, J., and J. Lawler. 2001. Ecology and demography of Dall's sheep in Yukon-Charley Rivers National Preserve: identifying critical Dall's sheep habitat and habitat use patterns. Technical Report NPS/AR/NRTR-2001/39. National Park Service, Fort Collins, Colorado.

Clough, G. 1976. Mammals of the Yukon-Charley River area, Alaska. Pages 204-232 *in* The environment of the Yukon-Charley Rivers area Alaska. S. Young, editor. Center for Northern Studies, Wolcott, Vermont.

Heimer, W. 1972. *In* L. Nichols and W. Heimer, editors, sheep report. Federal Aid Annual Research Performance Report: Wildlife Restoration, Vol. 13. Alaska Department of Fish and Game, Juneau, Alaska.

Lawler, J. 2004. Demography and home ranges of Dall's sheep in the Central Brooks Range, Anaktuvuk Pass, Alaska: Gates of the Arctic National Park and Preserve. Technical Report NPS/AR/NRTR-2004-43. National Park Service, Anchorage, Alaska.

Lawler, J., B. Griffith, D. Johnson, and J. Burch. 2004. The effects of military jet overflights on Dall's sheep in interior Alaska: report to the Department of the Air Force. National Park Service, Fort Collins, Colorado.

Lenart, E. A., T. R. Bowyer, J. Ver Hoef, and R. W. Ruess 2002. Climate change and caribou: effects of summer weather on forage. Canadian Journal of Zoology 80:664-678.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). 1991. 1991 Ogilvies unit sheep survey. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Ulvi, S. 1984. Aerial Dall sheep survey, June – August 1984. Research and Resource Management Report Series 84-06. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

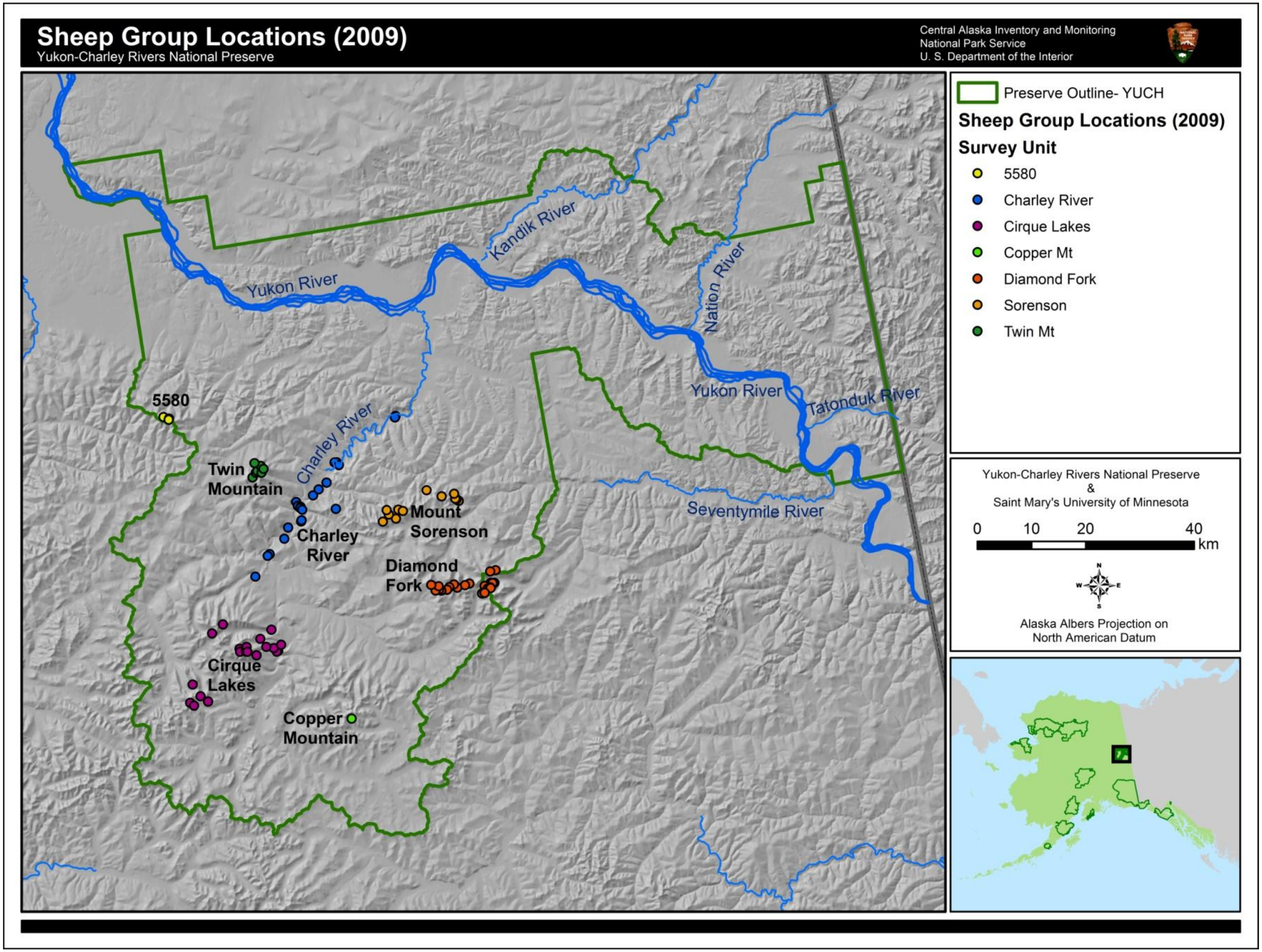


Plate 14. Sheep group locations during the 2009 aerial survey in YUCH (Burch 2010).

4.7 Moose

Description

Moose (*Alces alces*) have been identified as good indicators of long-term habitat change because "they depend on large scale, healthy habitats for food and cover, which in turn are dependent on weather and other habitat patterns across the entire landscape" (Burch 2010, p. 3). They are specifically mentioned in the YUCH enabling legislation and have historically been an important component of local subsistence harvest. Moose may also have a significant impact on vegetation and succession within the preserve. Population surveys of moose at YUCH are part of the larger CAKN Vital Signs monitoring program.

Photo 17. Bull moose at Slaven's Roadhouse in YUCH (NPS photo by C. Stapler).

NPS aerial survey reports have consistently identified the YUCH moose population as a low-density, stable population. The population density is among the lowest reported in interior Alaska and is attributed partly to poor recruitment (Burch 2010). Very little is known about natural mortality within the preserve. Wolf and bear predation is a common cause of death among adults and calves; however, the overall effect of predation on moose population change in YUCH is unknown.

Measures

- Population size estimates
- Composition (calf: cow ratios, bull: cow ratios)
- Harvest Rates

Reference Conditions/Values

The reference condition for moose in the preserve is within the range of natural variability, as determined from aerial surveys dating back to 1994.

Data and Methods

Survey reports and literature were provided by YUCH staff. The ADF&G's 2008 moose management report and additional literature were downloaded from the ADF&G website.

Current Condition and Trend

<u>Population Size Estimates</u>

Since 1987, moose population surveys have been conducted every few years along the Yukon River corridor between Eagle and Circle, Alaska. Although survey units were reconfigured in 2003, the five surveys conducted since 1997 are directly comparable in terms of survey areas and collection methods (Burch 2010). The most recent survey occurred in November of 2009 (Figure 34). Based on the number of moose observed and incorporating a sightability correction factor, the total population of YUCH was estimated at 1,331 moose, a density of 0.166 moose/km^2

($0.429/mi^2$) (Table 26) (Burch 2010). This is an increase from the previous survey conducted in 2006, which resulted in a total population estimate of 726 moose. Wildfires in the past decade and the resulting changes in vegetation may have contributed to this increase, although a direct cause-effect relationship is not clear. The density estimate is nearly twice that observed in earlier surveys but is still one of the lowest in the region. Observers noted an unusually high number of yearling bulls, suggesting a "bumper crop" of calves in 2008 and/or an excellent survival rate among those calves (Burch 2010).

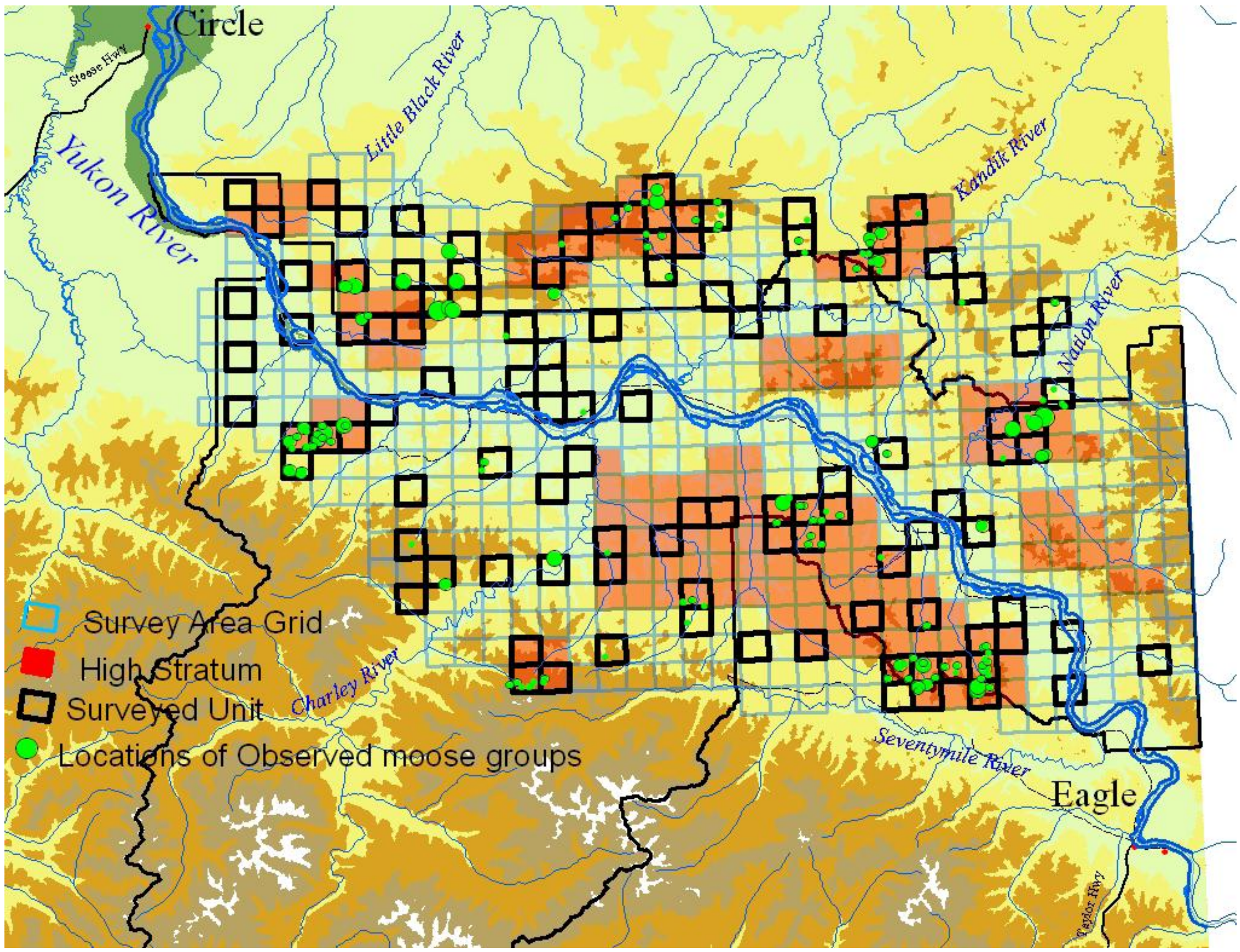


Figure 34. Location of the moose survey area and all survey units (light blue grid). Locations of moose groups observed during the 2009 survey are depicted as green dots. The smallest dots are single moose, largest dots are groups of 6 – 9 moose (the largest seen). Clear units were low stratum and red units were high stratum. Units with heavy black outlines (111 of them) were surveyed in November 2009. Reproduced from Burch (2010).

Table 26. November moose survey data from past years for Yukon-Charley Rivers National Preserve, Alaska. Population estimates for 1987 and 1994 data are not directly comparable to later surveys. Composition ratios are comparable. Reproduced from Burch (2010).

Year	Bull: Cow ratio	Calf: Cow ratio	Yrlbull:Cow ratio [1]	Density moose/ mi^2	Population estimate (90% CI)
1987 [2]	121	10	14	0.62	1116 (no CI)
1994 [2]	84	21	7	0.31	735 (+/- 166)
1997	60	28	8	0.27	737 (+/-148)
1999	51	36	5	0.36	979 (+/-188)
2003 [3]	61	25	6	0.265	835(+/-199)
2006 [3]	73	33	7	0.234	726(+/-139)
2009 [3]	59	26	12	0.429	1331(+/-209)

[1] spike fork bulls only, not corrected

[2] not directly comparable with later surveys

[3] SCF of 1.2 applied to Geo Spatial Estimates. Gassaway estimates have their respective SCF's

The ADF&G collects moose population data in Game Management Units (GMUs). YUCH contains portions of three GMUs: 20E, 25C, and 25B (Plate 3). In addition, there are three GMUs adjacent to YUCH: 20D, 20B, and 25D. Comparing ADF&G data with NPS data builds trends and shows potential overall condition for the moose in YUCH. From regulatory years 2003-2006, densities in southern Unit 20E averaged 0.23 moose/km^2 (0.59 moose/mi^2) (Gross 2008). The last recorded total population estimate in Unit 20D was 1,929, in 2004 (DuBois 2008). No population data have been collected for GMU 25B since 1987.

Composition (calf:cow ratios, bull:cow ratios)

During the 2009 survey, the estimated calf to cow ratio was 26:100 and the bull to cow ratio was 59:100 (Figure 35). These numbers are both slightly down from 2006 when ratios were 33 calves to 100 cows and 73 bulls to 100 cows. However, 2009 ratios are similar to those observed in 2003 and 1997, suggesting estimates are within the range of natural variability for the preserve.

The ADF&G has established a management objective of maintaining a post-hunting ratio of at least 40 bulls to 100 cows for two of the GMUs within the preserve (ADF&G 2008). According to all the data available, this objective is being met.

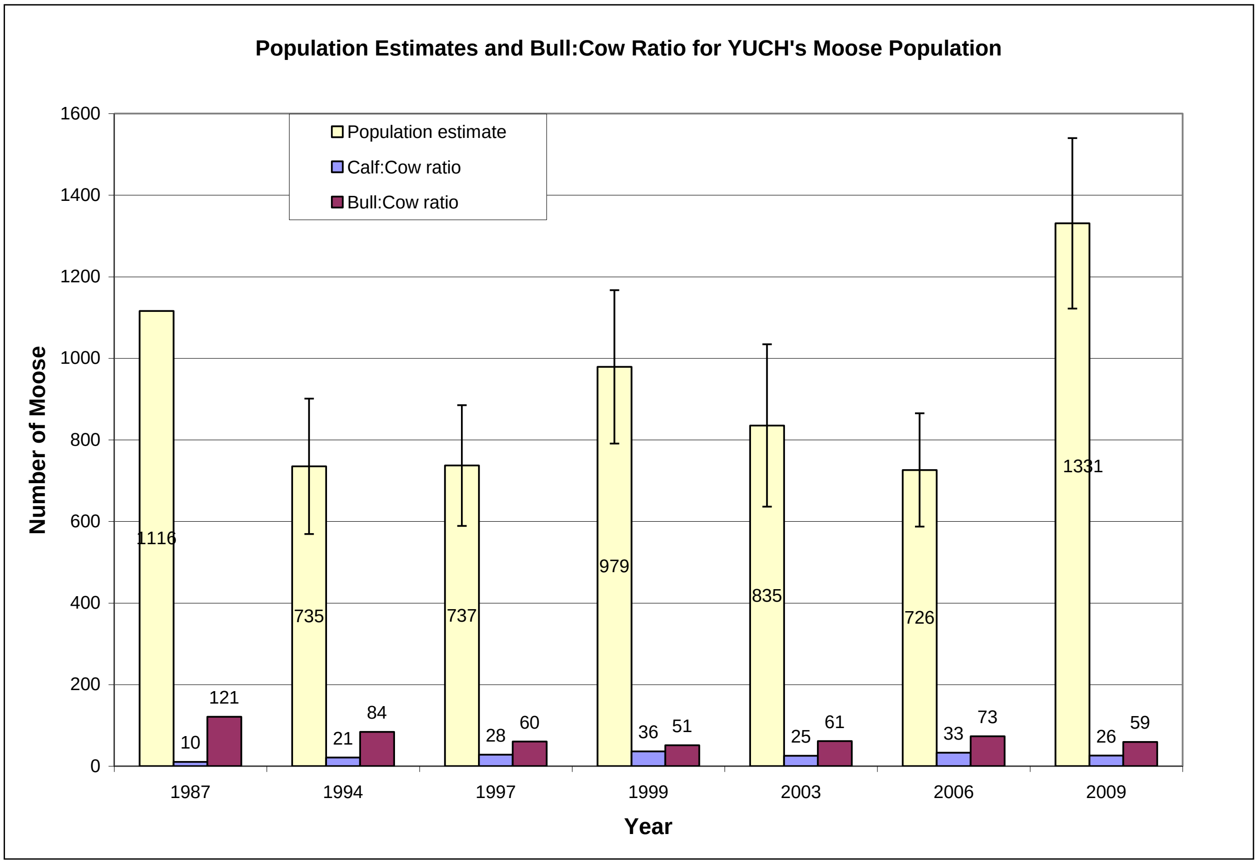


Figure 35. Trends in moose population size, calf:cow ratios and bull:cow ratios 1987 to 2009. A sightability correction factor was applied to all estimates including the 2003 to 2009 Geo Spatial estimates. Reproduced from Burch (2010).

Harvest Rates

Moose harvest data from 1983 to 2007 shows an average harvest of 26 bulls per year within YUCH (Figure 36). During the same 24-year time period, the number of hunters in the preserve averaged 92 a year, each spending an average of 7-8 days per hunt. Over the last ten years alone, harvest has increased slightly to an average of 29.3 bulls per year. The number of hunters has also increased significantly over time (Figure 36). Average hunter success is 30% and has decreased over time, although the change is not significant despite an increase in hunter numbers (Burch 2010).

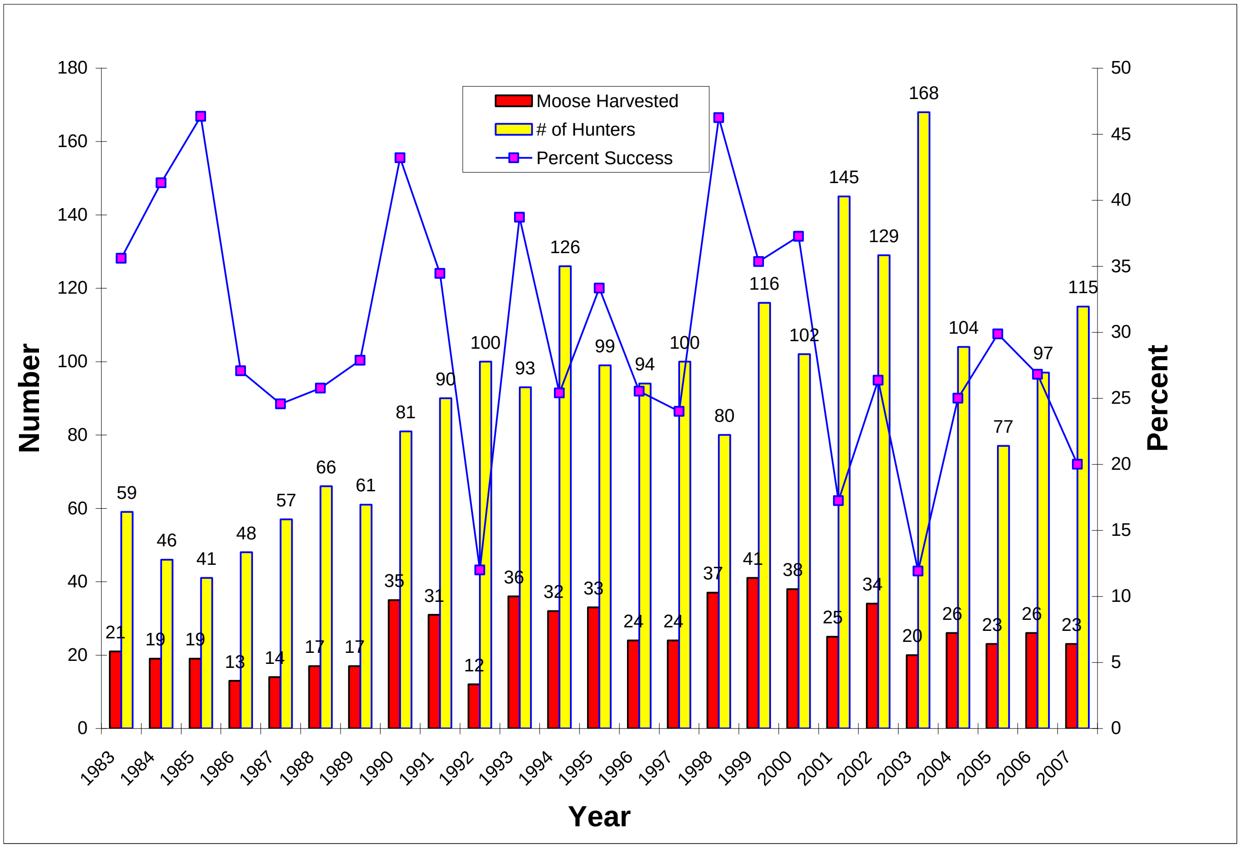


Figure 36. Reported moose harvest, number of hunters, and hunter success in YUCH, 1983- 2007 (data gathered from 2008 ADF&G harvest reports; 2008 & 2009 data were not available). Reproduced from Burch (2010).

<u>Threats and Stressor Factors</u>

Sport and Subsistence Harvest

Pressure on the YUCH moose population from subsistence harvest is influenced by the availability of other game species, particularly caribou. Reductions in the harvest limit for the local Fortymile caribou herd starting in 1996 triggered a proposal from local subsistence hunters for a longer fall moose season and removal of antler size restrictions (Burch 2010). The proposal was accepted and the subsistence hunting season now runs from 20 August to 30 September. Caribou harvest limits began increasing incrementally in 2001, which could gradually reduce pressure on moose populations (Burch 2010).

Local residents have expressed concern about increasing competition from non-local hunters. ADF&G statistics show that from 2003-2006, non-locals made up 61-66% of the total hunters. Local hunters were just 21-25% and took only 15-21% of the overall harvest (ADF&G 2008). If hunter numbers continue to increase or if other game species populations decline, local hunters may request an additional March hunting season (something that was proposed but rejected in 1998) or the harvest of cows. According to the 2009 survey report, the preserve's moose population "could be at the maximum sustainable harvest levels right now" (Burch 2010, p. 23). It states that any increase in harvest pressure could adversely affect the YUCH moose population

(Burch 2010). ADF&G (2008) also lists an increasing number of hunters as their primary management concern in the GMU containing a majority of the preserve.

Forage Availability and Nutritional Quality

According to ADF&G, the availability of browse in the GMU that contains most of YUCH did not seem to be limiting moose population growth (Gross 2008). Other studies from interior Alaska also suggest that forage availability and quality are only minor limiting factors in low-density populations (Gasaway et al. 1983, Gasaway et al. 1992). However, local conditions within the preserve could vary from conditions in the GMU as a whole, and other parts of the region. Forage availability is likely influenced by disturbance, particularly fire, which is important in regenerating the early successional habitats preferred by moose. The secondary plant compounds produced by plants as a chemical defense against browsing may have an effect on forage quality, but further research is needed to better understand this relationship.

Very little research has been done in the preserve on the relationship between moose population and forage availability or quality. Lawler et al. (2005) conducted a pilot study in YUCH to assess the feasibility of winter forage quality sampling as a component of CAKN's Vital Signs monitoring program. Due to small sample sizes, it is difficult to draw any conclusions from their research. Fecal pellet analysis showed that moose consumed primarily willow species (62-73%) and dwarf birch (20-30%). Aspen made up a much smaller portion of their diet at 5-10%. A comparison with Dall's sheep and caribou fecal pellets showed very little plant species overlap, suggesting there is little competition for food between these three mammal species. Moose pellets also showed that their winter diets consist of over 80% twigs or stems and less than 10% leaves (Lawler et al. 2005).

The pilot study collected vegetation samples from areas of both high and low moose density, as determined by the 2003 aerial survey. Analysis of this vegetation showed no difference in nutritional quality between high and low density sites. However, researchers noticed a difference in willow species distribution between sites. Diamondleaf willow (*Salix planifolia*) was found at only one high density site while feltleaf willow (*S. alaxensis*) was scarce in low density moose areas (Lawler et al. 2005). Further research would be needed to determine if the moose population's preferred browse species differs between areas of the preserve, and if tracking willow presence and abundance could be used to monitor available moose habitat.

Snow Depth

No research has been conducted in the preserve on the impact snow depth has on the moose population. Snow depth likely has a significant effect on forage availability and moose movements. Deeper snows could also make moose more vulnerable to predation (Adams et al. 2006).

Research conducted by Gasaway et al. (1983) indicated that snow depth was a key factor in the moose population decline seen across interior Alaska in the late 1960s and early 1970s. Based on age structure data, they determined that calf survival decreased significantly during years that snow depth was well above average. However, a later study conducted just south of YUCH in the Fortymile River basin found that snow depth was a "minor limiting factor when moose were at low densities" (Gasaway et al. 1992, p. 32).

Data Needs/Gaps

The need for a study of moose movements in and adjacent to YUCH has been noted in every survey report since 1994. Studies of other moose populations have shown "significant movements", some migratory and seasonal in nature (Burch 2010). Population surveys are conducted in November when moose seem to congregate in the hills on either side of the Yukon River. Without information on moose movements, managers cannot be certain these survey results are representative of the population during the August-September hunting season.

With the exception of hunting, factors that affect the population require further study. NPS staff report that wolf predation is not extensive but no research has been conducted within the preserve to support this. For management purposes, it would be helpful to better understand what stressors (predation, harvest, snow depth, forage quality, etc.) are limiting the preserve's low-density moose population.

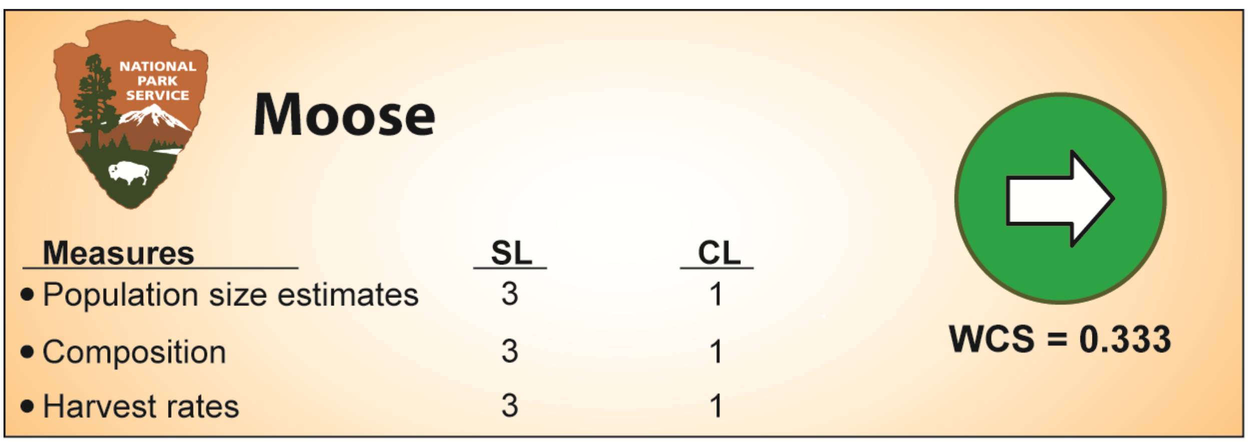
Overall Condition

Population Size Estimates
The project team defined the *Significance Level* for population size estimates as a 3. Survey results suggest that the YUCH moose population is stable and in good condition for a low-density population. However, since little is known about the factors controlling the population, it is difficult to say with any confidence that it is not at risk. Population size is of low concern (*Condition Level = 1)* since recent estimates are within the range of natural variation, with the 2009 survey reporting the highest population in over 20 years.

Composition
The project team defined the *Significance Level* for composition as a 3. Population composition ratios are also within the range of natural variation and are therefore of low concern. The *Condition Level* for low concern is a 1.

Harvest Rates
The project team defined the *Significance Level* for harvest rates as a 3. Harvest rates have remained relatively stable despite an increase in number of hunters and are considered of low concern. The *Condition Level* for harvest rates is a 1.

Weighted Condition Score
The Weighted Condition Score (WCS) for moose in YUCH is 0.333, indicating the condition is of low concern with a stable trend.



Sources of Expertise
John Burch, YUGA Wildlife Biologist, CAKN.

Literature Cited

Adams, L., T. Meier, P. Owen, and G. Roffler. 2006. Interrelationships of Denali's large mammal community. Alaska Park Science 5(1):36-40.

Alaska Department of Fish and Game (ADF&G). 2008. Moose management report of survey-inventory activities 1 July 2005-30 June 2007. P. Harper, editor. Alaska Department of Fish and Game, Juneau, Alaska.

Burch, J. 2010. Annual report on vital signs monitoring of moose (*Alces alces*) distribution and abundance in Yukon-Charley Rivers National Preserve, Central Alaska Network, November 2009 survey report. Natural Resource Technical Report NPS/CAKN/NRTR—2010/331. National Park Service, Fort Collins, Colorado.

DuBois, S. 2008. Unit 20D moose. Pages 386-423 *in* P. Harper, editor. Moose management report of survey and inventory activities 1 July 2005-30 June 2007. Alaska Department of Fish and Game, Juneau, Alaska.

Gross, J. 2008. Unit 20E moose. Pages 424-440 *in* P. Harper, editor. Moose management report of survey and inventory activities 1 July 2005-30 June 2007. Alaska Department of Fish and Game, Juneau, Alaska.

Gasaway, W., R. Stephenson, J. Davis, P. Shepherd, and O. Burris. 1983. Interrelationships of wolves, prey, and man in interior Alaska. Wildlife Monographs No. 84.

Gasaway, W., R. Boertje, D. Grangaard, D. Kelleyhouse, R. Stephenson, and D. Larsen. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildlife Monographs No. 120.

Lawler, J. P., J. W. Burch, and M. MacCluskie. A pilot study for evaluating forage quality and browse utilization in the Central Alaska Network. Unpublished report. National Park Service, Central Alaska Network, Fairbanks, Alaska.

4.8 Wolves

Description

Wolves (*Canis lupus*) are considered one of the six keystone large mammal species in interior Alaska and are important to humans for both consumptive and non-consumptive purposes (Burch 2009). They are also specifically mentioned in the YUCH enabling legislation. Wolves are considered indicators of habitat change in park ecosystems as they rely upon healthy populations of large ungulate prey (primarily moose and caribou) that respond to changes in vegetation, weather and other habitat patterns (Mech and Peterson 2003, Fuller et al. 2003 as cited in Burch 2009). The Central Alaska Network (CAKN) has therefore selected wolves as a Vital Sign and conducts a monitoring program to track changes in their distribution and abundance.

Photo 18. John Burch with two sedated YUCH wolves (NPS photo, from Burch 2009).

Measures

- Population size
- Population distribution
- Density estimates
- Change in population from October to April
- Dispersal rates
- Mortality rates
- Harvest rates

Reference Conditions/Values

The reference condition for YUCH wolves is population size and demography remaining within the range observed 1993-2009.

Data and Methods

All YUCH wolf population data were obtained from John Burch's annual reports on Vital Signs monitoring of wolf distribution and abundance in YUCH. The wolf population data for game management units (GMUs) surrounding YUCH were collected from the ADF&G wolf management reports, primarily in the years of 2003, 2006 and 2008. Data used to describe ungulate conditions were found in NPS and ADF&G annual reports on moose and caribou. For data on snow depth and accumulation, Pam Sousanes (NPS) provided snow on ground depth at Eagle, AK, for several previous decades.

Current Condition and Trend

<u>Population Size</u>
Wolf populations depend upon and respond to surrounding prey populations (Fuller et al. 2003). The prey's vulnerability to predation is a major factor determining wolf population size (YUGA, John Burch, Wildlife Biologist, pers. comm., 7 January 2011). Important factors affecting prey vulnerability include prey population size, age and physical condition and nutrition of prey, and depth of snow on the ground (Burch, pers. comm., 2011). The current population of wolves in YUCH is fluctuating due to changes in the accessibility and vulnerability to predation of the Fortymile caribou herd and the local moose population (Burch 2009).

Two different agencies have collected data on the wolves of YUCH. The NPS collects data specifically from wolf packs that utilize land within the boundaries of YUCH, while the ADF&G collects data within GMUs that partly reside within and border YUCH (see Plate 3). ADF&G data are less consistent than the NPS data in terms of years, locations, and methods of data collection. The data collected by GMU may be useful to understanding trends within the boundaries of YUCH and may include data on wolves that have dispersed outside or into the boundaries of YUCH.

NPS Data
Mean pack size is the preferred metric used to indicate how a population of wolves in a given area is fluctuating (Burch, pers. comm., 2011). From 1993 to 1999, fall mean pack size increased from 4.3 to a maximum of 9.1 individuals, with an overall average of 7.1 (Burch 2009). From 2000 to 2004, fall mean pack size ranged from 8.3 to 8.7, with the overall average increasing to 8.5. From 2005 to 2007, fall mean pack size fell, but then rose in 2008 (Figure 37; Burch 2009). The average total population estimate from fall 1993 to fall 2002 was 43 wolves with a range of 31- 60 (Burch 2009, Burch, pers. comm. 2011). Total population is relevant because it is the method of collection primarily used by the ADF&G.

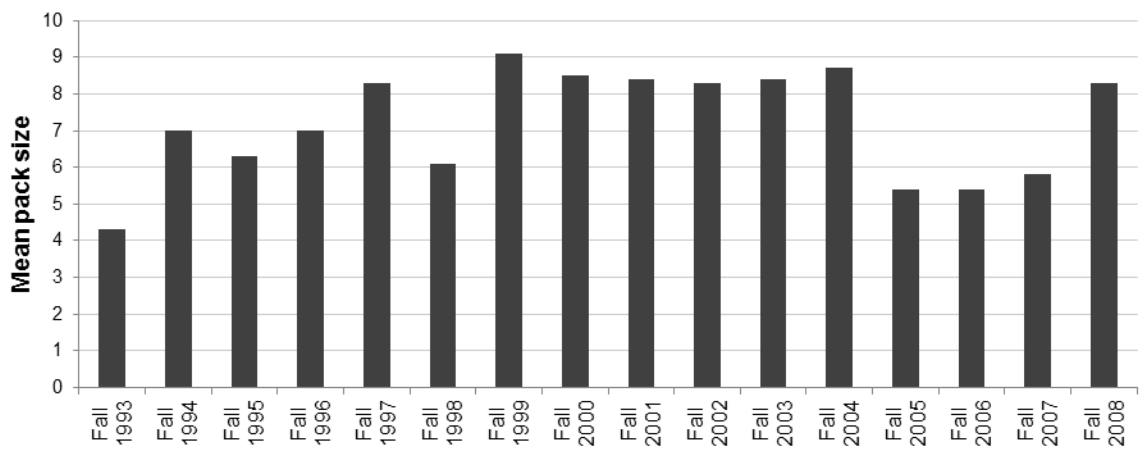


Figure 37. Fall mean pack size from 1993 to 2008 (Burch 2010).

ADF&G Game Management Unit Data
YUCH contains portions of three GMUs: 20E, 25C, and 25B (Plate 3). In addition, there are three GMUs adjacent to YUCH: 20D, 20B, and 25D. Population data from the ADF&G is often

summarized by regulatory year (RY), beginning 1 July and ending 30 June and by GMU (Gardner 2003). For the GMUs within YUCH, 20E has the most data that is comparable with the data from the NPS (Table 27). During February-April 2002, 124-127 wolves in 18 packs ranging from 2-16 wolves, were found in a 11,137 km^2 (4,300 mi^2) area of Units 20E and 12 (Gardner 2003). In RY02, the average wolf pack size in GMU 20E was 6.7 individuals (Gardner 2003). In years where the NPS and ADF&G both collected mean pack size data, the numbers tend to be similar with the exception of three years (1993, 1994, and 1997) (Figure 38). In spring 2008, the ADF&G conducted an aerial survey and estimated the GMU 20E total wolf population at 114 (Nowlin 2009).

Table 27. Unit 20E fall wolf population estimates[a], regulatory years 1990-1991 through 2004-2005[b] Reproduced from Gross (2006).

Regulatory Year	Population Estimate [c]	Number of packs	Mean pack size [d]	Basis of estimate
1990-1991	231	33	6.3	Aerial survey, observations, reports
1991-1992	169-184	31	5.1	Aerial survey, observations, reports, radio collars
1992-1993	194-214	32	5.7	Aerial survey, observations, reports, radio collars
1993-1994	200-224	34	5.7	Aerial survey, observations, reports, radio collars
1994-1995	192-204	34	5.3	Aerial survey, observations, reports, radio collars
1995-1996	227-238	34	6.2	Aerial survey, observations, reports, radio collars
1996-1997	220-230	34	6.0	Aerial survey, observations, reports, radio collars
1997-1998	221-236	34	6.0	Aerial survey, observations, reports, radio collars
1998-1999	195-225	34	5.6	Aerial survey, observations, reports, radio collars
2002-2003	245-260	34	7.4	Aerial survey, observations, reports, radio collars
2003-2004	234-265	24-36	6.6-11.0	Aerial survey, observations, reports, radio collars
2004-2005	252-313	26-42	6.0-12.1	Aerial survey, observations, reports, radio collars

[a] Fall estimate = pre-trapping season population

[b] No unit-wide surveys were conducted during RY99-RY01, therefore no estimates are available.

[c] Includes 10% estimated number of single wolves present.

[d] Calculated using mean population estimate x 0.9 divided by number of packs.

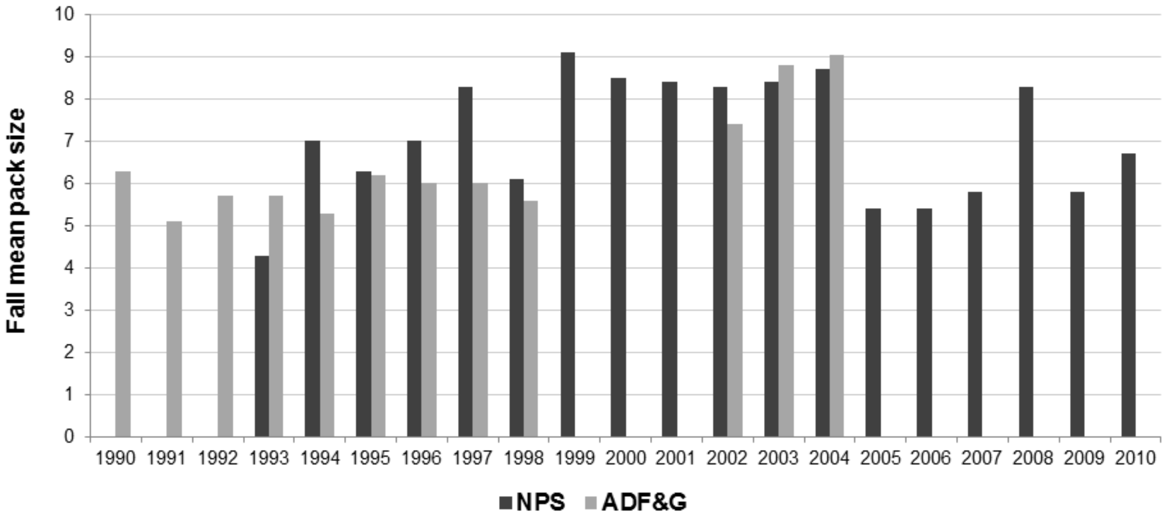


Figure 38. Fall mean wolf pack sizes, comparing YUCH NPS data (Burch 2009, Burch, pers. comm. 2011) with GMU 20E ADF&G data (Gross 2006).

For the GMUs surrounding YUCH, the primary form of data collection is total population estimates. From 2000-2004, estimates indicate that there were 10-20 wolf packs and 75-125 wolves in GMU 25C and the same estimates in 20B (estimate based on extrapolation from the previous year) (Young 2006). For RY02, estimates indicate that there were eight wolf packs and 52-56 wolves in GMU 20D (DuBois 2006). In RY04 the estimate was eight packs and 32-36 wolves (DuBois 2006). In March of 2000, an aerial survey documented 125-133 wolves in a 35,700 km^2 area in the southern part of GMU 25B and the eastern portion of GMU 25D (Stephenson 2003). Mean pack size was 5.3 individuals. In April 2001, an estimated 181-204 wolves were located within a 69,160 km^2 (26,703 mi^2) area within the eastern part of GMU 25D and central part of GMU 25B (Stephenson 2003). The 2001 mean pack size in this area for groups of three or more averaged 4.6.

<u>Population Distribution</u>

NPS Data

In the past, home range size was measured for each radiocollared pack that contained more than 20 locations in a two-year time span (Burch 2009). From 1993-1996, annual minimum wolf pack home ranges in YUCH ranged from 141 to 4,105 km^2 (Demma et al. 1997). Burch (2009) found that home range size was dependent on the sample size of locations when calculated using the Minimum Convex Polygons (MCPs). Even with a large number of known locations such as 300, home range size was still dependent on sample size (Burch 2010). From 1993-2008, range size for packs within YUCH varied from 268 to 7,067 km^2 (Burch 2009). Annual means for packs ranged from 1,639 to 3,253 km^2 with a grand mean of 2,295km^2 (Burch 2009). Figure 39 displays home range data from 1 May 2008- 30 April 2009 for YUCH.

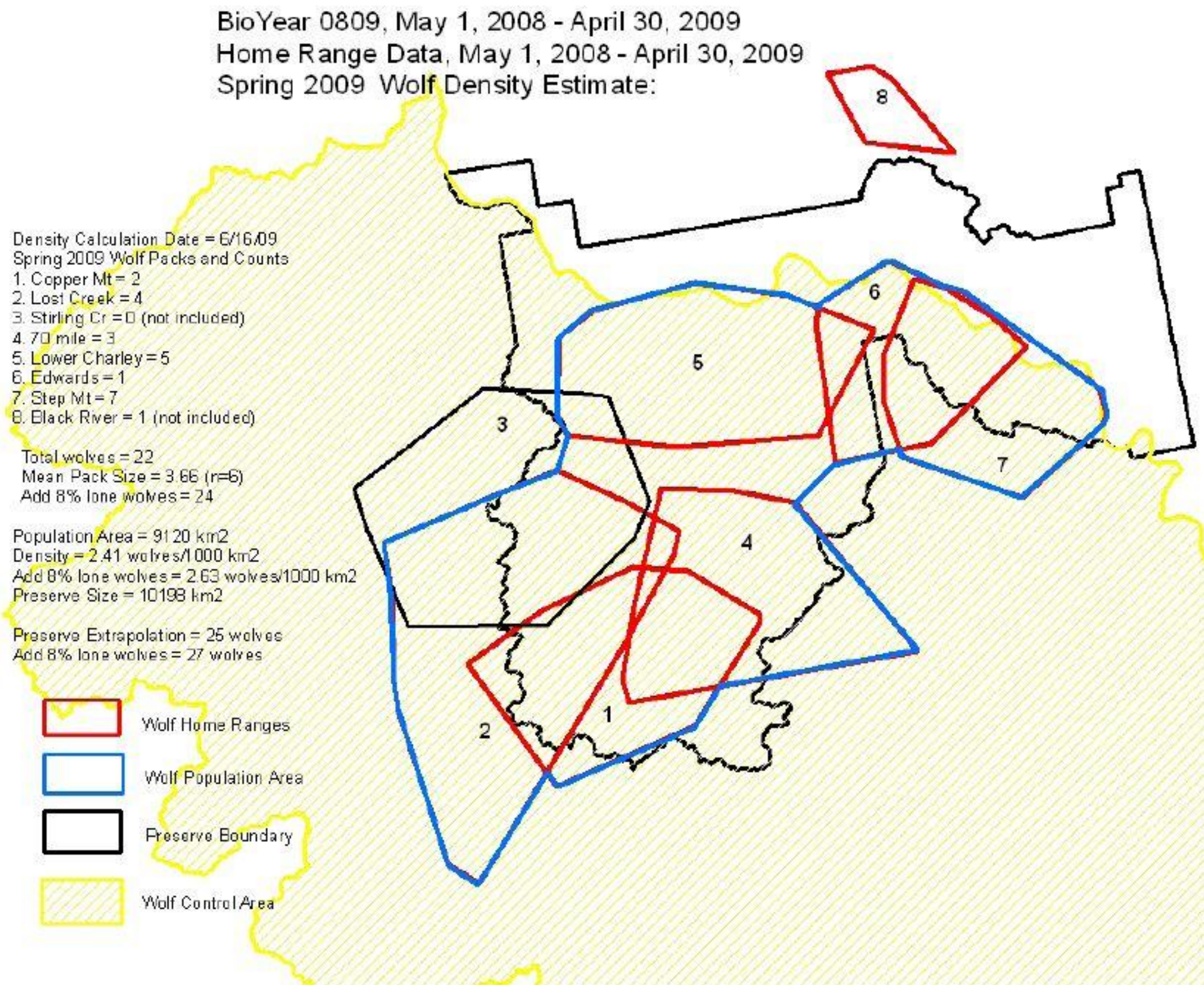


Figure 39. Spring 2009 home range data, pack counts, and density calculation for individual packs in YUCH. Reproduced from Burch (2009).

<u>Density Estimates</u>

NPS Data

Density estimates follow the same trends as mean pack sizes (Burch 2009). Data collection methods make precise density estimates of wolves hard to determine, and even the best estimates of wolf density can be subjective (Burch, pers. comm. 2011). In studies of the Fortymile Caribou Herd (FCH) annual range, autumn densities of 6-8 wolves/1000 km^2 have been reported since 1985 (Boertje and Gardner 2000). From 1993 to 2002, the average density of wolves per 1000 km^2 within YUCH was 4.12 in the fall and 2.76 in the spring (Burch 2002). In spring 2007, the density estimate was the lowest recorded since 1993 at 1.6 wolves/1000 km^2 (Burch 2009). The 2008 spring density estimate was 2.5 wolves/1000 km^2 and in spring 2009 density was estimated at 2.41 wolves/1000 km^2 (Burch 2009). Burch (2009) offers fall wolf population densities from 1993 to 2008 (Figure 40) and spring wolf population densities from 1993 to 2009 (Figure 41).

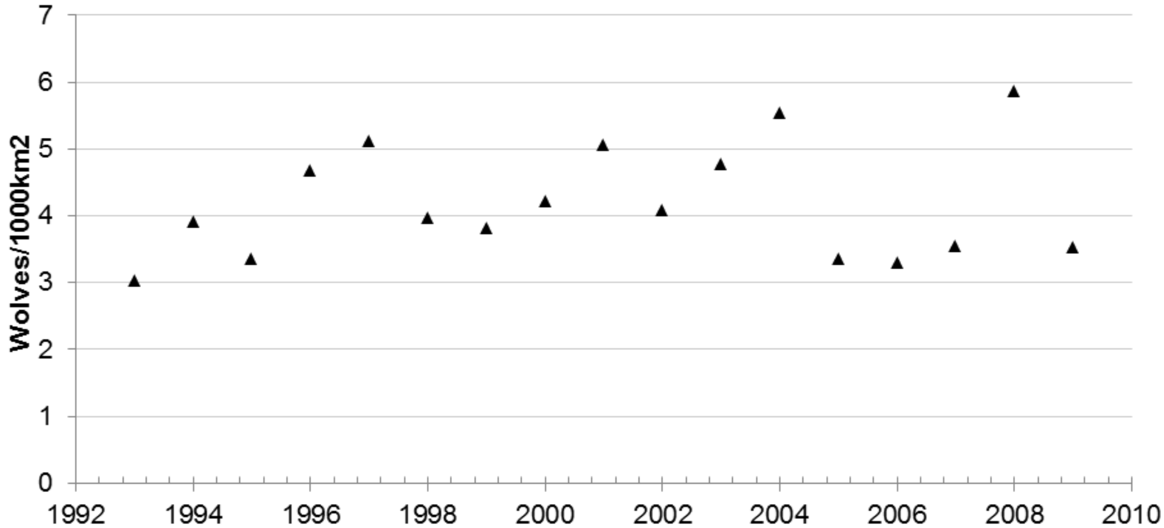


Figure 40. Fall wolf densities (wolves/1000 km^2) in YUCH, 1993-2009 (Burch 2009, Burch, pers. comm. 2011).

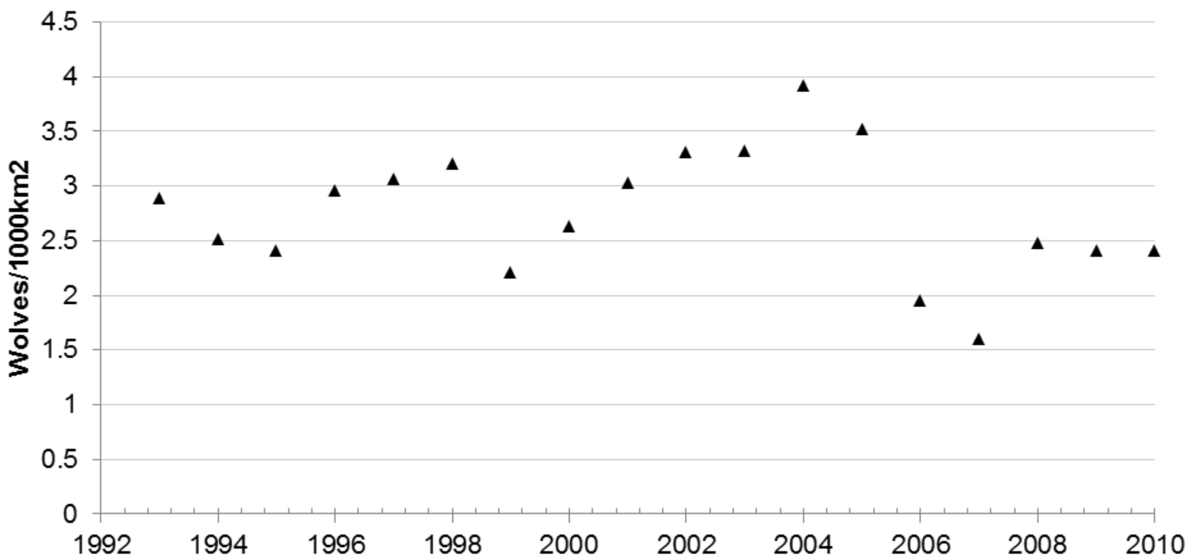


Figure 41. Spring wolf densities (wolves/1000 km^2) in YUCH, 1993-2009 (Burch 2009, Burch, pers. comm. 2011).

ADF&G Game Management Unit Data

From RY00 through RY04, the fall wolf density estimates in GMU 20D ranged from 6.5 to 8.5 wolves/1000 km^2 (DuBois 2006; Appendix 23).

In RY02, the wolf density estimate for GMU 20E was 8.9 wolves/1000 km^2 (Gross 2006). In 2003, the wolf density estimate for GMU 20E, weighted equally for border packs, was 12.1 wolves/1000 km^2. Without equal weight for border packs the estimate was 8.9 wolves/1000 km^2 (Gardner 2003).

Change in Numbers from October to April

Understanding the changes in numbers from fall to spring helps managers to better interpret the collected data. Fuller et al. (2003) reports wolf population numbers typically decrease from the fall into the spring. Mortality and dispersal typically take place during fall and winter, resulting in spring estimates lower than those from the fall (Fuller et al. 2003). While population size estimates are not available for both fall and spring for YUCH, fall and spring density estimates for the preserve are shown in Figure 42 below.

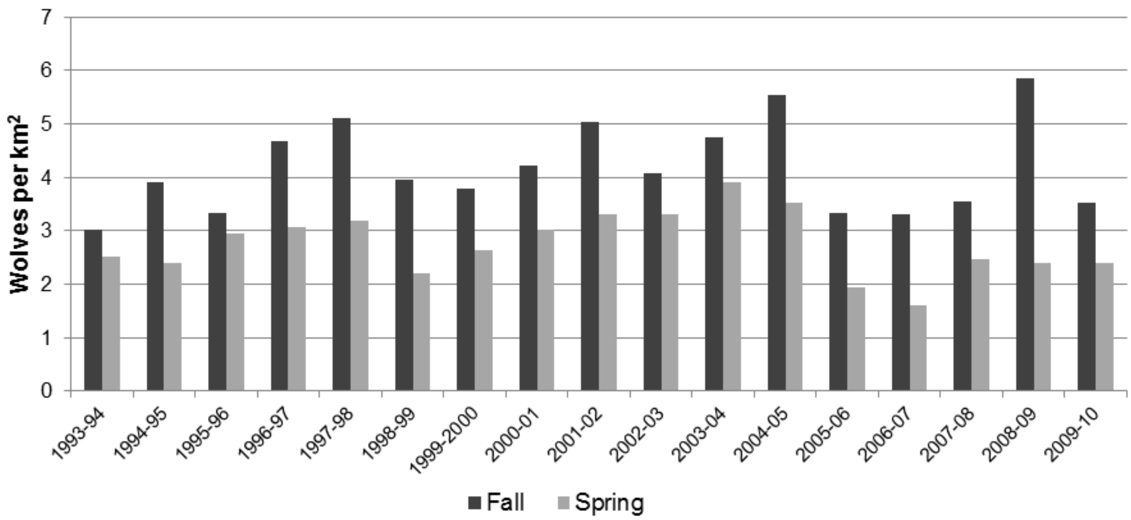


Figure 42. Change in YUCH wolf density estimates from fall to the following spring (Burch 2009, Burch pers. comm. 2011).

Dispersal Rates

Dispersal is a process in which maturing wolves of both sexes leave their natal packs, reproduce, and expand their population's geographic range (Fuller et al. 2003). Wolves are constantly dispersing across Alaska and Canada, possibly forming new pairs or joining an established pack (Burch 2002). Wolves can disperse at any time, but most dispersal has been documented in March-April and November-December (Burch 2002). Fuller et al. (2003) observed annual dispersal rates from 10-40% with most variation due to the irregular dispersal of non-breeding wolves older than one year. Dispersal regulates population size and fluctuates based on pack size, prey vulnerability, and food availability (Messier 1985, Gese and Mech 1991, Mech et al. 1998 as cited in Burch 2002). The average age for dispersal is about 34 months for males and 51.5 months for females (Burch 2002).

In 1996, nine of 29 radio-collared wolves in YUCH were known or assumed to have dispersed (Demma et al. 1997). Then, in 2002, 25 of 91 captured wolves dispersed from the pack they were previously captured in (Burch 2002). Burch (2009) suggests that low snowfall during the winters of 2005-2007 may have resulted in prey becoming less vulnerable, causing an increase in wolf dispersal. In summarizing the fates of 123 radio-collared wolves from 1993-2009, Burch (2009) indicates that 38 wolves (30% of the 123 total wolves) dispersed outside the preserve (Figure 43). These dispersal rates are minimums because the NPS targets the adult breeding wolves for capture and collaring and therefore the collared sample is not representative of the population.

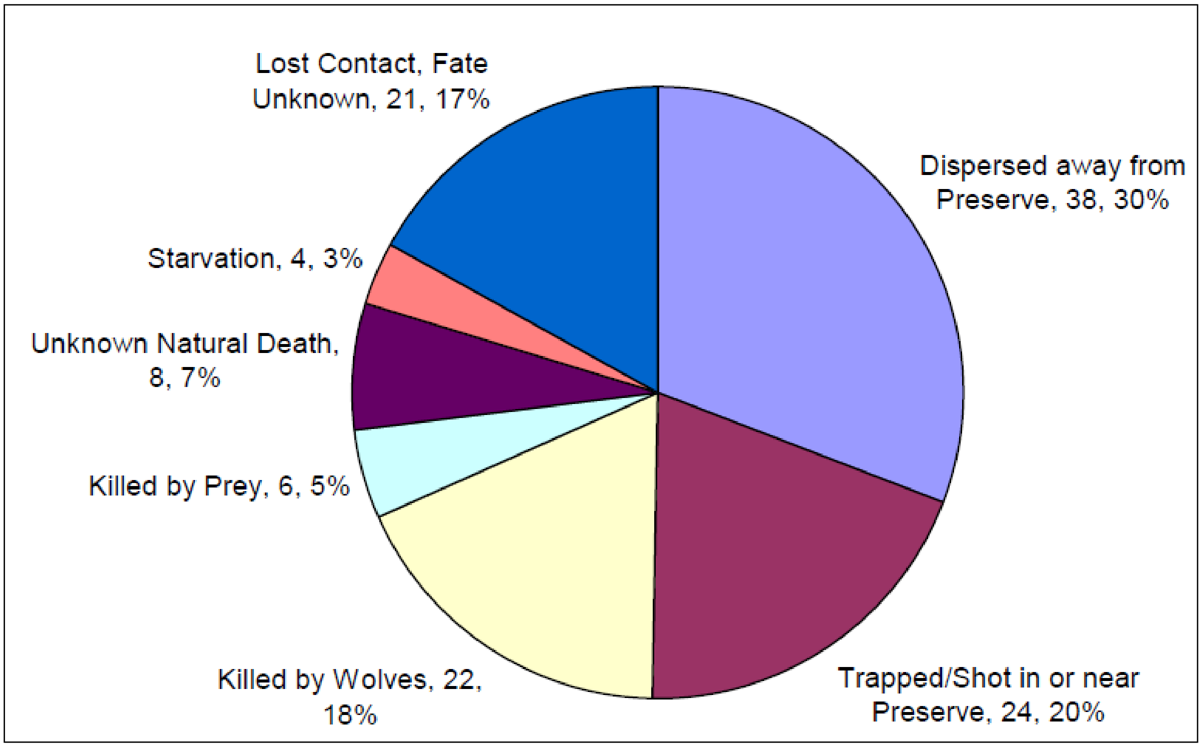


Figure 43. Fates of 123 collared wolves within YUCH from 1993-2009. Reproduced from Burch (2009).

<u>Mortality and Harvest Rates</u>

Causes of natural wolf mortality include starvation, accidents, disease, and intraspecific conflict (Fuller et al. 2003). From March 1993 to September 2002, 24 collared wolves died of natural causes within YUCH. Of the 24 deceased wolves, five were killed by prey, ten were killed by other wolves, two died of starvation, and seven died from undetermined causes (but without human involvement) (Burch 2009). Burch (2009) provides natural mortality causes for the 64 known wolf deaths in YUCH from 1993-2009 (Figure 43). From March 1993 to September 2002, an average of 7.17 wolves were reportedly harvested annually within YUCH (Burch 2009). Burch (2009) presents the number of wolves harvested per year during the winter period from 1984 to 2007 (Figure 44). Appendix 20 presents harvest data by GMU for varying years.

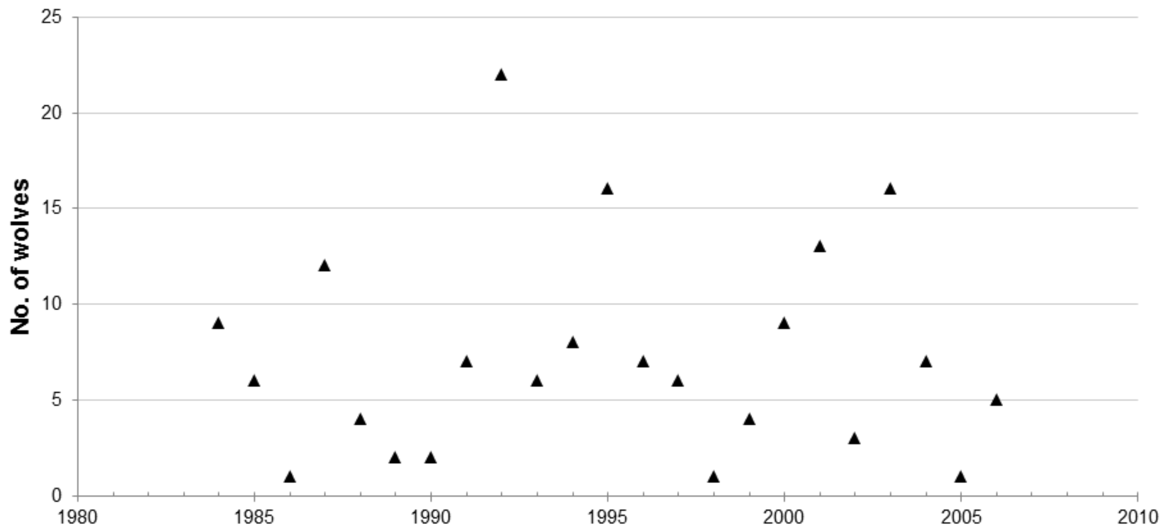


Figure 44. Number of wolves harvested in and around YUCH during the winter period from 1984 to 2007 (Burch 2009).

Threats and Stressor Factors

Predator Control Activities near the Preserve
During the winters of 1997-1998 and 1998-1999, the Alaska Board of Game approved non-lethal treatment to a maximum of seven wolf packs per year in order to manage the FCH (Boertje and Gardner 2000). The packs treated were those that prey on the FCH, but do not use YUCH. The first winter treatment, completed in April 1998, resulted in an 84% reduction in total wolves across seven different packs (Boertje and Gardner 2000). During the second winter, an additional seven packs were treated using 15 sterilizations and 39 relocations, while continuing non-lethal population treatments on the original seven packs (Boertje and Gardner 2000). During the third winter, an additional pack was added to treatment efforts. In total, 15 packs were treated using non-lethal population management techniques from 1997-1999 (Boertje and Gardner 2000).

In the winter of 2004-2005, a predator control program was enacted to increase moose populations and later the growth of the FCH was added as an objective (Titus 2007). Harvest objectives were to remove/kill 197-322 wolves in the fall of 2006 in the Upper Yukon/Tanana control area (refer to Figure 39 for control area in relation to YUCH) (Titus 2007). Conditions were unfavorable for aerial hunting of wolves during the winters of 2006-2007 and 2007-2008 and therefore few wolves were killed outside of YUCH's boundaries (Burch 2009). From 14 March 2009 to 19 March 2009, the ADF&G shot 84 wolves from helicopters throughout the Upper Yukon/Tanana Predator Control Area. No wolves from radio-collared packs from YUCH's wolf study were killed (Burch 2009).

Harvest
Based on ADF&G sealing records, an average of seven wolves were harvested in YUCH each year for the last 20 years, and the harvest has had little impact on the wolf population within the preserve (Burch 2009).

Ungulate Population Change and Nutritional Health

Moose and caribou populations have only shown an increase in GMU 20E when spring wolf densities have been held below 69-85% of initial autumn levels for several years (Boertje and Gardner 2000). In YUCH, the NPS has conducted comparable moose population surveys every few years since 1997 (Burch 2010). Moose densities in YUCH per km^2 were 0.60 in 1997, 0.93 in 1999, 0.69 in 2003, 0.61 in 2006, and 1.11 in 2009 (Burch 2010). YUCH moose densitys are among the lower estimates in the region (Burch 2010). The sex and age composition and population estimates for moose within YUCH are consistent with a low density, stable population (Burch 2010). The moose population in GMU 20A was about 2,500 in 1975 (Titus 2007). A lethal wolf control program was then enacted in 1975 and continued through 1982. The moose population increased to between 10,000 and 11,000 by 1989 (Titus 2007). Gasaway et al. (1983, as cited in Dubois 2006) predicted that moose:wolf ratios greater than 30 would not limit moose population growth. In RY04, the moose:wolf ratio in southern GMU 20D was 151:1, indicating a population size that should not be limited by wolves (DuBois 2006).

Habitat condition and availability in YUCH provide the opportunity for sufficient moose nutrition. Gross (2008) reported that browse availability in GMU 20E was not limiting moose population growth. Also, empirical observation and habitat surveys indicated that the upper Yukon River valley provided excellent habitat conditions for moose in Unit 25B (Caikoski 2008).

The Fortymile Caribou Herd population increased during the 1990s to approximately 40,000 in 2002 (ADF&G 2006). Since then, the population has been estimated at 40,000-45,000 each year (Figure 45) (ADF&G 2006, Burch 2009). In 2010, a photocensus by the ADF&G found and photographed 51,000 caribou in the Fortymile Herd (Gross 2011).

During winters 1991-92, 92-93, 95-96, 96-97, and 99-2000, range conditions for the Fortymile Caribou Herd were excellent, as shown by high proportions of lichen fragments (72-81%) and a low proportion of mosses (8%) in collected fecal samples (Gross 2007). Although fire has destroyed a percentage of the herd’s winter habitat in recent years, a large portion of the historic range remains uninhabited (Gross 2007).

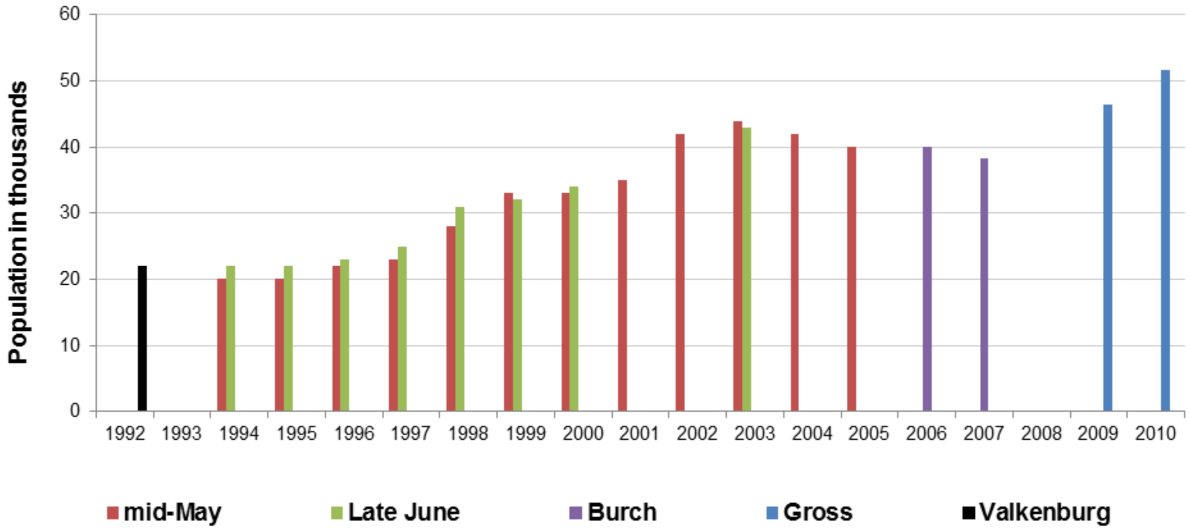


Figure 45. Estimated population of the FCH from 1992 (Valkenburg et al. 1996), 1994 to 2005 (ADF&G 2006), 2006 to 2007 (ADF&G 2010), and 2009 & 2010 (Gross 2011).

Snow Depth/accumulation

NPS (2011) compiled the average end of month snow on the ground depth at Eagle, AK from October through April since 1972 to 2009 (Figure 46). While no studies have been conducted regarding the impact of snow depth on wolves, deeper snows may make large ungulates (e.g., moose, caribou) more vulnerable to predation, which would benefit wolves (Adams et al. 2006).

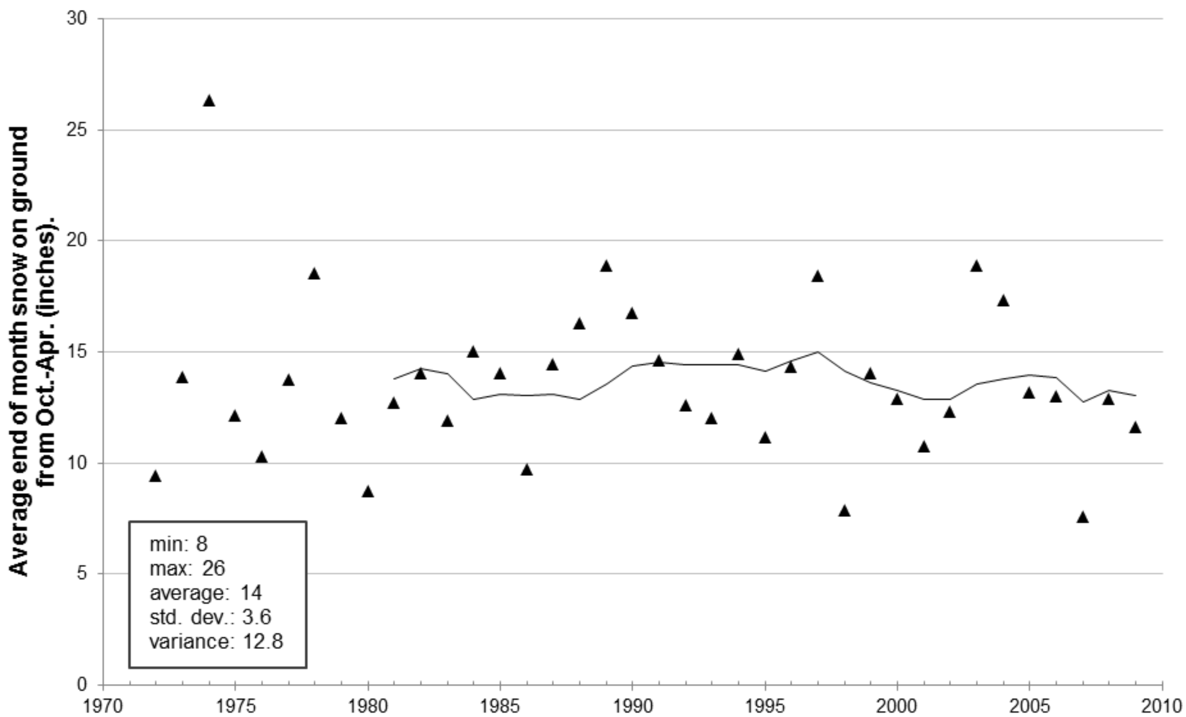


Figure 46. Average depth snow on ground at end of month from October - April for the years 1972-2009 (NPS 2011). Shown with a 10-year moving average line.

Data Needs/Gaps

Comparable wolf population data between the NPS and ADF&G is lacking. ADF&G has several years in which no data were collected. There is also a need for research into the effects of snow depth on wolves, caribou, and moose.

Overall Condition

Population Size

The project team defined the *Significance Level* for wolf population size as a 3. Based on Unit 20E ADF&G and YUCH NPS data, current mean wolf pack size estimates are within the natural range of variability from 1993 to 2009. Total population estimates from both agencies also remain within the natural range of variability. The *Condition Level* for population estimates is 0 because it is of no concern.

Population Distribution

The project team defined the *Significance Level* for population distribution as a 1. Individual pack home range sizes between 1993 and 2008 varied from 268 to 7,067 km^2. Annual means ranged from 1,639 to 3,253 km^2 with an overall mean of 2,295 km^2. The *Condition Level* for population distribution is 0 because current home range sizes are within the previously observed range of values.

Density Estimates
The project team defined the *Significance Level* for density estimates as a 3. From 1993 to 2002, the YUCH average density of wolves per 1000 km^2 was 4.12 in the fall and 2.76 in the spring. Fall densities ranged from 3.02 to 5.86 wolves/1000 km^2 with spring densities from 1.6 to 3.92 wolves/1000 km^2. Current densities reside within this recorded range, resulting in a *Condition Level* of 0 for density estimates.

Fall to Spring Population Change
The project team defined the *Significance Level* for fall to spring population change as a 3. Mortality and dispersal during the fall and winter decrease wolf population numbers from the fall into the spring. YUCH fall and spring mean pack sizes and density estimates all reside within the trend observed over their recorded periods giving a *Condition Level* of 0 for fall to spring population change.

Dispersal Rates
The project team defined the *Significance Level* for dispersal rates as a 1. From 1993 to 2009, 30% of radiocollared YUCH wolves dispersed from the preserve. In 2002, 25 of 91 wolves dispersed from the pack they were previously captured in. Low snowfall in 2002, causing prey to become less vulnerable, is the suggested cause of the dispersal. Dispersal of YUCH wolves is of low concern (*Condition Level* =1*)*.

Mortality Rates
The project team defined the *Significance Level* for mortality rates as a 2. From 1993 to 2009, 33% of radiocollared YUCH wolves were found deceased. Of the deceased wolves, 18% were killed by other wolves. Population numbers have not decreased from mortality rates. The *Condition Level* of mortality rates is 0 because it is of no concern.

Harvest Rates
The project team defined the *Significance Level* for harvest rates as a 2. From 1984 to 2006, a range of 1-22 wolves were harvested each year during the winter periods. Wolf population numbers did not significantly decline after high harvest years. Harvest is not seen as a concern for the wolves of YUCH and has a *Condition Level* of 0.

Weighted Condition Score
The Weighted Condition Score (WCS) for YUCH wolves is 0.042, indicating the component is of low concern.

Wolves

Measures	SL	CL
• Population size	3	0
• Population distribution	1	0
• Density estimates	3	0
• Fall to spring pop. change	3	0
• Dispersal rates	2	1
• Mortality rates	2	0
• Harvest rates	2	0

WCS = 0.042

Sources of Expertise

John Burch, YUGA Wildlife Biologist, CAKN was consulted extensively for this assessment.

Literature Cited

Adams, L. G., T. Meier, P. Owens, and G. H. Roffler. 2006. Interrelationships of Denali's large mammal community. Alaska Park Science 5(1):36-40.

Alaska Department of Fish and Game (ADF&G). 2006. The Fortymile Caribou Herd harvest plan 2006-2012. Online. (http://www.wc.adfg.state.ak.us/management/planning/planning_pdfs/fortymile_harvest_plan.pdf). Accessed 7 December 2010.

Alaska Department of Fish and Game (ADF&G). 2010. The comeback trail. News of the Fortymile Caribou Herd. Alaska Department of Fish and Game, Tok, Alaska.

Boertje, R. D., and C. L. Gardner. 2000. Reducing mortality on the Fortymile Caribou Herd. 1 July 1999-30 June 2000. Federal aid in wildlife restoration performance report, grant W-27-3, study 3.43. Alaska Department of Fish and Game, Juneau, Alaska.

Burch, J. W. 2002. Ecology and demography of wolves in Yukon-Charley Rivers National Preserve, Alaska. NPS Technical Report NPS/AR/NRTR-2001/41. National Park Service, Fort Collins, Colorado.

Burch, J. W. 2009. Annual report on vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Yukon-Charley Rivers National Preserve, Central Alaska Network: 2009 report. Natural Resource Technical Report NPS/CAKN/NRTR—2009/228. National Park Service, Fort Collins, Colorado.

Burch, J. W. 2010. Annual report on vital signs monitoring of moose (*Alces alces*) distribution and abundance in Yukon-Charley Rivers National Preserve, Central Alaska Network, November 2009 survey report. Natural Resource Technical Report NPS/CAKN/NRTR—2010/331. National Park Service, Fort Collins, Colorado.

Caikoski, J. R. 2008. Units 25A, 25B, and 25D moose. Pages 617-647 *in* P. Harper, editor. Moose management report of survey and inventory activities 1 July 2005-30 June 2007. Alaska Department of Fish and Game, Juneau, Alaska.

Demma, N. J., B. W. Dale, L. G. Adams, and K. B. Fox. 1997. Ecology and demography of a low density wolf population in Yukon-Charley Rivers National Preserve, Alaska. NPS Technical Report NPS/AR/NRTR-97/31. National Park Service, Fort Collins, Colorado.

DuBois, S. D. 2006. Unit 20D wolf management report. Pages 166-175 *in* P. Harper, editor. Wolf management report of survey and inventory activities 1 July 2002-30 June 2005. Alaska Department of Fish and Game, Juneau, Alaska.

Fuller, T. K., L. D. Mech, and J. F. Cochrane. 2003. Wolf population dynamics. Pages 161-191 *in* Mech, L. D., and L. Boitani, eds. Wolves: Behavior, ecology, and conservation. University of Chicago Press, Chicago, Illinois.

Gardner, C. L. 2003. Unit 20E wolf management report. Pages 179-194 *in* C. Healy, editor. Wolf management report of survey and inventory activities 1 July 1999-30 2002. Alaska Department of Fish and Game, Juneau, Alaska.

Gasaway, W. C., R. O. Stephenson, J. L. Davis, P. E. K. Shepherd, and O. E. Burris. 1983. Interrelationships of wolves, prey, and man in interior Alaska. Alaska Department of Fish and Game. The Wildlife Society, Wildlife Monographs 84:1-50.

Gese, E. M. and L. D. Mech. 1991. Dispersal of wolves *(Canis lupus)* in northeastern Minnesota, 1969-1989. Canadian Journal of Zoology 69:2946-2955.

Gross, J. A. 2006. Unit 20E wolf. Pages 176-187 *in* P. Harper, editor. Wolf management report of survey and inventory activities 1 July 2002-30 June 2005. Alaska Department of Fish and Game, Juneau, Alaska.

Gross, J. A. 2007. Unit 20B, 20C, 20D, 20E, and 25C caribou. Pages 135-157 *in* P. Harper, editor. Caribou management report of survey and inventory activities 1 July 2004-30 June 2006. Alaska Department of Fish and Game, Juneau, Alaska.

Gross, J. A. 2008. Unit 20E moose. Pages 424-440 *in* P. Harper, editor. Moose management report of survey and inventory activities 1 July 2005-30 June 2007. Alaska Department of Fish and Game, Juneau, Alaska.

Gross, J. A., 2011. 2011. Unpublished data. Received from Jeff Gross of the Alaska Department of Fish and Game (ADF&G), 3 March 2011.

Mech, L. D., L. G. Adams, T. J. Meier, J. W. Burch, and B. W. Dale. 1998. The wolves of Denali. University of Minnesota Press, Minneapolis, Minnesota.

Mech, L. D., and R. O. Peterson. 2003. Wolf-prey relations. Pp. 131-160 *in* Mech, L. D., and L. Boitani, eds., Wolves: Behavior, Ecology, and Conservation. University of Chicago Press, Illinois.

Messier, F. 1985. Social organization, spatial distribution, and population density of wolves in relation to moose density. Canadian Journal of Zoology 63:1068-1077.

National Park Service (NPS). 2011. Unpublished Data. Snow on ground at Eagle, AK. Received from Pam Sousanes, 13 January 2011.

Nowlin, R. A. 2009. The status of wolves and factors influencing their populations. Alaska Department of Fish and Game, Juneau, Alaska.

Stephenson, R. O. 2003. Units 25 & 26 wolf management report. Pages 232-246 *in* C. Healy, editor. Wolf management report of survey and inventory activities 1 July 1999-30 June 2002. Alaska Department of Fish and Game, Juneau, Alaska.

Stephenson, R. O. 2006. Units 25A, 25B, 25D, 26B, and 26C wolf management report. Pages 239-252 *in* P. Harper, editor. Wolf management report of survey and inventory activities 1 July 2002-30 June 2005. Alaska Department of Fish and Game, Juneau, Alaska.

Titus, K. 2007. Intensive management of wolves and ungulates in Alaska. Transactions of the North American Wildlife and Natural Resource Conference 72:366-377.

Valkenburg, P., J. L. Davis, J. M. Ver Hoef, R. D. Boertje, M. E. McNay, R. M. Eagan, D. J. Reed, C. L. Gardner, and R. W. Tobey. 1996. Population decline in the Delta Caribou Herd with reference to other Alaskan herds. Rangifer Special Issue 9:53-62.

Young, D. D. 2006. Units 20A, 20B, 20C, 20F, and 25C wolf management report. Pages 154-165 *in* P. Harper, editor. Wolf management report of survey and inventory activities 1 July 2002-30 June 2005. Alaska Department of Fish and Game, Juneau, Alaska.

4.9 Bears*

* During initial project scoping, project stakeholders identified bears as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data are not summarized nor condition assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

MacCluskie and Oakley (2005) noted that black (*Ursus americanus*) and brown (*Ursus arctos*) bears are present throughout YUCH. Bears are valued for hunting and viewing opportunities as well as their role in the ecosystem in Interior Alaska. Brown bears are long-lived species requiring large amounts of essential resources from their surroundings. Changes in brown bear populations may indicate drastic long term changes to their surrounding resources (MacCluskie and Oakley 2005). Bears are also an important predator regulating moose and caribou populations, primarily feeding on calves (Ballard 1992, MacCluskie and Oakley 2005).


Photo 19. Brown bear (left, ADF&G photo) and black bear in YUCH (right, NPS photo by C. Stapler).

Measures

- Abundance
- Distribution

Reference Conditions/Values

As defined in the YUCH NRCA framework, the reference condition for bears is within the range of natural variability.

Data and Methods

Bear abundance and distribution data was obtained from ADF&G management reports. All population data presented was collected in GMU 20E (27,661 km^2) (refer to Plate 3), the largest GMU residing in YUCH. The 2000 population estimate for brown bears was extrapolated from previous (1977) harvest estimates. The 2006 brown bear population estimate was calculated using a DNA-based mark-recapture technique in a 5,185 km^2 portion of southern Unit 20E. Density estimates in 2006 for the core area (a 1,778 km^2 area in the west-central portion of the 5,185 km^2 area) were also conducted.

Current Condition and Trend

<u>Distribution</u>
According to Gross (2008), black bears live in forested habitat throughout GMU 20E, with the highest densities near the town of Chicken and along the Yukon River. Black bear movement patterns in the unit are unknown (Gross 2008).

Reported harvests and habitat availability suggest brown bears are located throughout GMU 20E (Bentzen 2009). Bentzen (2009) suggests that brown bears in GMU 20E stay away from recently burned areas.

<u>Abundance</u>
Black bear populations are suspected to have been the highest in the early 1950s, before federal predator control poisoning during the 1950s caused a severe drop in numbers. Population numbers remained low in the late 1950s through the 1980s (Gross 2008). In the 1990s and early 2000s, recorded black bear populations were stable. Black bear population surveys were not conducted in the regulatory year 2004-2005 and 2006 population estimates were still being evaluated in 2008 (Gross 2008). The GMU 20E black bear population is estimated between 1,000 and 1,500, based on data collected in GMUs 12 and 20A in the early 1980s.

The estimated brown bear population for GMU 20E in autumn 2000 was 475-550 (17.1-19.8 bears/1000 km^2) (Bentzen 2009). Using a DNA-based mark-recapture technique, the 2006 population estimate decreased to 10.7-13.4 bears/1000 km^2 (28-35 bears/1000 mi^2) in the core area. Extensive fires from 2004-2005 burned significant portions of GMU 20E, causing bear populations to fluctuate. The northwestern portion of GMU 20E (8,728 km^2) was not damaged by fire and the 2006 brown bear population was labeled "stable" at 13.1-15.8 bears/1000km^2 (34-41 bears/1000 mi^2). The eastern and southern portions (18,933 km^2) experienced extensive fire from 2004-2005 and the population was estimated at 10.8-13.5 bears/1000km^2 (28-35 bears/1000 mi^2). Extrapolating the density estimates, the 2008 midsummer population estimate was 320-394 bears (Bentzen 2009).

<u>Threats and Stressor Factors</u>
During initial project scoping, YUCH resource specialists identified harvest as a regional threat to YUCH's bears.

Harvest
Hunters harvested an average of 13 black bears annually from RY99-RY03 in GMU 20E. In 2004, management set an objective to harvest at least 55% of male black bears in GMU 20E for three years. Annual GMU 20E black bear harvest from RY04 to RY06 ranged from 7 to 28 (Gross 2008). A total of 45 black bears were harvested during the three-year duration: 35 males and 10 females. In 2009 and 2010, 14 and 18 black bears were harvested in the unit respectively

(ADF&G 2011). Gross (2008) claims that the GMU 20E black bear harvests were light and had little effect on the current or future populations.

Bentzen (2009) provides the most current brown bear harvest numbers for GMU 20E. Hunters harvested six bears in RY06 and 13 in RY07. Then ten bears were harvested in the autumn of 2008. The five-year average (RY03-07) harvest for GMU 20E was 13 bears (Bentzen 2009).

Data Needs/Gaps

Historic population estimates for black and brown bears are lacking for Unit 20E. Brown bear estimates were extrapolated from density estimates taken in Unit 20E from 1985-1986 and Unit 20A from 1981-1998, and harvest statistics collected from 1977-2001. Brown bear surveys were then conducted in 2006, and density estimates were used to extrapolate 2008 estimates (Bentzen 2009). There are no past or current estimates specific to YUCH for either species of bear.

Overall Condition

Because this is a “placeholder” component, SMUMN GSS staff did not assess the condition of bears in YUCH.

Sources of Expertise

John Burch, YUGA Wildlife Biologist, CAKN

Literature Cited

Alaska Department of Fish and Game (ADF&G). 2011. 2009 and 2010 black bear harvest reports, GMU 20E. Online. (https://secure.wildlife.alaska.gov/index.cfm?fuseaction=harvestreports.main). Accessed 9 November 2011.

Ballard, W. 1992. Bear predation on moose: A review of recent North American studies and their management implications. Alces Supplement 1:162-176.

Bentzen, T. W. 2009. Unit 20E brown bear. Pages 245-257 *in* P. Harper, editor. Brown bear management report of survey and inventory activities 1 July 2006-30 June 2008. Alaska Department of Fish and Game, Juneau, Alaska.

Gross, J. A. 2008. Unit 20E black bear. Pages 242-248 *in* P. Harper, editor. Black bear management report of survey and inventory activities 1 July 2004-30 June 2007. Alaska Department of Fish and Game, Juneau, Alaska.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Central Alaska Network, Fairbanks, Alaska.

4.10 Small Mammals/Hares*

* During initial project scoping, project stakeholders identified small mammals as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data are not summarized nor condition assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

Small mammals such as mice, voles, and shrews are important to the YUCH food web (MacCluskie and Oakley 2005). Recorded small mammal populations in interior Alaska show fluctuations from high to low numbers over just a couple of years (Rexstad and Kielland 2006). Although some observations suggest these fluctuations follow a pattern, Rexstad and Kielland (2006) state there is not enough evidence to declare the studied population patterns as cyclical. Biotic, climatic and disturbance factors influence Alaskan mammal population fluctuations, with small mammals strongly affected by climatic factors (Rexstad and Kielland 2006).

Photo 20. Collared pika (*Ochotona collaris*) (photo by Kevin Stark, SMUMN GSS).

Measures

- Abundance and distribution

Reference Conditions/Values

As defined in the YUCH NRCA framework, the reference condition for small mammals is abundance and distribution within the range of natural variability.

Data and Methods

MacDonald and Cook (2001) conducted a small mammal inventory during July and August 2001 at ten different locations within YUCH. Shults (2001) also sampled small mammals in the preserve as part of a marten study from 1991-93. Rexstad and Kielland (2006) conducted a literature review and study on herbivorous mammals in interior Alaska.

Current Condition and Trend

<u>Abundance and Distribution</u>

Over half of the 40 resident species of mammals found in the preserve are small mammal species (MacDonald and Cook 2001). Patterns of small mammal abundance and habitat occupancy in YUCH are similar to other studies conducted in Central Alaska. MacDonald and Cook (2001) briefly describe the small mammal species found within YUCH in the summer of 2001 (Table 28). During the 2001 survey, 17 different species were found and 1,891 small mammal specimens were collected. Fifty-seven percent of the species collected were either the cinereus shrew (*Sorex cinereus*) or the northern red-backed vole (*Clethrionomys rutilus*). Meadow voles (*Microtus pennsylvanicus*) comprised 17% of the total species collected (MacDonald and Cook 2001). Shults (2001) had similar results, with northern red-backed vole (54%) and shrew species (29%) comprising the majority of small mammals captured.

Table 28. Species of small mammals documented in YUCH ("V" represents a collected voucher specimen, "O" represents an observed, but not collected species). Reproduced from MacDonald and Cook (2001). Column "through 2011" added from updated University of Alaska Museum mammal collection list.

Species	Studies			Notes
	Through 2011[a]	MacDonald & Cook (2001)	Previously conducted	
INSECTIVORA - Shrews				
Family Soricidae				
Sorex cinereus, cinereus shrew		V	V	
S. hoyi, pygmy shrew		V	V	
S.monticolus, montane shrew		V	V	
S.tundrensis, tundra shrew		V		
S. yukonicus, tiny shrew		V		New species for preserve
CARNIVORA - Carnivores				
Family Mustelidae				
Mustela erminea, ermine	V	O	V	USNM[b] ("Upper Yukon") specimens, John Burch collected voucher in 2002
M.nivalis, least weasel				USNM
Martes americana, American marten	V			No date, identified by Brad Shultz
RODENTIA - Rodents				
Family Sciuridae				
Marmota caligata, hoary marmot		V	V	
Spermophilus parryii, Arctic ground squirrel		V	V	
Tamiasciurus hudsonicus, red squirrel		V	V	
Family Muridae				
Clethrionomys rutilus, N. red-backed vole		V	V	
Lemmus trimucronatus, brown lemming		V	V	Type specimen for *L. t. yukonensis* from "Charley Creek" (=Kandik R.)
Microtus longicaudus, long-tailed vole		V	V	
M. miurus, singing vole			V	USNM Clough (1976) verified *M. miurus* by Dr. R. Hoffman
M. oeconomus, tundra vole		V	V	
M. pennsylvanicus, meadow vole		V	V	
M. xanthognathus, taiga vole		V	V	

Table 28. (continued) Species of small mammals documented in YUCH ("V" represents a collected voucher specimen, "O" represents an observed, but not collected species). Reproduced from MacDonald and Cook (2001). Column "through 2011" added from updated University of Alaska Museum mammal collection list. (continued)

Species	Studies			Notes
	Through 2011[a]	MacDonald & Cook (2001)	Previously conducted	
Ondatra zibethicus, muskrat			V	
Synaptomys borealis, N. bog lemming		V	V	
Family Erethizontidae				
Erethizon dorsatum, N.A. porcupine		V		
LAGOMORPHA - Pikas & Hares				
Family Ochotonidae				
Ochotona collaris, collared pika		V	V	
Family Leporidae				
Lepus americanus, snowshoe hare	V	O	V	USNM specimen, John Burch collected voucher in 2002

[a] Column added from a query of the mammal collection at the University of Alaska, Fairbanks, Museum of the North
[b] USNM = U.S. National Museum

Threats and Stressor Factors
During initial project scoping, YUCH resource specialists identified harvest, fluctuations in predator populations, and wildland fire as regional threats to YUCH's small mammals.

Data Needs/Gaps
The abundance and distribution of small mammals is a data gap in the Central Alaska Network (Swanson et al. 2000). MacDonald and Cook (2001) suggest that future small mammal studies in YUCH should focus on water shrews (*Sorex palustris*), the meadow jumping mouse (*Zapus hudsonius*), little brown bats (*Myotis lucifugus*), deer mice (*Peromyscus maniculatus*) or non-native house mice (*Mus musculus*), least weasel (*Mustela nivalis*), ermine (*M. ermine*), and flying squirrel (*Glaucomys sabrinus*) to clear up discrepancies regarding the presence and distribution of these species.

Overall Condition
Because this is a placeholder component, SMUMN GSS staff did not assess the condition of small mammals in YUCH.

Sources of Expertise
John Burch, YUGA Wildlife Biologist, CAKN

Literature Cited

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Central Alaska Network, Fairbanks, Alaska.

MacDonald, S. O., and J. A. Cook. 2001. Mammal inventory of Alaska's National Parks and Preserves: Yukon-Charley Rivers National Preserve. University of Alaska Museum, Fairbanks, Alaska.

Rexstad, E., and K. Kielland. 2006. Mammalian herbivore population dynamics in the Alaskan boreal forest. Pages 121-132 *in* F. S. Chapin, M. W. Oswood, K. van Cleve, L. A. Viereck, and D. L. Verbyla, eds. Alaska's changing boreal forest. Oxford University Press, New York, New York.

Shults, B. 2001. Abundance and ecology of martens (*Martes americana*) in Interior Alaska. Thesis. University of Alaska, Fairbanks, Alaska.

Swanson, S., M. Cook., C. Roland, J. Burch., and E. Veach. 2000. Biological inventory study plan for the Central Alaska Network. National Park Service, Fairbanks, Alaska.

4.11 Furbearers*

* During initial project scoping, project stakeholders identified furbearers as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data will not be summarized nor will condition be assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

Furbearer trapping has been economically important in eastern Interior Alaska for many years (Hollis 2007). From 1900 to the 1920s, furbearer trapping provided miners and Alaskan natives with income. The most economically important furbearers in GMU 20E are the lynx (*Lynx canadensis*) and marten (Hollis 2007). Currently, natives trap furbearers for means of subsistence and supplemental income (Hollis 2007). According to MacCluskie and Oakley (2005), furbearers play a vital role in the food chain in Denali National Park, YUCH and WRST. Furbearers are a part of the wide array of subarctic mammals living in the YUCH habitats. Furbearers in the area include wolves, coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), mink (*Neovison vison*), river otters (*Lontra canadensis*), wolverines (*Gulo gulo*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*). Hollis (2007) states that furbearer populations in GMU 20E fluctuate based on weather patterns, habitat conditions, avian predation, and food abundance. According to Golden (2004, p. 1), furbearers are some of the most difficult species to monitor "because of their small body size and secretive, wide-ranging behaviors."

Photo 21. Marten (ADF&G photo by J. Whitman) and lynx (ADF&G photo).

Measures

- Abundance and distribution

Reference Conditions/Values

As defined in the YUCH NRCA framework, the reference condition for furbearers is within the range of natural variability.

Data and Methods

Shults (2001) conducted marten population estimates within YUCH in August of 1991, 1992, and 1993 using live trapping, mark-recapture, and aerial radiotelemetry techniques.

Nikki Guldager completed 3 years, 2002 - 2004, of aerial furbearer track counts in YUCH using a video camera mounted in an airplane. The recorded video was later viewed and tracks were identified and counted (Table 29). Track counts were conducted again in 2009, 2010, and 2011 via snowmobile by John Burch. These data are under development.

The ADF&G (Hollis 2007) collected lynx population data and produced population estimates based on track surveys, harvest data, lynx necropsy, and interviews with local trappers. Population estimates for marten, wolverine, red fox, coyote, and beaver were based on interviews with trappers. Trapper interviews, pilot observations, and ADF&G employees provided indications on the status of river otter, ermine, and mink populations.

Current Condition and Trend

Table 29. Number of tracks for each species encountered in tracks/km through aerial video and ground-truthed comparison in 2002 - 2004. Unpublished data from Niki Guldager, USFWS, Yukon Flats, Alaska, wildlife biologist/pilot.

Species	Tracks/km Air/Video 2002	Tracks/km Ground Truth 2003	Tracks/km Air/Video 2004
Fox	0.15	0.61	--
Lynx	0.33	0.05	--
Marten	3.67	1.96	7.94
Otter	--	--	--
Weasel	1.48	0.61	1.58
Hares	10.83	1.26	5.52
Wolverine	N/A	0.19	--
Wolf	N/A	0.05	--
Beaver	N/A	--	--

*Note, all non-furbearer species (e.g., ptarmigan) were excluded from this table

<u>Abundance and Distribution</u>

Lynx

Perham et al. (1993) found lynx densities in GMU 12 south of YUCH were 4.8-5.95 lynx/km^2 (12.5-15.5 lynx/mi^2). The average male lynx home range for GMU 12 was 139 km^2 (53.6 mi^2), but ranged from 13-242 km^2 (5-93.4 mi^2). Females' home ranges were smaller than males, averaging 56 km^2 (21.6 mi^2) (Perham et al. 1993). The last recorded lynx cyclic high in GMU 20E was 1997 to 1999 (Hollis 2007). High lynx kitten production has been associated with high snowshoe hare (*Lepus americanus*) population numbers. From 2002 to 2004, aerial surveys recorded 0.19 lynx tracks per mile (Hollis 2007). In 2003-2004, aerial surveys found 1.08 hare tracks per mile, a 280% increase over 2002-2003. Low track numbers and few juveniles harvested suggest the lynx population was in a cyclic low in RY03. Hollis (2007) predicted the population increased in RY04 and RY05 based on observed placental scars (indicating successful reproduction) during necropsy, increased harvest, and an increase in harvested juveniles.

Wolverine, Marten, Red Fox, Muskrat, Coyote, and Beaver
Estimated marten populations in Brad Shults' study area in YUCH based on mark-recapture techniques were 29, 19, and 25 for the years 1991 to 1993 respectively (Shults 2001). Density estimates from 1991 to 1993 in YUCH were 0.69 martens/km^2 (0.26 martens/mi^2), 0.41 martens/km^2 (0.16 martens/mi^2), and 0.58 martens/km^2 (0.20 martens/mi^2) respectively (Shults 2001).

From RY03 to RY05, trappers interviewed claimed wolverine, red fox, coyote, and beaver populations were stable between moderate to high numbers and marten populations had declined to moderate to low numbers (Hollis 2007).

River Otter, Ermine, and Mink
From RY03 to RY05, trapper questionnaires indicated that the river otter population was reportedly low, while ermine and mink populations were considered prevalent and stable in comparison to previous years (Hollis 2007).

Threats and Stressor Factors

During initial project scoping, YUCH resource specialists identified harvest as a regional threat to YUCH's furbearers. Hollis (2007) provides lynx, river otter, and wolverine harvest estimates from RY97-RY06.

Data Needs/Gaps

Data concerning abundance, distribution, and harvest estimates for furbearers specific to YUCH is currently unavailable. The most recent furbearer management report from the ADF&G was published in 2007. Recent (2007-2011) furbearer data for Unit 20E is needed to establish the current condition.

An NPS furbearer monitoring project was started in YUCH in 2009 by wildlife biologist John Burch; relative abundance counts (tracks per km) of furbearer tracks in the snow are gathered while traveling extensively through the preserve via snowmachine. Data have been collected in February of 2009, 2010 and 2011. These data are currently being summarized and will be published soon. Plans are to continue this monitoring annually for the foreseeable future.

Overall Condition

Because this is a placeholder component, SMUMN GSS staff did not assess the condition of furbearers in YUCH.

Sources of Expertise
John Burch, YUGA Wildlife Biologist, CAKN.

Literature Cited

Golden, H. 2004. Furbearer management technique development. Federal aid in wildlife restoration study 7.19 final report. Alaska Department of Fish and Game, Juneau, Alaska.

Hollis, A. L. 2007. Units 12 and 20E furbearer. Pages 140-154 *in* P. Harper, editor. Furbearer management report of survey and inventory activities 1 July 2003-30 June 2006. Alaska Department of Fish and Game, Juneau, Alaska.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Central Alaska Network, Fairbanks, Alaska.

Perham, C., T. Doyle, and B. Route. 1993 Mortality factors, home range characteristics, and habitat preferences of lynx inhabiting Tetlin National Wildlife Refuge and Wrangell-St. Elias National ... report: April 1991 to September 1992.

Shults, B. S. 2001. Abundance and ecology of martens (*Martes americana*) in interior Alaska. Thesis. University of Alaska, Fairbanks, Alaska.

4.12 Peregrine Falcons

Description

The North American peregrine falcon (*Falco peregrinus*) is a medium-sized raptor with a breeding range extending from Mexico to northern Canada and Alaska (Ambrose 1998). In the northern part of the species' range, the peregrine falcon is highly migratory. Birds will travel as far south as Brazil and Argentina for the winter months (Ambrose and Riddle 1988). The peregrine's diet consists almost exclusively of avian species; the peregrine falcon strikes its prey in mid-air with an open foot, stunning or killing it, and then turns to catch it in mid-air (Skip Ambrose, retired USFWS biologist, Sandhill Company, UT, pers. comm., 2011).

In Alaska, there are three subspecies of peregrine falcon: *F.p. tundrius*, a resident of the northern tundra; *F.p. pealei*, which is found in the coastal regions of Alaska; and *F.p. anatum*, a resident of the forested interior of Alaska (Ambrose et al. 1985). YUCH is located in eastern Alaska and is home to only the *F.p. anatum* subspecies. Its range includes most of the continental United States, and it is commonly referred to as the American peregrine falcon (del Hoyo et al. 1994).

Photo 22. Adult American peregrine falcon (NPS photo by Melanie Flamme).

The American peregrine falcon in interior Alaska normally nests on cliffs or steep slopes, often but not always near water. They occasionally use the abandoned stick nests of other raptor species. The American peregrine falcon's clutch size typically consists of three to four eggs (White et al. 2002). Fledged falcons will reach sexual maturity around two years of age, although one-year-old birds will occasionally attempt to breed (White et al. 2002).

American peregrine falcon populations experienced a well-documented population decline between the 1950s and late 1970s. The use of persistent organochlorine pesticides, particularly dichlorodiphenyltricholoroethane (DDT), had devastating effects on falcon populations. Because of DDT's lipophilic properties, it was able to rapidly bioaccummulate in ecosystems (especially in predatory birds). DDT magnified though the food chain, and more chemicals were concentrated within apex predators (such as the American peregrine falcon) than in other animals within the same environment (Connell et al. 1999). The most significant effect of the pesticide was that it caused the birds to lay thin-shelled eggs that often failed to hatch and, consequently, lowered the species productivity (Ratcliffe 1993).

By the mid-1970s, the American peregrine falcon population in interior Alaska had declined to 20% of its historic levels (Ambrose et. al. 1988). Peregrine populations were nearly completely eradicated from the eastern and midwestern U.S., and only a few hundred breeding pairs remained in the western U.S. (USFWS 2003). As a result, the American peregrine falcon was federally listed as endangered in 1970 under the Endangered Species Conservation Act of 1969, a precursor to the Endangered Species Act (ESA) of 1973 (U.S. Congress 1973, USFWS 2003).

In 1972, the use of DDT and other organochlorine pesticides was restricted in the U.S. (USFWS 2003). Due to this restriction, American peregrine falcon populations in the continental U.S. rebounded to over 2,000 breeding pairs in 2002 (White et al. 2002, USFWS 2003).

The American peregrine falcon population in YUCH responded similarly to those populations occurring in the continental U.S., and has been increasing in size since 1978. Unlike the continental U.S., however, the YUCH population was never manipulated by humans; no reintroductions, captive breeding, or take for harvest have ever occurred in the preserve (Ambrose and Ritchie 2003). This makes YUCH's American peregrine falcon population unique, as the recovery is well documented and studied and has recovered completely naturally (Ambrose and Ritchie 2003). Because of the range-wide recovery of the American peregrine falcon following the DDT ban, the species was removed from the USFWS List of Threatened and Endangered Species on 25 August 1999 (Mesta 1999, USFWS 2003).

The upper Yukon River in YUCH provides excellent cliff-nesting habitat for American peregrine falcons; the riparian areas along the river support an abundant variety of prey species (Flamme et al. 2008). The well documented abundance of American peregrine falcons along the upper Yukon River and abundant available habitats for the species were the primary reason for the preserve's establishment in 1980 (Flamme et al. 2008). The enabling legislation establishing YUCH states:

> The preserve shall be managed for the following purposes… to protect habitat for, and populations of, fish and wildlife, including but not limited to peregrine falcons and other raptorial birds … (U.S. Congress 1980).

Furthermore, American peregrine falcons in the upper Yukon River corridor (both within and adjacent to YUCH) were identified by NPS as an important Vital Sign within the CAKN (MacCluskie and Oakley 2005). The upper Yukon River corridor was also identified as one of two index areas for Alaska in the National Monitoring Plan for the American peregrine falcon (USFWS 2003). As a top trophic level predator of national and state-wide significance, monitoring the American peregrine falcon in YUCH is an important priority for the preserve.

Measures

- Number of pairs in the upper Yukon River index study area (Circle to AK-Yukon Territory border, within 1 km of the river)
- Reproductive performance (percent pairs successful, number of young/pair)
- Contaminants analysis

Reference Conditions/Values

The reference conditions defined for this component include pre-endangered levels for the listed measures and populations falling within the range of natural variability.

Data and Methods

The Fish and Wildlife Service (USFWS), NPS, and/or volunteers have conducted yearly censuses of American peregrine falcon populations in YUCH since 1973. The censuses are conducted twice a year. There is an early census in late May to early June to locate occupied nesting territories, and a late census in July to determine breeding success and productivity (Guldager et al. 2005). During these censuses, NPS staff, affiliates, and/or volunteers launch a river boat from Circle, AK and motor up the Yukon River to the Alaska/Yukon Territory, Canada border (Plate 15). Recently, the results of these censuses have been reported each year in the form of a Technical Report Summary (Guldager et al. 2005, Flamme et al. 2008, Ambrose et al. 2008). These reports contain productivity and census data dating back to 1973.

Skip Ambrose, retired USFWS biologist, currently of Sandhill Company, Castle Valley, UT, has been responsible for organizing the survey effort and collecting most of the data (over 95%) since the beginning of peregrine surveys in 1973 (Ambrose and Florian 2011). Data from these surveys (i.e., occupancy, total number of adults, productivity) were made available for this assessment. These data were current from 1973-2011, although data were not collected in 1974 or 1976, and only 39 of 52 pairs were surveyed in 2004 due to reduced loss of visibility caused by smoke from large forest fires. Literature from online queries was also used in this assessment.

Current Condition and Trend

The majority of data regarding the American peregrine falcon population in YUCH were gathered through the annual population censuses (Guldager et al. 2005, Flamme et al. 2008, Ambrose et al. 2008). According to Ambrose et al. (2008, pp. 2-3), the three primary objectives of the annual American peregrine falcon monitoring program in YUCH are:

> 1. To monitor trends in the breeding performance of American peregrine falcons along the upper Yukon River index study area. This includes annual measures of number of pairs, territory occupancy, breeding success and productivity.
>
> 2. To monitor levels of contaminants in eggs produced by American peregrine falcons breeding in YUCH. This includes repeated analyses of eggs for persistent organic pollutants (e.g., DDT, polychlorinated biphenyls [PCBs], and heavy metals such as mercury and cadmium); contaminants found in eggs reflect contaminants that the birds were exposed to at wintering grounds and along migration routes.
>
> 3. To monitor levels of contaminants accumulated in feathers of nestling American peregrine falcons on the breeding grounds within YUCH. This includes repeated analyses of nestling feathers for heavy metals (e.g., mercury and cadmium); contaminants found in nestling feathers reflect natal area contaminants exposure.

Data related to objective one will be covered in detail in this section of the assessment as the specified measures (population size, nest occupancy, productivity) are specific to the objectives of the censuses. Objectives two and three will be discussed as potential threats and stressors facing the YUCH peregrine population later in this document.

Number of Pairs in the Upper Yukon River Index Study Area

American peregrine falcons are not monitored annually throughout YUCH; thus, population size estimates are not available. However, raptor biologists annually monitor the index study area (Yukon River from Circle, AK, to the AK-Yukon Territory border). This annual survey documents the number of occupied territories, the total number of adults, total nesting pairs, and total number of observed unpaired birds. Census estimates are intense and every effort is made to observe all falcons along the Yukon River. During the two yearly censuses, researchers spend about 20-28 days in the field monitoring YUCH's stretch of the Yukon River (Ambrose et al. 2008). Each potential nesting territory is monitored for a minimum of four hours during both the early and late censuses. Censuses and data are current through 2011.

Ambrose et al. (1988) reported that the peregrine population of the upper Yukon River declined through 1973, stabilized from 1974-1977, and began increasing from 1978-1983. The increase in YUCH's peregrine population (i.e., total number of adults observed per year in YUCH) continued after 1983; YUCH's peregrine population has been increasing from 1973 (11 pairs) to 2011 (53 pairs) (Figure 47). However, it should be noted that since 2004, the YUCH peregrine population has fluctuated between 48-53 pairs (Figure 47). Whether or not this is indicative of a population stabilization or plateau is yet to be determined and may warrant further investigation.

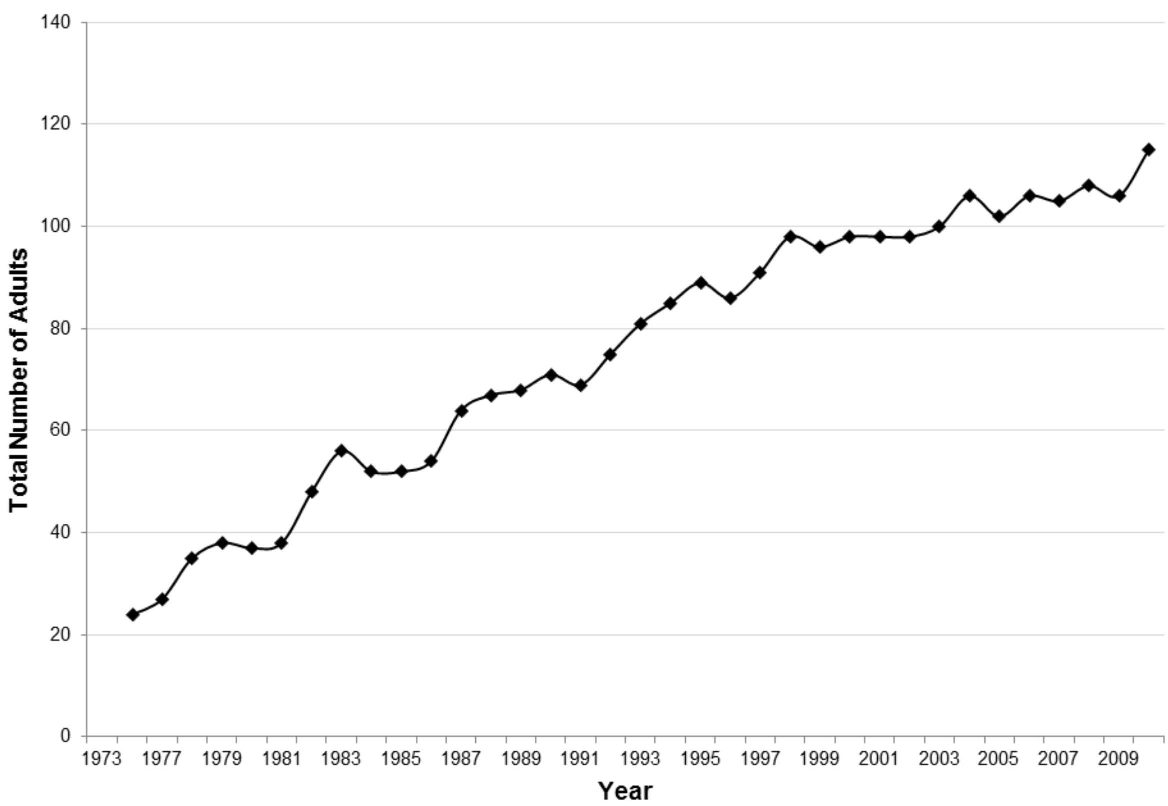


Figure 47. Total number of adult American peregrine falcons observed in YUCH 1973-2010. No surveys were conducted in 1974 or 1976. In 2004, only 39 of the 52 pairs were checked for breeding success and productivity due to smoke from forest fires (Ambrose et al. 2008).

Reproductive Performance

Peregrine populations experienced drastic reductions in rates of territory occupancy and nest success in the 1950s and 1960s. In some regions of the continental U.S., rates of territory occupancy and nest success were at or near zero (USFWS 2003); it is believed that no peregrines fledged in the northeast U.S. in 1962 (Hickey and Anderson 1969). In interior Alaska, populations declined to approximately 20% of pre-DDT levels (Ambrose and Ritchie 2003).

In 2011, 54 nesting territories were occupied by peregrine falcons in YUCH (53 pairs and one single adult on territories). Of the 53 occupied territories, 37 (70%) were successful (i.e., >1 nestling observed) (Figure 48), and in total 75 nestlings were observed (Ambrose and Florian 2011). This is a marked difference from 1973 when 12 territories were occupied (11 pairs and one single adult on a territory) (Figure 48). Only six pairs (55%) were successful, producing a total 16 nestlings for the year (Ambrose et. al. 1988).

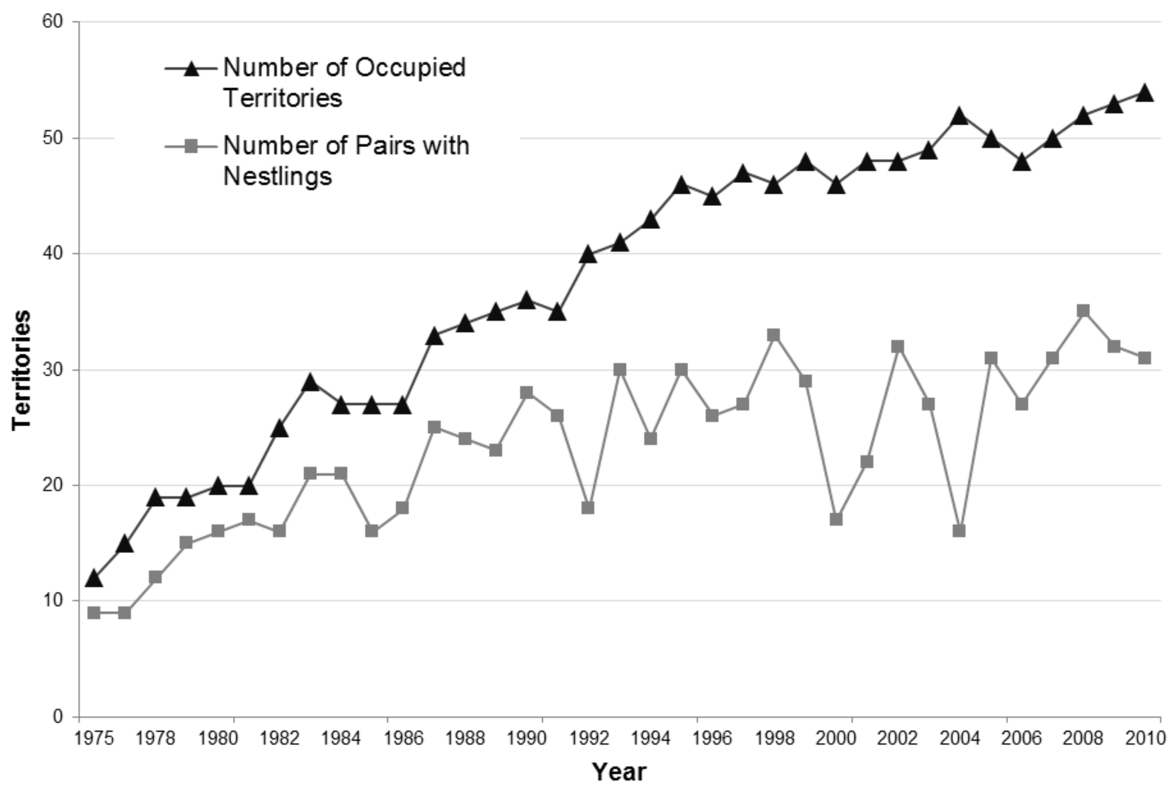


Figure 48. Number of occupied and successful (> 1 nestlings) American peregrine falcon territories in YUCH from 1973 – 2010. No surveys were conducted in 1974 or 1976. In 2004, only 39 of the 52 pairs were checked for breeding success and productivity due to smoke from forest fires (Ambrose et al. 2008).

According to data collected pre-1955 and post-1985 (Hickey and Anderson 1969, Enderson and Craig 1974, Ratcliffe 1993, USFWS 2003), a healthy peregrine falcon population typically has nest success rates of 45-66%. Figure 49 displays the percent successful territories in YUCH from 1973-2008 and also displays the lower threshold (45%) of a healthy peregrine population as discussed in USFWS (2003). A truly healthy peregrine population (pre-DDT) has never been studied in Alaska; therefore, current surveys of an apparently recovered, healthy population are essential to more fully understand this species (Ambrose and Florian 2011).

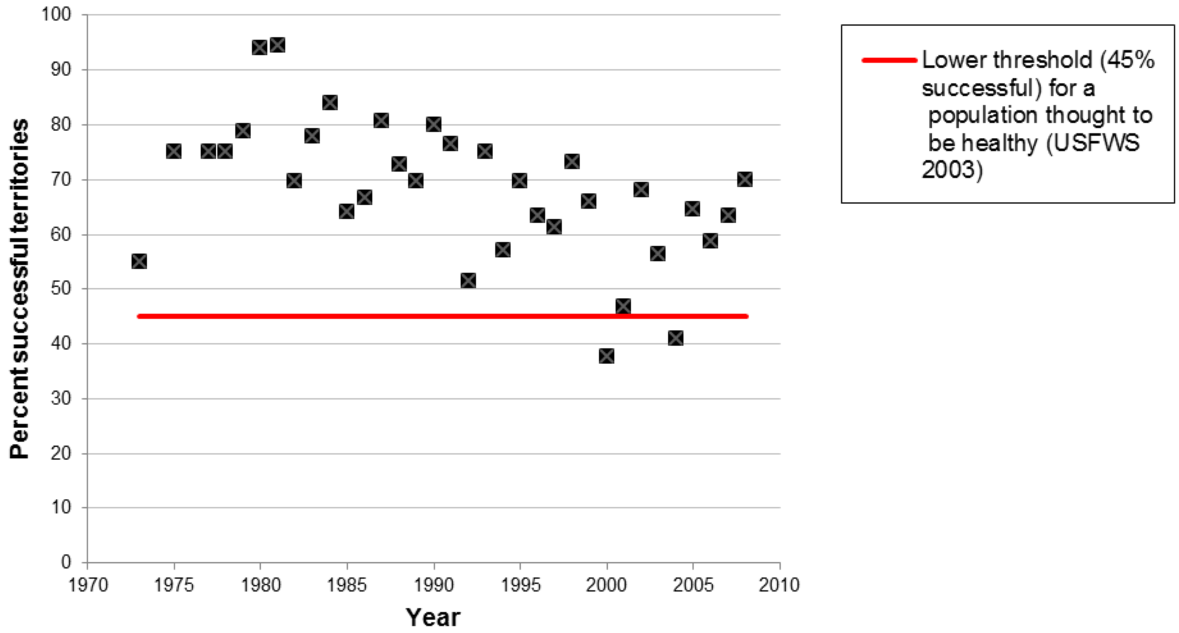


Figure 49. Percent of successful American peregrine falcon territories in YUCH, 1973 – 2008 (Ambrose et al. 2008). No surveys were conducted in 1974 or 1976. In 2004, only 39 of the 52 pairs were checked for breeding success and productivity due to smoke from forest fires (Ambrose et al. 2008).

From 1973-2011, the numbers of total and successful pairs nesting along YUCH's reach of the upper Yukon River have been increasing (Figure 48). The percentage of total pairs nesting successfully has been lower in recent years (1995-2011) as compared to the recovery years (1978-1995), with some apparent stability in most recent years (2009-2011) (Ambrose and Florian 2011). This may be due to the increased competition for resources in YUCH due to the population's increase in density (Ambrose et al. 2008).

In YUCH, productivity has been reported as the number of nestlings per total and successful pairs (Ambrose et al. 2008). Productivity has fluctuated throughout the census period in YUCH (Figure 50). The number of nestlings per total pair has ranged from 0.78 (2000) to 3.00 (1981), and the number of nestlings per successful pair has ranged from 1.89 (1975) to 3.18 (1981) (Figure 50). Over the course of the censuses, the mean number of nestlings per total pair is 1.65, and the mean number of nestlings per successful pair is 2.39.

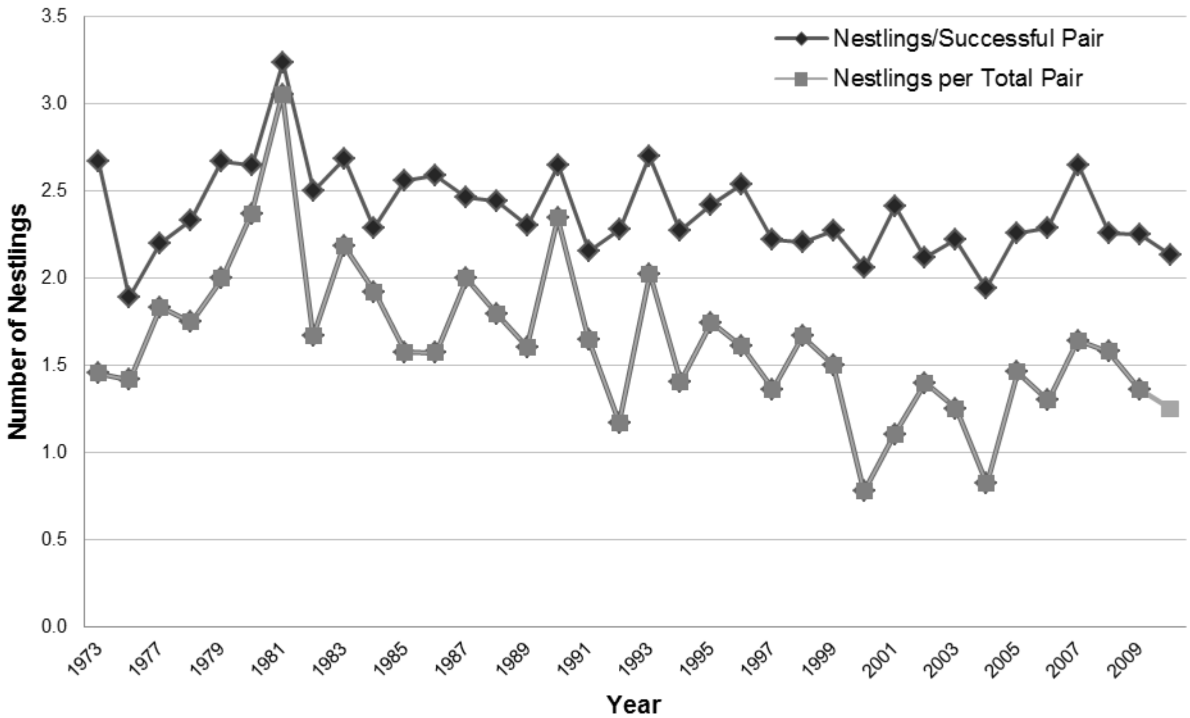


Figure 50. Nestlings per total pair and nestlings per successful pair, Upper Yukon River, Alaska, 1973 – 2010. No surveys were conducted in 1974 or 1976. In 2004, only 39 of the 52 pairs were checked for breeding success and productivity due to smoke from forest fires (Ambrose et al. 2008).

Intensive American peregrine falcon censuses and surveys were not conducted in interior Alaska before DDT's introduction and use in the 1940s. As a result, little is known about nesting densities, breeding success, and productivity of a healthy American peregrine falcon population in Alaska's interior (Ambrose et al. 2008). Hunt (1998) modeled the population dynamics of peregrines in the continental U.S. under various rates of adult mortality and juvenile survival and found that peregrine populations were at least stable when productivity was 1.0 to 2.0 young per pair, annual adult mortality was <15%, and annual juvenile mortality was <70%. These productivity estimates are consistent with estimates in expanding or stable populations in the U.S. (Corser et al. 1999, Mesta 1999, Hayes and Buchanan 2002, USFWS 2003). Since the peregrine falcon was delisted in 1999, the USFWS has enacted a policy that initiates a special review for populations falling below 1.0 young per pair (USFWS 2003).

While there are marked differences in the population dynamics of peregrine populations in the continental U.S. compared to Alaska, the productivity of the YUCH peregrine population falls well within the Hunt (1998) range of a healthy population in the continental U.S. (average number of nestlings per total pair is 1.65, and the average number of nestlings per successful pair is 2.39). However, as the annual censuses in YUCH do not account for adult or juvenile mortality, and because Hunt (1998) only looked at the continental U.S., a conclusion on the overall health of the YUCH population according to Hunt (1998) cannot be made.

Contaminants Analysis

Contaminants continue to be a threat for raptor populations worldwide. DDT and other similar pesticides are still used in peregrine wintering grounds (MacCluskie et al. 2010). This exposure can cause continued risk to the YUCH population (Ambrose et al. 2008). Mercury is another contaminant that peregrines are exposed to. Mercury is a persistent compound that bioaccumulates at high trophic levels and causes toxic effects similar to DDT (Ambrose et al. 2008). High levels of mercury are released through industrial processes such as mining and waste incineration, and levels are likely to increase with global industrialization.

Ambrose et al. (2000) found that mercury concentrations were significantly higher in eggs that came from unsuccessful American peregrine falcon nests. From 1988-1995, mercury concentrations in Alaska did not decline (Ambrose et al. 2000). Mercury was also the "only contaminant of concern that exceeded published thresholds for reproductive impairment in the most recent time period (1991-1995), and had increasing percentages of threshold exceedances over time" (Ambrose et al. 2000, p. 27).

Yukon-Charley Rivers National Preserve, in collaboration with the USFWS, actively monitors the contaminant levels in the peregrine population. To determine the level of contaminant exposure on the nesting grounds, biologists collect addled eggs and feather samples from nestlings. To determine the level of contaminant exposure in the wintering grounds, YUCH collects molted adult feathers whenever possible. Recent contaminants analyses of American peregrine falcon eggs from YUCH reveal that mercury exposure in the preserve is at levels that may affect reproduction (Ambrose et al. 2000). Trend data suggest that mercury levels are increasing in the population.

Threats and Stressor Factors

The most current version of the State of Alaska Falconry Manual (No. 8) allows for take of wild nestling American peregrine falcons for falconry from May 26 to August 5 annually (Alaska Board of Game 2008). This time frame in Alaska overlaps two sensitive periods for the American peregrine falcon nestlings on the upper Yukon River, including the times just after hatch and just prior to fledging. Hatch dates in the YUCH survey area range from mid June to late July (YUGA, Melanie Flamme, Biologist, pers. comm., 2011). During the first 10 days after hatching, the nestlings cannot thermoregulate independently and require parental brooding (Ambrose, pers. comm., 2011). If the parents are flushed off the nest during this period, nestlings may be at risk.

The second sensitive time frame occurs from mid to late July, just prior to fledging. If humans enter eyries when nestlings are not yet ready to fledge, they may be spooked and jump from the nest before they are capable of flight (Flamme, pers. comm., 2011). While the main-stem of the upper Yukon River from Circle, AK to the Yukon-Territory Border is exempted from falconry take, other tributaries within the preserve are available for falconry take (Alaska Board of Game 2008). Other American peregrine falcon nesting areas within YUCH are known to occur on the Tatonduk, Nation, and Charley Rivers.

While falconry take may be infrequent in Alaska, it does occur; the Sagavanirktok River in northern Alaska had three arctic peregrine nestlings taken in 1996, two in 1997, and two in 1998 (Wright and Bente 1999). In addition, the American Falconry Conservancy has prepared a proposal for non-resident take of Alaska's raptors for falconry to be included in the 2012 Alaska Board of Game meeting agenda, and has crafted a petition for all American falconers to sign in favor of non-resident take in Alaska (American Falconry Conservancy 2011).

The USFWS (2011) is considering creating migratory bird permit regulations (50 CFR 21) for a permit to use trained captive-bred raptors as non-lethal management tools in abatement activities. The consideration is in response to public interest in the use of raptors in abatement of problem birds on airfields and crop lands. The increased interest in this use of raptors for abatement may increase interest in the take of peregrine falcons from Alaska in the future.

Photo 23. American peregrine falcon chicks (NPS Photo by Melanie Flamme).

Data Needs/Gaps

The extensive census efforts in YUCH have produced one of the largest, most continuous data sets for peregrine falcons in the world. Because of this, there are few data gaps for this component at this time. Satellite imagery of the surrounding landscape (approximately 1.5-3 km beyond the canyon wall near eyries) could provide insight into potential correlations between landcover and eyrie success. Also, the other drainages of YUCH do not have a continuous data set for nesting peregrines. YUCH staff makes efforts to survey these areas every 3-5 years, but the rivers are challenging to navigate and staffing such expeditions with personnel possessing the required raptor observation skills is often difficult and expensive (Flamme, pers. comm., 2011).

Overall Condition

YUCH staff assigned each of the measures (population size estimates, nest occupancy, productivity) a *Significance Level* of 3.

Number of Pairs in the Upper Yukon River Index Study Area

The number of American peregrine falcon pairs in the upper Yukon River index study was assigned a *Condition Level* of 0. YUCH's peregrine population has been increasing since 1973 (11 pairs), and in 2011 the population reached 53 pairs (Figure 47). It should be noted, however, that between 2003 and 2010 the YUCH peregrine population has fluctuated between 100-115 adults (Figure 47). Whether or not this is indicative of a population approaching stabilization or plateau is yet to be determined and may warrant further investigation.

Reproductive Performance
YUCH's American peregrine falcon reproductive performance measure was assigned a *Condition Level* of 1. There has been a well-documented increase in YUCH peregrine nest occupancy over the past four decades. Fifty-four nesting territories were occupied by American peregrine falcons in YUCH in 2010 (53 pairs and one single adult on territories). Of the 54 occupied territories, 31 (58.5%) were successful (i.e., $\geq$1 nestling observed) (Figure 48), and in total 66 nestlings were produced. In 1973, only 12 territories were occupied (11 pairs and one single adult on territory) (Figure 48), yet six pairs (55%) were successful, producing a total 16 nestlings for the year.

Yukon-Charley Rivers National Preserve's census area experienced the lowest population density from 1973 – 1985; however, most occupied territories still successfully produced nestlings (Ambrose et al. 2008). From 1986 – present, the number of occupied territories has continually increased, but a lower percentage of the YUCH population has produced nestlings. This lower proportion of successful pairs may be explained by an increase in competition in YUCH for resources and nesting habitats (Ambrose et al. 2008).

Productivity has fluctuated throughout the census period in YUCH (Figure 50). The number of nestlings per total pair has ranged from 0.78 (2000) to 3.00 (1981), and the number of nestlings per successful pair has ranged from 1.89 (1975) to 3.18 (1981) (Figure 50). Over the course of the censuses, the mean number of nestlings per total pair is 1.65, and the mean number of nestlings per successful pair is 2.39.

Contaminants Analysis
The contaminants analysis measure for American peregrine falcons in YUCH was assigned a *Condition Level* of 1. While peregrine populations experienced a dramatic recovery following the regulation of DDT and other organochlorides, the threat of contaminants still exists. Contaminants are still frequently used in peregrine wintering habitats, and Ambrose et al. (2000) has shown that mercury concentrations in Alaska are at levels that may affect peregrine falcon reproduction.

Weighted Condition Score (WCS)
The Weighted Condition Score (WCS) (see Chapter 3 for methodology) for American peregrine falcons in YUCH is 0.222. A WCS of 0.222 represents an overall condition of low concern.

Surveys along the Upper Yukon River in 1898 (Bishop 1900, as cited in Ambrose et al. 1985), and in 1952 (Cade 1960, as cited in Ambrose et al. 1985) recorded just 16 pairs in the study area. However, these surveys were not nearly as intensive as current monitoring efforts. Bishop (1900) and Cade (1960) surveyed in late July and early August and could have missed unsuccessful pairs, unpaired birds, or adults and young away from the cliff after the young had fledged (Ambrose et al. 1985).

It is not possible to compare the current population to the range of natural variability in peregrine populations at this time. While Hunt (1998) (along with Corser et al. 1999, Mesta 1999, Hayes and Buchanan 2002, USFWS 2003) has established a threshold for a healthy peregrine population in the continental U.S., no such work has been done in interior Alaska. Intensive American peregrine falcon censuses and surveys were not conducted in interior Alaska before DDT's introduction and use in the 1940s. As a result, little is known about population size, nesting densities, breeding success, and productivity of a healthy American peregrine falcon population in Alaska's interior (Ambrose et al. 2008).

Despite the absence of information regarding the historic peregrine population in YUCH, the current condition of the population is of low concern. Population size has dramatically rebounded since the decline from the late 1960s to the early 1970s. Nest occupancy has continued to increase, productivity appears to reflect that of a healthy population (although this is speculation and cannot be confirmed with an established Alaskan population threshold), and contaminants do not appear to be adversely affecting reproduction rates (although further investigation may be warranted to confirm this). Available survey data suggest that this local peregrine population is in good condition.

Peregrine Falcons

Measures	SL	CL
• # of pairs in the Upper Yukon River index study area	3	0
• Reproductive performance	3	1
• Contaminants analysis	3	1

WCS = 0.222

Sources of Expertise
Skip Ambrose, Retired USFWS Biologist, Sandhill Company, Castle Valley, UT

Melanie Flamme, YUGA Biologist, CAKN.

Literature Cited

Alaska Board of Game. 2008. Alaska falconry manual No. 8. Alaska Department of Fish and Game, Fairbanks, Alaska.

Ambrose, R. E., R. J. Ritchie, C. M. White, P. F. Schempf, T. Swem, and R. Dittrick. 1985. Status of peregrine falcon populations in Alaska. U.S. Fish and Wildlife Service, Fairbanks, Alaska.

Ambrose, R. E., and K. E. Riddle. 1988. Population dispersal, turnover, and migration of Alaska peregrines. Pages 677-684 *in* T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White (eds). Peregrine falcon populations: Their management and recovery. Proceedings of the 1985 International Peregrine Conference. The Peregrine Fund, Inc., Boise, Idaho.

Ambrose, R. E., R. J. Ritchie, C. M. White, P. F. Schempf, T. Swem, and R. Dittrick. 1988. Changes in the status of peregrine falcon populations in Alaska. Pages 73-82 *in* T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White (eds). Peregrine falcon populations: Their management and recovery. Proceedings of the 1985 International Peregrine Conference. The Peregrine Fund, Inc., Boise, Idaho.

Ambrose, R. E. 1998. American peregrine falcons along the Upper Yukon River, Alaska, 1998. MIPR Number 9805S021. U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, Alaska.

Ambrose, R. E., A. Matz, T. Swem, and P. Bente. 2000. Environmental contaminants in American and arctic peregrine falcon eggs in Alaska, 1979-95. Technical Report NAEC-TR-00-02. U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, Alaska.

Ambrose, R. E., C. Florian, J. Burch, and M. Flamme. 2008. American peregrine falcon (*Falco peregrinus anatum*) monitoring along the Upper Yukon River in Yukon-Charley Rivers National Preserve, Central Alaska Network: 2008 report. Natural Resource Technical Report NPS/CAKN/NRTR—2008/138. National Park Service, Fort Collins, Colorado.

Ambrose, S., and R. J. Ritchie. 2003. Peregrine falcons, naturalists, scientists, and biologists in Alaska, 1900-2000. Pages 188-197 *in* Return of the peregrine, A North American saga of tenacity and teamwork. W. Burnham and T. J. Cade (eds). The Peregrine Fund, Inc., Boise, Idaho.

Ambrose, S., and C. Florian. 2011. Status of American peregrine falcon (*Falco peregrinus anatum*) along the Upper Yukon River, Alaska, 2011. Unpublished report. Sandhill Company, Castle Valley, Utah.

American Falconry Conservancy. 2011. Non-resident take update. Online. (http://falconryconservancy.org/component/content/article/34-publicpages/108-non-resident-take-update). Accessed 15 September 2011.

Bishop, L. B. 1900. Annotated list of birds. Pages 47-96 *in* Results of a biological reconnaissance of the upper Yukon River region, W. H. Osgood. North American Fauna No. 19.

Cade, T. J. 1960. Ecology of peregrine and gyrfalcon populations in Alaska. University of California Publications in Zoology 63:151-290.

Connell, D., P. Lam, B. Richardson, and R. Wu. 1999. Introduction to ecotoxicology. Blackwell Science Ltd, Oxford, United Kingdom.

Corser, J. D., M. Amaral, C. J. Martin, and C. C. Rimmer. 1999. Recovery of a cliff-nesting peregrine falcon, *Falco peregrinus*, population in northern New York and New England, 1984-1996. The Canadian Field-Naturalist 113:472-480.

del Hoyo, J., A. Elliot, and J. Sargatal. 1994. Handbook of birds of the world: New World vultures to guineafowl. Lynx Edicions, Barcelona, Spain.

Enderson, J. H., and J. Craig. 1974. Status of the peregrine falcon in the Rocky Mountains in 1973. The Auk 91:727-736.

Flamme, M. J., J. Burch, R. E. Ambrose, C. Florian, and N. Guldager. 2008. 2007 American peregrine falcon (*Falco peregrinus anatum*) monitoring along the Upper Yukon River in Yukon-Charley Rivers National Preserve, Central Alaska Network. Natural Resource Report NPS/CAKN/NRTR - 2008/079. National Park Service, Fort Collins, Colorado.

Guldager, N., R. E. Ambrose, and C. Florian. 2005. American peregrine falcon monitoring along the Upper Yukon River, Alaska, 2005. Technical Report. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Hayes, G. E., and J. B. Buchanan. 2002. Washington state status report for the peregrine falcon. Washington Department of Fish and Wildlife, Olympia, Washington.

Hickey, J. J., and D. W. Anderson. 1969. The peregrine falcon: Life history and population literature. Pages 3-42 *in* Peregrine falcon populations: their biology and decline. J. J. Hickey (ed). University of Wisconsin Press, Madison, Wisconsin.

Hunt, W. G. 1998. Raptor floaters at Moffat's equilibrium. Oikos 82(1):191-197.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Central Alaska Network, Fairbanks, Alaska.

MacCluskie, M., S. Ambrose, C. Florian, and M. Flamme. 2010. The American peregrine falcons of Yukon-Charley Rivers National Preserve, Alaska. Alaska Park Science 9(1):28-31.

Mesta, R. 1999. Final rule to remove the American peregrine falcon from the federal list of endangered and threatened wildlife, and to remove the similarity of appearance provision for free-flying peregrines in the conterminous United States. Federal Register 64(164):46541-46558.

Ratcliffe, D. 1993. The peregrine falcon. T & A Poyser Ltd., London, England.

U.S. Congress. 1973. Endangered Species Act, PUBLIC LAW 39-205-DEC. 28, 1973. 87 STAT. 884 (16 U.S.C. 1531 et seq.).

U.S. Congress. 1980. Alaska National Interest Lands Conservation Act, PUBLIC LAW 96-487-DEC. 2, 1980. 94 STAT. 2371. (www.r7.fws.gov/asm/anilca/toc.html).

U.S. Fish and Wildlife Service (USFWS). 2003. Monitoring plan for the American peregrine falcon, a species recovered under the Endangered Species Act. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Pacific Region, Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 2011. Migratory bird permits; Abatement regulations. Advanced Notice of Proposed Rulemaking. Federal Register 76(129):39368-39369.

White, C. M., N. J. Clum, T. J. Cade, and W. G. Hunt. 2002. Peregrine falcon, (*Falco peregrinus*). *In* The Birds of North America, No. 660 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania.

Wright, J. M., and P. J. Bente. 1999. Documentation of active peregrine falcon nest sites. Unpublished Report. Alaska Department of Fish and Game, Division of Wildlife Conservation, Fairbanks, Alaska.

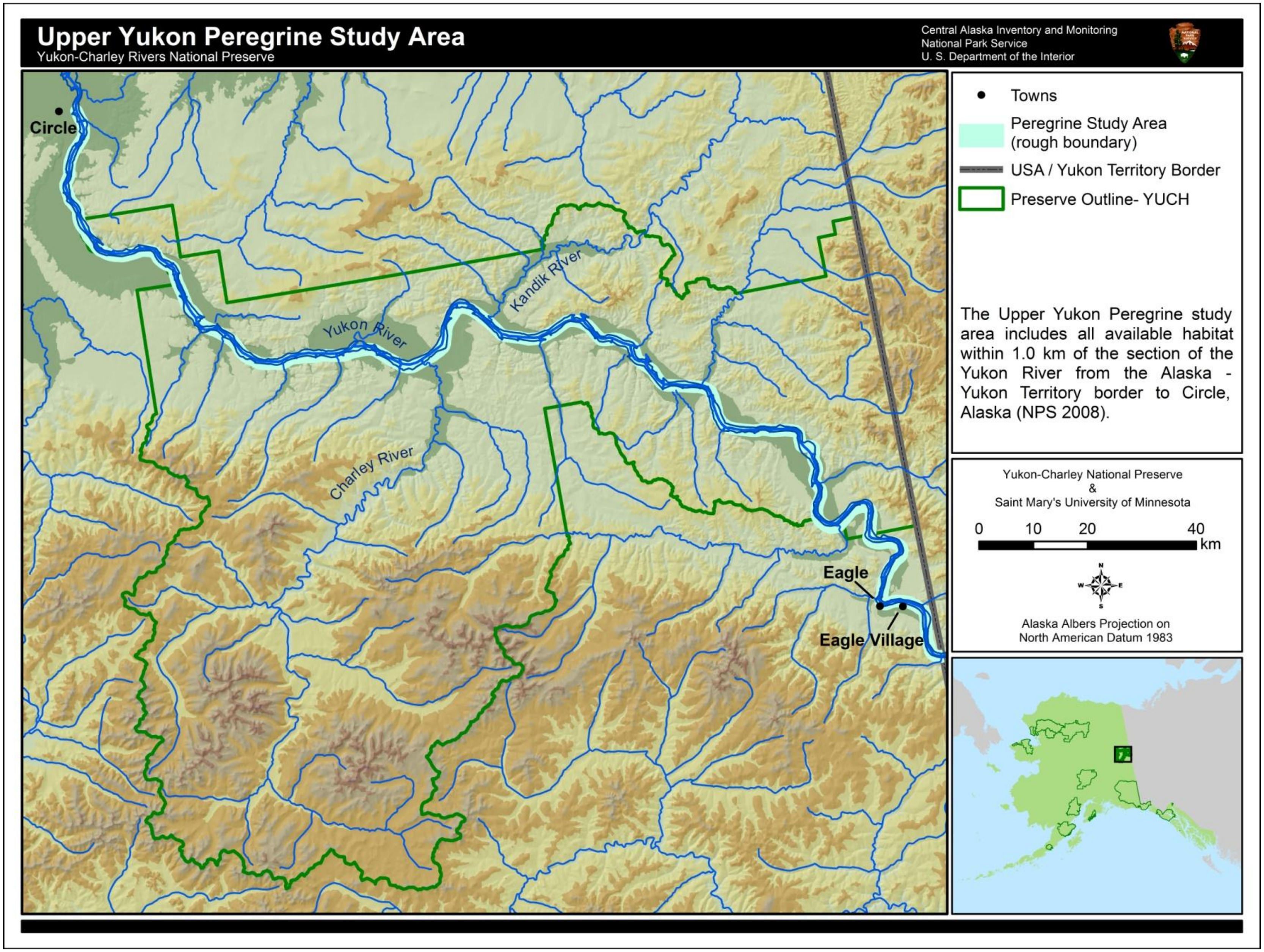


Plate 15. The Upper Yukon River peregrine falcon index study area.

4.13 Ptarmigan*

* During initial project scoping, project stakeholders identified ptarmigan as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data are not summarized nor condition assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

The CAKN selected ptarmigan as one of 34 Vital Signs for the network. However, ptarmigan are one of 13 selected Vital Signs that does not yet have an established monitoring program in the CAKN (NPS 2011). YUCH is home to two species of ptarmigan, the willow ptarmigan (*Lagopus lagopus*) and the rock ptarmigan (*L. muta*).

The willow ptarmigan is the largest of the Alaskan ptarmigan and has a thick, wide bill. The willow ptarmigan nests in sparsely timbered or treeless areas and chooses nesting areas that are wetter and more vegetated than the other species of ptarmigan in Alaska (ADF&G 2011). The rock ptarmigan breeds on hilly and mountainous tundra throughout Alaska, and nesting sites are on slopes in high valleys with patchy shrubs, low herbs, and grasses (ADF&G 2011). Male rock ptarmigan have a similar breeding plumage as the male willow ptarmigan (a black tail and feathers tipped with white), but the rock ptarmigan has a narrower bill that clearly distinguishes it (ADF&G 2011).

Photo 24. Willow ptarmigan (NPS photo).

Measures

- Abundance
- Distribution

Reference Conditions/Values

As agreed upon in the YUCH NRCA framework, the reference condition for ptarmigan is defined as being within the range of natural variability.

Data and Methods

The sources of data for ptarmigan in YUCH include:

- Moldenhauer (1982) surveyed the YUCH bird population from 15 June - 17 July 1982 and documented a single rock ptarmigan at American Summit.

- Ulvi et al. (1984) identified all bird species encountered during a survey of the Crescent Creek area, counted or estimated the number of observations, and determined the breeding status for each species. The surveys took place from 26 June – 2 July 1984. A total of nine willow ptarmigan and 34 rock ptarmigan were documented.

- Swanson and Nigro (2000) summarized the results of an I&M funded bird inventory in YUCH from 1999-2000 and documented the number of detections, density, and distribution of both rock and willow ptarmigan.

- Handel et al. (2009) used the data from Swanson and Nigro (2000) to examine the distribution of breeding birds within five ecological landforms (Alpine, Subalpine, Hill/Bluff, Lowland, and Floodplain/Terrace). Ptarmigan were observed in the Alpine and Subalpine landforms; rock ptarmigan were detected more often in Alpine landforms while willow ptarmigan were seen more in Subalpine landforms (Handel et al. 2009).

- McIntyre et al. (2010) studied the distribution of breeding birds along the Taylor Highway and a portion of the upper Yukon River in YUCH, but did not detect any ptarmigan.

- The Breeding Bird Survey's (BBS) Eagle route (BBS route 03-001) occurs on the Taylor Highway just outside of Eagle, Alaska near YUCH. In 1982, 1991, 1992, 1994, 1996, 1997, 2001, 2002, 2007, 2008, 2010, and 2011, BBS surveys were conducted on this route along the Taylor Highway. Of these years, 2001-2011 surveys were conducted by YUCH staff and starting in 2010, repeat surveys of this route were conducted as part of the CAKN long-term passerine monitoring program. In 2011, the Chicken route (BBS route 03-101, along the Taylor Highway outside of YUCH and further to the southeast of the Eagle route) was also surveyed by YUCH staff, but is not part of CAKN passerine monitoring. One willow ptarmigan was observed on the Eagle route in 2007. These BBS data can be accessed online at the Patuxent USGS Wildlife Research Center website (https://www.pwrc.usgs.gov/BBS/PublicDataInterface/index.cfm).

Current Condition and Trend

Species Abundance

No studies to date have focused exclusively on ptarmigan abundance in YUCH. Swanson and Nigro (2000) documented the number of ptarmigan detections and roughly estimated the density and population size (Table 30), but the study looked at avian populations as a whole in YUCH and did not pay special attention to ptarmigan abundance.

Table 30. Observations and density and population estimates for ptarmigan in YUCH (adapted from Swanson and Nigro 2000).

Species	No. of observations	Estimated density (pairs/ha)	Population estimate	95% Confidence intervals (population)	
				Low	High
Rock ptarmigan	21	0.0199	19,031	5,379	67,333
Willow ptarmigan	21	0.0041	3,883	1,201	12,553

Species Distribution

Swanson and Nigro (2000) estimated the distribution and density of both ptarmigan species in YUCH (Figure 51, Figure 52). This represents the only study in YUCH that has attempted to address ptarmigan distribution in the preserve.

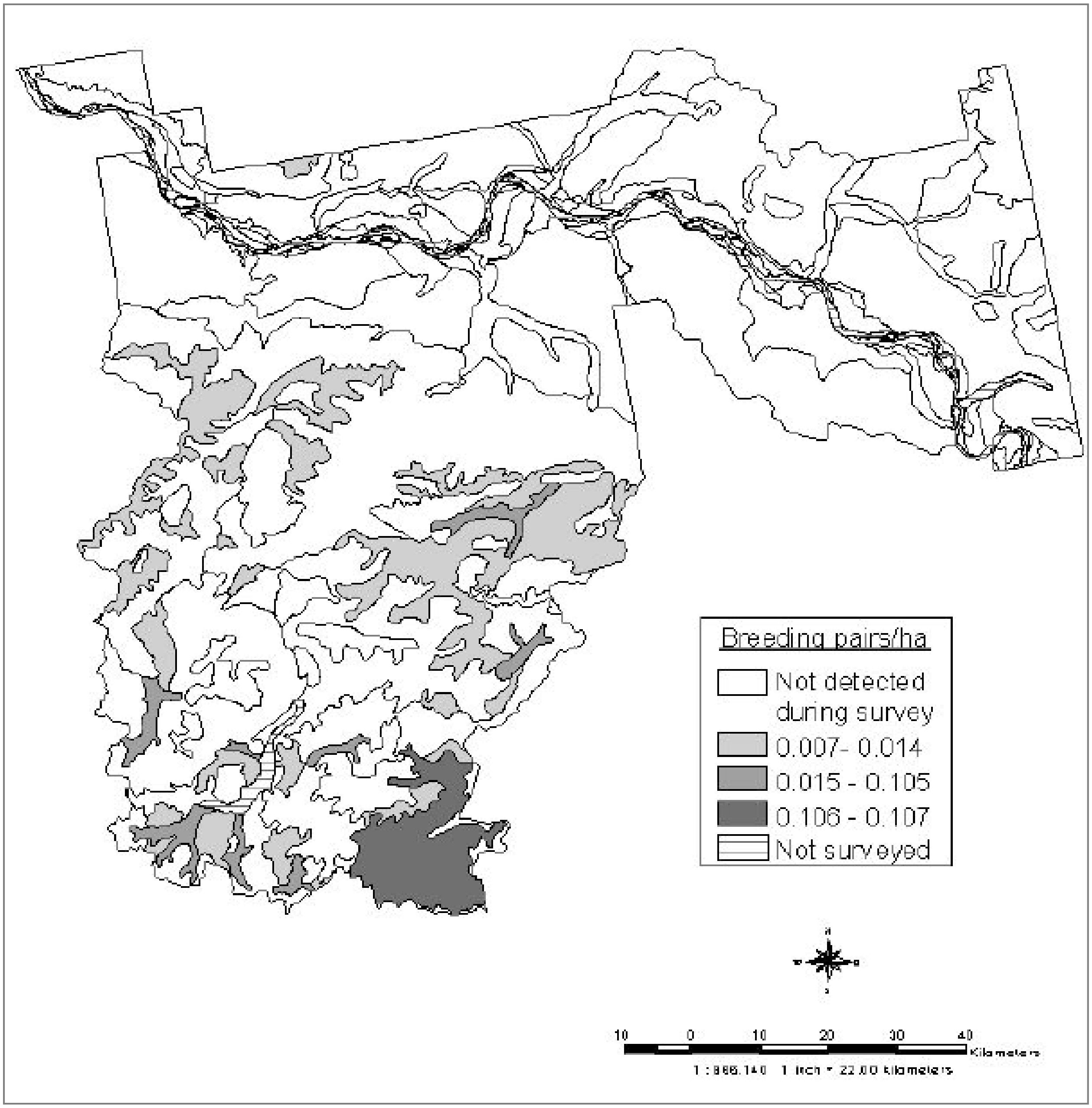


Figure 51. Density of willow ptarmigan by detailed ecological unit in YUCH from an avian inventory in June 1999 and 2000. Reproduced from Swanson and Nigro (2000).

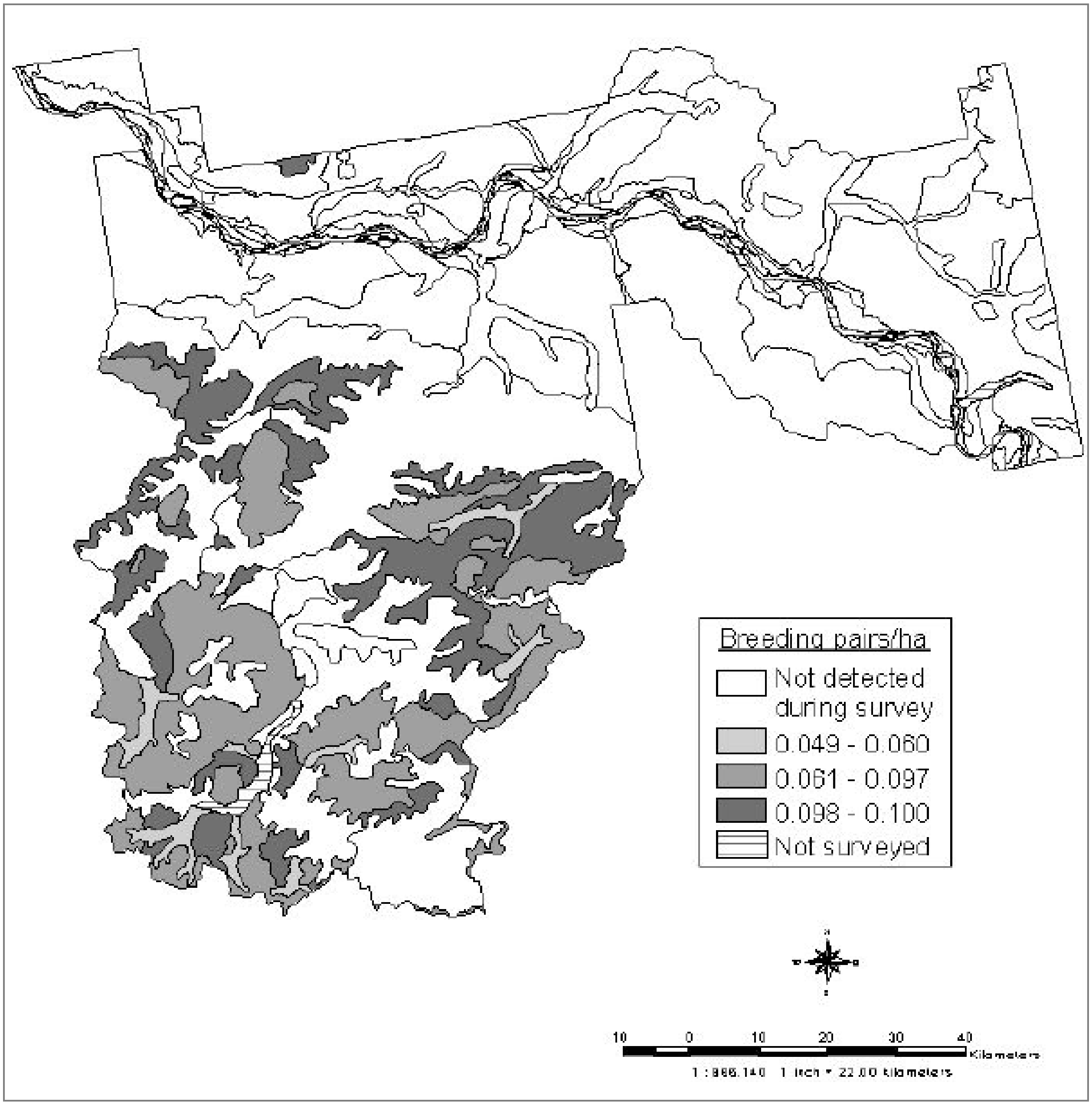


Figure 52. Density of rock ptarmigan by detailed ecological unit in YUCH from an avian inventory in June 1999 and 2000. Reproduced from Swanson and Nigro (2000).

<u>Threats and Stressor Factors</u>
During initial project scoping, YUCH resource specialists identified habitat change and climate warming as regional and global threats to ptarmigan populations in the preserve.

<u>Data Needs/Gaps</u>
Long-term abundance and distribution trend data are needed for ptarmigan in YUCH so that the condition of the ptarmigan can be monitored in the future. The establishment of a Vital Sign

monitoring program in YUCH could provide an opportunity for a thorough assessment of ptarmigan species abundance and distribution.

Overall Condition

Because this is a placeholder component, SMUMN GSS staff will not assess the condition of ptarmigan in YUCH.

Sources of Expertise

Melanie Flamme, YUGA Biologist, was the primary source of expertise for this assessment.

Literature Cited

Alaska Department of Fish and Game (ADF&G). 2011. Small game hunting in Alaska. Online. (http://www.adfg.alaska.gov/index.cfm?adfg=smallgamehunting.rock). Accessed 19 July 2011.

Handel, C. M., S. A. Swanson, D. A. Nigro, and S. M. Matsuoka. 2009. Estimation of population sizes and species richness across a boreal landscape in Alaska. The Wilson Journal of Ornithology 121(3):528-547.

McIntyre, M., J. Schmidt, M. Flamme, and M. Paulson. 2010. Monitoring passerine birds in the Central Alaska Network: Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve. Unpublished Report. National Park Service, Fairbanks, Alaska.

Moldenhauer, R. R. 1982. An avifaunal survey of the Yukon-Charley Rivers National Preserve: Summer 1982. Research and Resource Management Report Series 82-01.

National Park Service (NPS). 2011. Central Alaska Network Vital Signs. Online. (http://science.nature.nps.gov/im/UNITS/CAKN/pages_VS/VitalSigns.cfm). Accessed 19 July 2011.

Swanson, S. A., and D. A. Nigro. 2000. A breeding landbird inventory of Yukon-Charley Rivers National Preserve, Alaska, June 1999 and 2000. Unpublished report. National Park Service, Fairbanks, Alaska.

Ulvi, S., T. Swem, and R. R. Moldenhauer. 1984. A survey of the avian communities in the Crescent Creek area of Yukon-Charley Rivers National Preserve with reference to species status and relative abundance. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

4.14 Breeding Birds*

*During initial project scoping, project stakeholders identified breeding birds as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data are not summarized nor is condition assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

Bird populations often act as excellent indicators of an ecosystem's health (Morrison 1986, Hutto 1998, NABCI 2009). Birds are typically easy to observe and identify, and bird communities often reflect the abundance and distribution of other organisms with which they co-exist (Blakesley et al. 2010). The 10,194 km^2 (3,935 mi^2) of YUCH possesses complex geology, unique climatic conditions, natural fire regimes, and discontinuous permafrost, and provides habitat for a wide range of bird species (Swanson and Nigro 2000a). The Yukon River serves as a natural corridor that provides a migratory flyway for species migrating to and from Alaska during the spring and fall (Swanson and Nigro 2000a). This flyway is also responsible for the occurrence of many vagrant species from more southern and eastern temperate regions. Monitoring avian population health and diversity in YUCH habitats will be important for detecting population and ecosystem changes.

Photo 25. White-crowned sparrow (USFWS Photo).

Measures

- Diversity
- Population size and distribution

Reference Conditions/Values

As defined in the YUCH NRCA framework, the reference condition for breeding birds is within the range of natural variability.

Data and Methods

Sources of data for this placeholder component listed here exclude studies regarding non-breeding species of birds in YUCH. In addition, data sources regarding peregrine falcons are not defined here, as they are discussed in the peregrine falcon component section (Chapter 4.12). There are several sources of data for breeding birds in YUCH:

- Moldenhauer (1982) surveyed the YUCH bird population from 15 June – 17 July 1982.
- Swem (1984) reported the results of raptor population surveys in YUCH.
- Ulvi et al. (1984) identified all birds species encountered during a survey of the Crescent Creek area; their numbers were counted or estimated, and the breeding status of the species was determined. Surveys took place from 26 June – 2 July 1984.
- Knuckles and Ulvi (1990) conducted a bald eagle survey in YUCH. The objective was to ascertain the number of active eagle nests, map them, and compare the results to a similar survey conducted in 1986.
- Fox and App (1994) conducted monitoring of peregrine falcons and their prey as part of the Monitoring Avian Productivity and Survivorship (MAPS) program. The objectives in YUCH were to establish a neotropical migrant monitoring program of target species along the Yukon River and at Coal Creek, to monitor American Peregrine Falcon breeding and productivity along the Charley River and to produce a training video for Air Force pilots to mitigate impacts of low-level flights on peregrines.
- Fox and McGee (1997) conducted point counts for neotropical migrant songbirds in the Coal Creek drainage from 12 – 16 June 1997. These point count surveys were repeated by McGee (1998, 1999) from 18 – 19 June 1998 and from 13 - 14 June, 1999.
- Nigro (2000) conducted waterfowl staging surveys in YUCH as part of the bird inventory and monitoring project implemented in 1998 to assess locations of fall waterfowl staging areas, the magnitude of use of these areas and determine which species are staging in YUCH in fall.
- Swanson and Nigro (2000a) summarized the results of an I&M funded bird inventory in YUCH from 1999-2000.
- Swanson and Nigro (2000b) monitored the owl population of YUCH in March and April of 1999. The authors also conducted wintering bird surveys, but these surveys may not provide an accurate picture of the breeding bird population and should not be used in assessing condition of this component.
- Nigro and Guldager (2001) conducted point counts for neotropical migrant songbirds using variable circular plot techniques in the Coal Creek drainage of YUCH from 18 - 19 June 2001.

- The Breeding Bird Survey's (BBS) Eagle route (BBS route 03-001) occurs on the Taylor Highway just outside of Eagle, Alaska near YUCH. In 1982, 1991, 1992, 1994, 1996, 1997, 2001, 2002, 2007, 2008, 2010, and 2011, BBS surveys were conducted on this route along the Taylor Highway. Of these years, 2001-2011 surveys were conducted by YUCH staff and starting in 2010, repeat surveys of this route were conducted as part of the CAKN long-term passerine monitoring program. In 2011, the Chicken route (BBS route 03-101, along the Taylor Highway outside of YUCH and further to the southeast of the Eagle route) was also surveyed by YUCH staff, but is not part of CAKN passerine monitoring. These BBS data can be accessed online at the Patuxent USGS Wildlife Research Center website (https://www.pwrc.usgs.gov/BBS/PublicDataInterface/index.cfm).

- Handel et al. (2009) studied the distribution of breeding birds within five ecological landforms (Alpine, Subalpine, Hill/Bluff, Lowland, and Floodplain/Terrace) in YUCH.

- McIntyre et al. (2010) studied the distribution of breeding birds on the BBS routes along the Taylor Highway outside of Eagle, Alaska. The study also looked at a portion of the upper Yukon River within YUCH and discussed the detections of the passerine bird species encountered. As the first year of Phase I of the CAKN passerines long-term Vital Signs monitoring, the study was designed to detect passerine birds but all bird species detected are recorded (owls, raptors, grouse and ptarmigan, jays, and ravens).

Current Condition and Trend

Diversity

Swanson and Nigro (2000a) documented 86% of the 134 species expected to occur in the preserve. This percentage was very close to the CAKN Plan's goal of documenting the occurrence of 90% of the bird species currently estimated to exist in the park (Swanson and Nigro 2000a). NPS (2007) identified 30 bird species during the 2007 BBS, but did not provide long-term data. The NPS Certified Species List for birds in YUCH is also available online through the NPSpecies database (NPS 2011).

Population Size and Distribution

No existing studies document the size of the population of birds in YUCH, although Swanson and Nigro (2000a) documents the percentage of expected species in the park. Handel et al. (2009) is the most current study to document the distribution of breeding birds in YUCH. Many of the other studies that briefly discuss distribution are outdated and may not reflect current distribution in the park.

Threats and Stressor Factors

During initial project scoping, YUCH resource specialists identified habitat change and loss of wintering habitat as regional and global threats to YUCH's breeding birds:

Data Needs/Gaps

Long-term trend data are needed for breeding birds in YUCH so that the condition of these birds can be monitored in the future. Regular monitoring in YUCH would allow for enhanced assessment of current breeding bird species diversity, population size, and distribution. Annual bird surveys, such as raptor surveys, Christmas bird counts (CBCs), or continuation of the BBS route monitored in 2007 are a few ways that this monitoring could occur. Without monitoring in the preserve, these measures cannot be accurately determined. Annual surveys would also help to monitor the current abundance of priority species within preserve boundaries.

Overall Condition

Because this is a placeholder component, SMUMN GSS staff did not assess the condition of breeding birds in YUCH.

Sources of Expertise

Melanie Flamme, YUCH Biologist, was the primary source of expertise for this assessment.

Literature Cited

Blakesley, J. A., D. C. Pavlacky Jr., and D. J. Hanni. 2010. Monitoring bird populations in Wind Cave National Park. Tech. Rep. M-WICA09-01. Rocky Mountain Bird Observatory, Brighton, Colorado.

Fox, K., and J. App. 1994. Legacy Project 1055, Yukon Charley Rivers National Preserve: Monitor peregrine falcons and their Neotropical prey. Resource Management Report Series 94-02. National Park Service, Yukon-Charley Rivers National Preserve, Eagle, Alaska.

Fox, L., and C. McKee. 1997. Point counts for Neotropical migrant songbirds Coal Creek drainage. Resource Management Report Series 97-002. National Park Service, Yukon-Charley Rivers National Preserve, Eagle, Alaska.

Handel, C. M., S. A. Swanson, D. A. Nigro, and S. M. Matsuoka. 2009. Estimation of population sizes and species richness across a boreal landscape in Alaska. The Wilson Journal of Ornithology 121(3):528-547.

Hutto, R. L. 1998. Using landbirds as an indicator species group. Avian conservation: Research and management. Island Press, Washington, D.C.

Knuckles, P., and S. Ulvi. 1990. Bald eagle survey. Research and Resource Management Report Series 90-07. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

McGee, C. 1998. Coal Creek Neotropical bird surveys. Resource Management Report Series 98-001. National Park Service, Yukon-Charley Rivers National Preserve, Fairbanks, Alaska.

McGee, C. 1999. Coal Creek off-road point counts for migratory songbirds, 1997-1999. . Resource Management Report Series 99-006. National Park Service, Yukon-Charley Rivers National Preserve, Fairbanks, Alaska.

McIntyre, C., J. Schmidt, M. Flamme, and M. D. Paulson. 2010. Monitoring passerine birds in the Central Alaska Monitoring Network: Denali National Park & Preserve, Wrangell-St. Elias National Park & Preserve, and Yukon-Charley Rivers National Preserve. 2010 Annual Progress Report. National Park Service, Fairbanks, Alaska.

Moldenhauer, R. R. 1982. An avifaunal survey of the Yukon-Charley Rivers National Preserve: Summer 1982. Research and Resource Management Report Series 82-01. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Morrison, M. L. 1986. Bird populations as indicators of environmental change. Current Ornithology 3:429-451.

National Park Service (NPS). 2007. Yukon-Charley Rivers National Preserve annual report 2007. National Park Service, Fairbanks, Alaska. Available online at: http://www.nps.gov/yuch/parkmgmt/upload/YUCH_Annual_Report_2007.pdf.

National Park Service (NPS). 2011. NPSpecies. Online. (https://nrinfo.nps.gov/Species.mvc/Search). Accessed 14 September 2010.

Nigro, D. 2000. Waterfowl surveys in Yukon-Charley Rivers National Preserve, final report. Resource Management Report Series 00-003. National Park Service, Yukon-Charley Rivers National Preserve, Fairbanks, Alaska.

Nigro, D., and N. Guldager. 2001. Point counts for Neotropical migrant songbirds using variable circular plot techniques, Coal Creek drainage. Resource Management Report Series 01-001. National Park Service, Yukon-Charley Rivers National Preserve, Fairbanks, Alaska.

North American Bird Conservation Initiative (NABCI), U.S. Committee. 2009. The state of the birds, United States of America, 2009. U.S. Department of the Interior, Washington, D.C.

Swanson, S. A., and D. A. Nigro. 2000a. A breeding landbird inventory of Yukon-Charley Rivers National Preserve, Alaska, June 1999 and 2000. Unpublished report. National Park Service, Fairbanks, Alaska.

Swanson, S. A., and D. A. Nigro. 2000b. Owl and wintering bird surveys, Yukon-Charley Rivers National Preserve. Unpublished report. National Park Service, Fairbanks, Alaska.

Swem, T. 1984. Raptor surveys in and around Yukon-Charley Rivers National Preserve, Alaska, 1984. Research and Resource Management Report Series 84-01. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Ulvi, S., T. Swem, and R. R. Moldenhauer. 1984. A survey of the avian communities in the Crescent Creek area of Yukon-Charley Rivers National Preserve with reference to species status and relative abundance. Research and Resource Management Report Series 84-03. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

4.15 Anadromous Fish Species

Description

The anadromous species that use the waters within YUCH for spawning, rearing, or migrating include: Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), Bering cisco (*Coregonus laurettae*), and Arctic lamprey (*Lampetra camtschatica*). Managers responsible for the Alaskan portion of the Yukon River separated the drainage into seven districts and ten subdistricts. In the Upper Yukon River area near Fort Yukon, AK (Figure 53), Chinook, summer chum, fall chum, and coho salmon are all important human food sources, while fall chum and coho salmon are fed to dogs used for recreation, transportation, and drafting activities (Andersen 1992). YUCH resides in subdistrict 5d of the Yukon River fisheries management area, between the towns of Circle and Eagle on the Yukon River. Salmon in the upper Yukon are harvested mostly for human consumption and some for dog food. Arctic lamprey are incidentally caught as part of both subsistence and commercial salmon fisheries on the main stem of the Yukon River (USFWS, David Daum, Fisheries Biologist, pers. comm., 17 February 2011). Although Arctic lamprey occur in YUCH, insufficient data exist regarding the lamprey's population status in the preserve.

Photo 26. Migrating salmon (ADF&G photo).

The Board of Fisheries (BOF) declared the Yukon River stock of Chinook salmon a "yield concern" in 2000 (Howard et al. 2009, p. 1). The stock is measured on expected yields or harvestable surpluses above a stock's escapement needs. The salmon escapement goals are measured during salmon runs. Management then calculates if escapement goals for the year will be met. If goals are predicted to fall short, upper portions of the Yukon are asked to reduce harvest (JTC 2011). No escapement estimates or harvest numbers are available specifically for YUCH. The ADF&G reports harvests for Circle and Eagle each year, but the harvest numbers are not separated by what occurs within versus outside YUCH boundaries (Daum, pers. comm., 2011). However, escapement estimates and reported harvests at different locations on the Yukon River outside of YUCH boundaries may provide some broad indications for the status of Chinook salmon stock within YUCH.

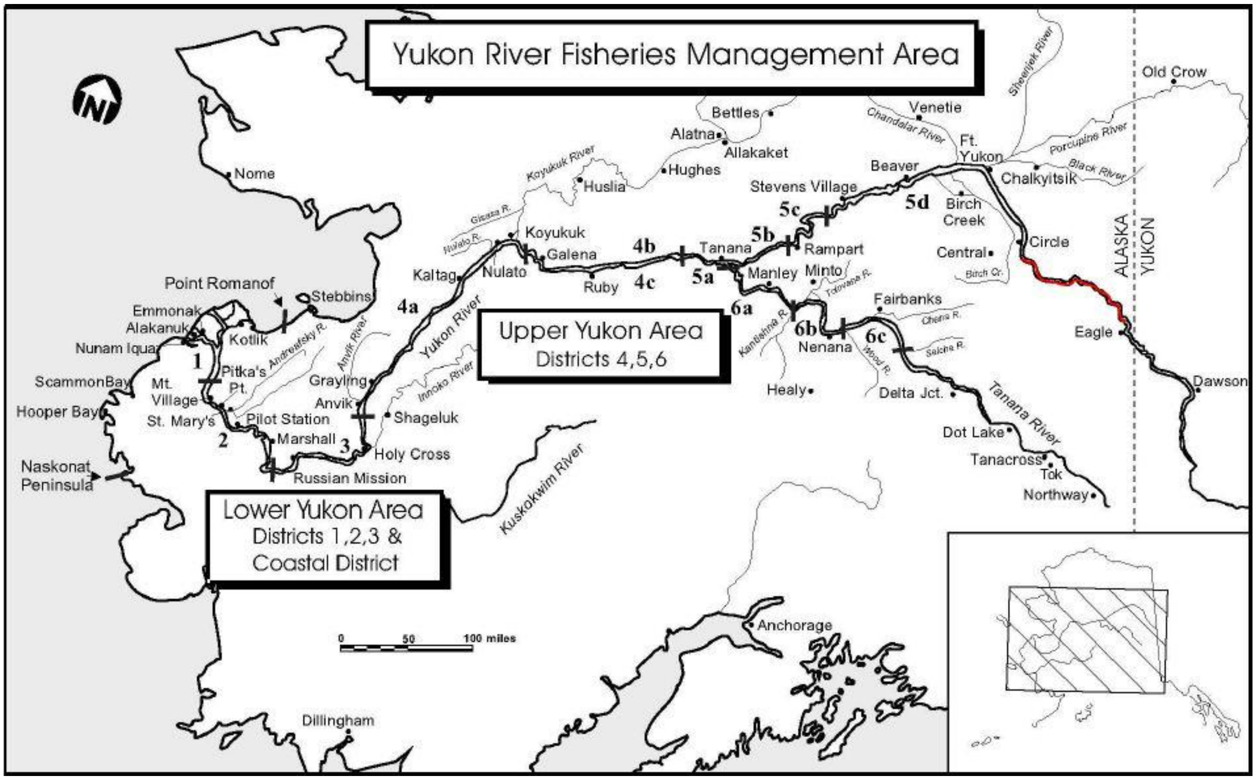


Figure 53. Yukon River fisheries management area (JTC 2011). YUCH area of the Yukon River highlighted in red between Eagle and Circle Alaska.

Measures

- Population size (annual escapement)
- Distribution of species

Reference Conditions/Values

Ideally, the reference condition for anadromous fish species population and distribution would be within the range of natural variability in the preserve. However, very little is known about the natural variability or range of fish populations in the waters of the preserve, only that salmon have been important resources for subsistence in the Yukon River drainage for hundreds of years (Schwatka 1893, Zagoskin 1967, as cited in Walker et al. 1989).

Data and Methods

The ADF&G is responsible for compiling the Anadromous Waters Catalog and Atlas (AWC), which identifies the streams, rivers, and lakes used by anadromous fish for spawning, rearing, or migrating in Alaska. Fish surveys are important for managing habitat and sport, personal use, subsistence and commercial fisheries (ADF&G 2011a). The ADF&G conducts surveys by aircraft, boat and foot. Due to weather and climate factors affecting stream condition, data collection of upper stream fish usage points may represent bodies of water with anadromous fish use and not actual known upper limit use points. Proposed updates to the AWC can be submitted by those outside the ADF&G; outside submissions must be in the proper format and are checked for accuracy (ADF&G 2011a). These data are the primary source of information describing anadromous fish distribution and populations in the preserve.

In addition to survey information, a sonar station near the city of Eagle, AK on the Yukon River, upstream from the southeastern corner of YUCH, is used to generate estimates of the number of fall chum and Chinook salmon escaping into Canada. The sonar does not record specific species, just a count. Depending on the spawning season, all recorded species are classified as Chinook or fall chum, respectively.

Current Condition and Trend

Population Size (annual escapement)
Escapement is a count measurement of fish passing a point on their way to spawning grounds. YUCH contains some spawning anadromous species, but numbers are not large enough to be considered a sustainable population (Daum, pers. comm., 2011). Daum (pers. comm., 2011) suggests that the preserve provides a migratory corridor for species traveling to their native spawning grounds and habitat for young species to mature. Since there are no sustainable anadromous populations within YUCH, the passing of fish through the preserve is not technically escapement; rather, the main-stem of the Yukon River is a migratory corridor for passing fish to reach spawning grounds in Canada (Daum, pers. comm., 2011).

The information presented here provides some indication of the status of anadromous fish that pass through the preserve, but little is known about anadromous species spawning within YUCH. In 2000, the Alaska Board of Fisheries (BOF) found the stock of Yukon River Chinook salmon to be a "stock of yield concern" (Howard et al. 2009). Howard et al. (2009, p. 1) defines a yield concern as, "a concern arising from a chronic inability, despite the use of specific management measures, to maintain expected yields, or harvestable surpluses, above a stock's escapement needs." Howard et al. (2009) note that a yield concern is less severe than a management concern. The stock of yield concern is measured on escapement performance, expected yields and harvestable surpluses. The yield concern was declared based on low harvest levels from 1998 to 2000 and an expected low harvest in 2001. The designation as a stock of yield concern for Yukon Chinook continued at the 2004, 2007, and 2009 BOF meetings. In addition, there are two goals for Canadian fish, border passage and actual escapement (border passage minus Canadian harvest). Neither of these goals were met in 2007, 2008, and 2010 (JTC 2011).

The Eagle sonar station provides an estimate of the number of fish (Chinook and chum salmon) that pass through YUCH in the Yukon River, and eventually cross the U.S./Canada border approximately 20 km upstream from the station. From 6 July 2008 to 16 August 2008, 38,097 Chinook salmon were estimated to have passed the Eagle sonar station (Crane and Dunbar 2009). The highest daily passage estimate was 1,956 on 30 July 2008. The lowest daily estimate was 298 on 16 August 2008. In 2009, estimated escapement past the sonar station was about 70,000 Chinook salmon (Eggers et al 2010). In 2010, the Chinook salmon escapement estimate was 34,465 (JTC 2011).

From 17 August 2008 to 6 October 2008, 171,347 fall chum salmon were estimated to have passed the Eagle sonar. The highest daily estimate was 6,551 on 11 September 2008 and the lowest estimate was 4,002 on the last day of data collection (Crane and Dunbar 2009). The 2010 fall chum salmon escapement passage estimate was 132,930 (JTC 2011). Table 31 displays the Chinook and fall chum salmon escapement estimates at the Eagle sonar station from 2005 to 2010.

Table 31. Eagle sonar station passage estimates, 2005-2010 (JTC 2011).

Year	No. of fish based on sonar estimate	
	Chinook	**chum**
2005	81,528	NA
2006	73,691	236,386
2007	41,697	282,670[a]
2008	38,097	193,397[a]
2009	69,957	101,734[a]
2010	35,074	132,930[a]

[a] Expanded sonar estimate, includes expansion for fish that may have passed after operations ceased.

Coho salmon numbers are low in YUCH and therefore no measurements of passage or escapement numbers are estimated at the Eagle sonar station (Daum, pers. comm., 2011).

COSEWIC (2004) found, through communication with experts and literature review, a general lack of data for population size, catch or abundance of Bering cisco. The only available information regarding Bering cisco simply indicate its presence in the Upper Yukon River. The population size of Bering cisco entering Canada is unknown (COSEWIC 2004). COSEWIC (2004) noted low numbers of Bering cisco (fewer than 100) captured by fishwheels since the 1980s; however, it is suspected that improper recording of species contributed to the low numbers.

Distribution

The distribution of anadromous species within YUCH is represented by the presence, rearing, and spawning points found in the AWC and data collected by Daum and Flannery (2011b). Chinook salmon use the Kandik, Nation, Tatonduk, and Charley Rivers and some of their corresponding tributaries for spawning and rearing (Daum 1994, ADF&G 2011a) (Plate 16). During a search for juvenile Chinook, Daum and Flannery (2009) found few instances of spawning Chinook salmon in the upper Yukon River drainage within Alaska. In 1985, juvenile Chinook salmon were rearing in most clear water tributary streams of YUCH (Daum and Flannery 2011a, Daum unpublished data). According to AWC points, the Nation, Charley, and Seventymile Rivers contain spawning chum salmon, and chum salmon are present in the Kandik River (ADF&G 2011a) (Plate 17). Coho salmon are only considered present within the boundaries of YUCH on the Yukon River; no AWC points have confirmed spawning or rearing in YUCH (ADF&G 2011a) (Plate 18).

Whitefish are present in the Yukon River within the boundaries of YUCH (Plate 19) (ADF&G 2011a). The AWC does not identify species of whitefish found within the boundaries of YUCH, but the points for whitefish may represent possible distribution of Bering cisco. Brown et al. (2007) found six species of whitefish at the middle Yukon River sampling point and five species of whitefish at the upper Yukon River sampling point, both including Bering cisco (Figure 54). The first Canadian record of Bering cisco in the Yukon River occurred 2,150 km from the sea in 1981 (deGraaf 1981, as cited in Brown et al. 2007). The route to Canada along the Yukon River passes through YUCH, and Bering cisco occupied areas of YUCH in 1981. However, juvenile Bering cisco were absent within the preserve, showing that the species rears in the ocean, defining the species as anadromous (Brown et al. 2007).

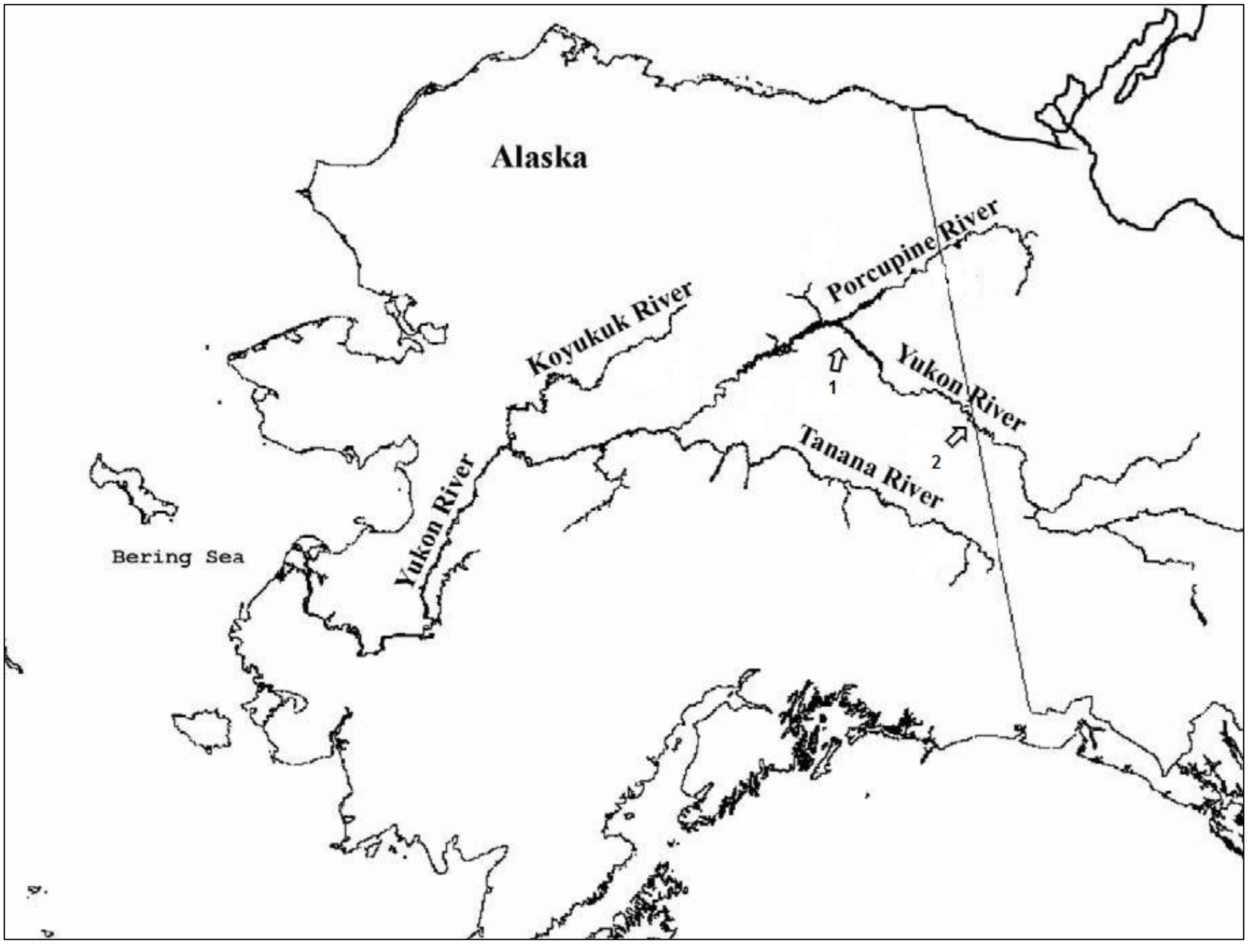


Figure 54. Two sampling locations most relevant to YUCH from the research conducted in Brown et al. 2007: (1) middle Yukon River (1,700 river km from the Bering Sea), and (2) upper Yukon River (2,000 river km).

Threats and Stressor Factors

Subsistence and Sport Harvest

Monitoring salmon harvest numbers is difficult for management because subsistence fishers are not required to report their harvest within the Yukon River drainage. The ADF&G conducts a voluntary participation survey to estimate subsistence harvest (JTC 2011). In 2010, shorefast sea ice resulted in a later than average start for Chinook salmon migration (JTC 2011). During the 2010 Chinook salmon run, fish numbers were not going to meet escapement goals. Once noticed, subsistence fishermen in subdistrict 5D were asked to practice conservation methods such as; harvesting other species, spreading harvest over the duration of the run, reducing extended sharing, and keeping salmon within their home community (JTC 2011). Unfavorable water conditions and high fuel costs made fishing difficult prior to the shortage in Chinook salmon numbers. Management tried to provide fishermen with the opportunity to continue harvesting locally while practicing conservation.

Sport fisheries, when compared to subsistence, commercial or personal fisheries, have little impact on salmon populations (Burr 2009). The average number of Chinook salmon harvested annually from sport fishing of the Yukon River Management Area was 1,040 from 1977 to 2008 (Howard et al. 2009). From 2005 to 2008, the average Chinook sport harvest declined to 648 fish (Table 32). Despite conservative management techniques, Canadian-origin stocks are notably decreasing (Howard et al. 2009). All sport harvesting of salmon primarily took place in the lower and middle Yukon River drainages (Burr 2009). Burr (2009) found zero sport harvests reported from Fort Yukon, AK to the Canadian Border on the Yukon River during 1998 to 2008 (Figure 53). ADF&G (2011b) reported a 2009 sport harvest from Fort Yukon to the Canadian border of 13 whitefish (no specific report of which species) and zero salmon species.

Table 32. Yukon River Management Area Chinook salmon sport harvest from 1977-2008 (Howard et al. 2009).

Year	Sport Harvest*	Year	Sport Harvest*	Year	Sport Harvest*
1977	156	1988	944	1999	1,023
1978	523	1989	1,053	2000	276
1979	554	1990	544	2001	679
1980	956	1991	773	2002	486
1981	769	1992	431	2003	2,719
1982	1,006	1993	1,695	2004	1,513
1983	1,048	1994	2,281	2005	483
1984	351	1995	2,525	2006	739
1985	1,368	1996	3,151	2007	960
1986	796	1997	1,913	2008	409
1987	502	1998	6,54		

*Sport fish harvest for the Alaskan portion of the Yukon River drainage. Most of this harvest is believed to have been taken within the Tanana River drainage (not within the preserve).

Annual commercial harvests of Chinook salmon in the Yukon River recently (2005-2009) decreased to around 23,000 from earlier (1989-1998) annual harvests of 100,700 fish (Howard et al. 2009). No directed commercial fishing for Chinook salmon occurred in 2008 or 2009 to promote population growth (Howard et al. 2009).

Habitat Loss

Daum and Flannery (2009) identify several potential threats to freshwater habitat in the upper portion of the Yukon River Basin within Alaska. These threats include mineral and gravel extraction, oil and gas exploration, hydrokinetic energy development, logging, transportation corridors, and private land development. Past gold mining has resulted in channel morphology changes, an increase in turbidity and sedimentation, denudation of stream bank vegetation, and alteration of flow patterns along the Yukon River (Daum and Flannery 2009).

Recently, Daum (unpublished data) found that most small creeks between Circle and the U.S./Canada border with clear water and a riffle/pool stream type contain rearing age 0 Chinook salmon. However, genetic tests show that all captured juveniles have come from spawning populations in Canada (Daum and Flannery 2011b). This provides evidence that small creeks within YUCH contain rearing habitat for Chinook.

Climate Warming (low H_2O flow)
Warming of surface water and groundwater from potential global climate change could have negative effects on the thermal habitat of freshwater fish. Rising air temperatures cause a direct rise in stream water temperature (Poff et al. 2002). In a climate warming effects study, Eaton and Scheller (1996) found a water temperature rise of 4°C (7°F) would result in almost a 50% loss in suitable habitat for cool or cold water species including Chinook, chum, and coho salmon. Eaton and Scheller (1996) claim, "detrimental environmental conditions caused by climate change, such as reduced stream flow or vegetation changes and reduced shading, will also influence future distribution, and these effects could likewise be magnified for species with the smallest initial distribution." Warmer temperatures would cause snowmelt to shift spring peak flows to earlier in the winter (Frederick and Gleick 1999). Increased streamflow and water velocity in winter and early spring decrease the areas where salmon can conserve energy, limiting the success of salmon returning to native spawning regions (Hinch et al. 1995). Warmer temperatures causing precipitation in the form of rain instead of snow will result in less snow runoff and lower stream levels in late summer. Minimized summer baseflow will result in less in-stream habitat for fish (Frederick and Gleick 1999). Reduced water flow or change in discharge or water quality in rivers where Bering cisco are known to spawn could limit or threaten future populations (COSEWIC 2004).

Data Needs/Gaps
No anadromous species population estimates exist within YUCH. The escapement measured at Eagle, AK only shows a representation of fish that pass through YUCH. The distribution estimates come from the AWC complied by the ADF&G. The AWC requires at least two appropriate fish be found in order to represent a location of known spawning or rearing. Data collection periods vary for surveying new AWC locations, but even with more extensive data collections, Daum (pers. comm., 2011) expects the efforts will probably not reveal any large anadromous fish populations, since in all likelihood there are not any large populations present. The majority of non-natal streams in the upper U.S. portion of the Yukon River drainage have not been surveyed for rearing habitats of juvenile Chinook salmon (Daum and Flannery 2009). At present, self-sustaining populations of anadromous fish have not been found in YUCH (Daum, pers. comm., 2011). Due to the lack of sustainable populations, agencies tend to not create management strategies for the anadromous species in those areas. Specific case studies of habitat loss for the preserve have not been conducted.

Overall Condition

Population Size
The project team assigned a *Significance Level* of 3 for this measure. A reference condition to base the current measurements of anadromous species against is not developed. Without past and current population numbers, it is not possible to measure the trend and current condition of anadromous species inside YUCH waters. The Eagle sonar station provides estimates of salmon species passing through YUCH via the main-stem Yukon River, but no estimates have been produced for anadromous species specifically in YUCH waters. Despite the lack of baseline or reference information that defines some natural variability in anadromous fish species stocks, there is a specific concern regarding Chinook stocks on the Yukon River because escapement goals for fish entering Canada have not been met three out of the last four years. It is unclear what this means for the status of anadromous fish as they relate specifically to YUCH habitat. The *Condition Level* for YUCH anadromous species is 2, indicating moderate concern, based on the previous years of missed escapement goals.

Distribution
The project team defined the *Significance Level* for distribution as a 3. The AWC points are the most complete form of data to represent the distribution of anadromous species in the preserve. Chinook salmon are rearing within YUCH, and in 2009, a few instances of spawning Chinook salmon were found within the preserve. In 1985, several studies found Chinook salmon rearing in most clear water tributaries within YUCH. The distribution of anadromous species in YUCH is of low concern (*Condition Level Score* = 1). Insufficient historic data for YUCH makes the current trend of distribution difficult to assess.

Weighted Condition Score
The Weighted Condition Score (WCS) for anadromous fish species is 0.500, indicating the condition is of moderate concern. Insufficient historic range data for escapement and distribution make it impossible to determine whether the condition is stable, increasing, or decreasing.

NATIONAL PARK SERVICE

Anadromous Species

Measures	SL	CL
• Population size	3	2
• Distribution	3	1

WCS = 0.500

Sources of Expertise
David Daum, Fisheries Biologist, U.S. Fish and Wildlife Service.

Literature Cited

Alaska Department of Fish and Game (ADF&G). 2011a. Anadromous waters catalog. Online. (http://www.adfg.alaska.gov/sf/SARR/AWC/). Accessed 11 April 2011.

Alaska Department of Fish and Game (ADF&G). 2011b. Alaska sport fishing survey. Online. (http://www.adfg.alaska.gov/sf/sportfishingsurvey/index.cfm?ADFG=area.home). Accessed 28 April 2011.

Andersen, D. B. 1992. The use of dog teams and the use of subsistence-caught fish for feeding sled dogs in the Yukon River Drainage, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Juneau, Alaska.

Brown, R. J., N. Bickford, and K. Severin. 2007. Otolith trace element chemistry as an indicator of anadromy in Yukon River drainage coregonine fishes. Transactions of the American Fisheries Society 136:678-690.

Burr, J. 2009. Fishery management report for sport fisheries in the Yukon Management Area, 2008. Fishery Management Report No. 09-51. Alaska Department of Fish and Game, Anchorage, Alaska.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2004. COSEWIC assessment and update status report on the Bering cisco (*Coregonus laurettae*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.

Crane, A. B., and R. D. Dunbar. 2009. Sonar estimation of Chinook and fall chum salmon passage in the Yukon River near Eagle, Alaska, 2008. Fisher Data Series No. 09-30. Alaska Department of Fish and Game, Anchorage, Alaska.

Daum, D. W., and B. G. Flannery. 2009. Canadian-origin Chinook salmon rearing in non-natal U.S. tributary streams of the Yukon River, Alaska, 2006-2007. Alaska Fisheries Technical Report Number 102. U.S. Fish and Wildlife Service, Fairbanks, Alaska.

Daum, D. W. 1994. Fisheries investigations on the Kandik, Charley, Nation, and Tatonduk rivers, Yukon-Charley Rivers National Preserve, 1987 and 1988. Alaska Fisheries Technical Report Number 23. U.S. Fish and Wildlife Service, Fairbanks, Alaska.

Daum, D. W., and B. G. Flannery. 2011a. Canadian-origin Chinook salmon rearing in nonnatal U.S. tributary streams of the Yukon River, Alaska. Transactions of the American Fisheries Society 140:207-220.

Daum, D. W., and B. G. Flannery. 2011b. Stock composition of age-0 Chinook salmon rearing in nonnatal U.S. tributary streams of the Yukon River. Yukon River Panel Restoration and Enhancement Fund, Whitehorse, Yukon Territory.

deGraaf, D. A. 1981. First Canadian record of Bering cisco at Dawson, Yukon Territory. Canadian Field-Naturalist 95:365.

Eaton, J. G., and R. M. Scheller. 1996. Effects of climate warming on fish thermal habitat in streams of the United States. Limnology & Oceanography 41(5):1109-1115.

Eggers, D. M., M. D. Plotnick, and A. M. Carroll. 2010. Run forecasts and harvest projections for 2010 Alaska salmon fisheries and review of the 2009 season. Special Publication No. 10-02. Alaska Department of Fish and Game, Anchorage, Alaska.

Frederick, K. D., and P. H. Gleick. 1999. Water and global climate change: potential impacts on U.S. water resources. Pew Center on Global Climate Change, Arlington, Virginia.

Hinch, S. G., M. C. Healey, R. E. Diewert, K. A. Thomson, R. Hourston, M. A. Henderson, and F. Juanes. 1995. Potential effects of climate change on marine growth and survival of Fraser River sockeye salmon. Canadian Journal of Fisheries and Aquatic Sciences 52:2651-2659.

Howard, K. G., S. J. Hayes, and D. F. Evenson. 2009. Yukon River Chinook salmon stock status and action plan 2010; a report to the Alaska Board of Fisheries. Special Publication No. 09-26. Alaska Department of Fish and Game, Anchorage, Alaska.

Johnson, J. 2011. Unpublished data. Anadromous waters catalog draft data additions. Alaska Department of Fish and Game. Received February 2011.

Joint Technical Committee of the Yukon River US/ Canada Panel (JTC). 2011. Yukon River salmon 2010 season summary and 2011 season outlook. Regional Information Report No. 3A11-01. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska.

Poff, L. N., M. M. Brinson., and J. W. Day. 2002. Aquatic ecosystems & global climate change: Potential impacts on inland freshwater and coastal wetland ecosystems in the United States. Pew Center on Global Climate Change, Arlington, Virginia.

Schwatka, F. 1893. A summer in Alaska. J.W. Henry Publishing, St. Louis, Missouri.

Walker, R. J., E. F. Andrews, D. B. Andersen, and N. Shishido. 1989. Subsistence harvest of Pacific salmon in the Yukon River Drainage, Alaska, 1977-88. Technical paper No. 187. Alaska Department of Fish and Game, Division of Subsistence, Juneau, Alaska.

Zagoskin, L. A. [1847] 1967. Lieutenant Zagoskin’s travels in Russian America, 1842-44. H. M. Michael, ed. University of Toronto Press, Toronto, Ontario.

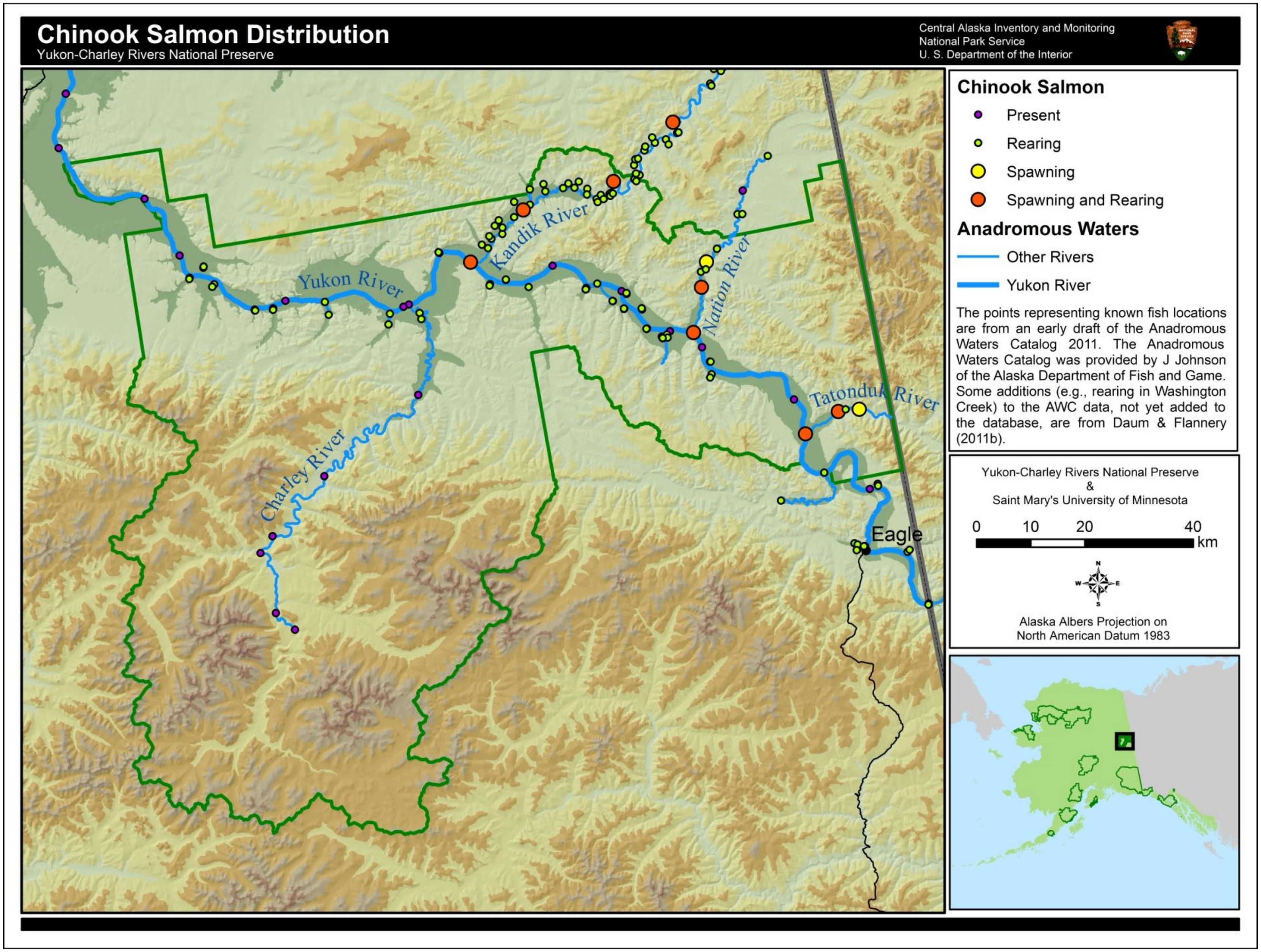


Plate 16. Presence, rearing, and spawning locations of Chinook salmon within YUCH (Johnson 2011).

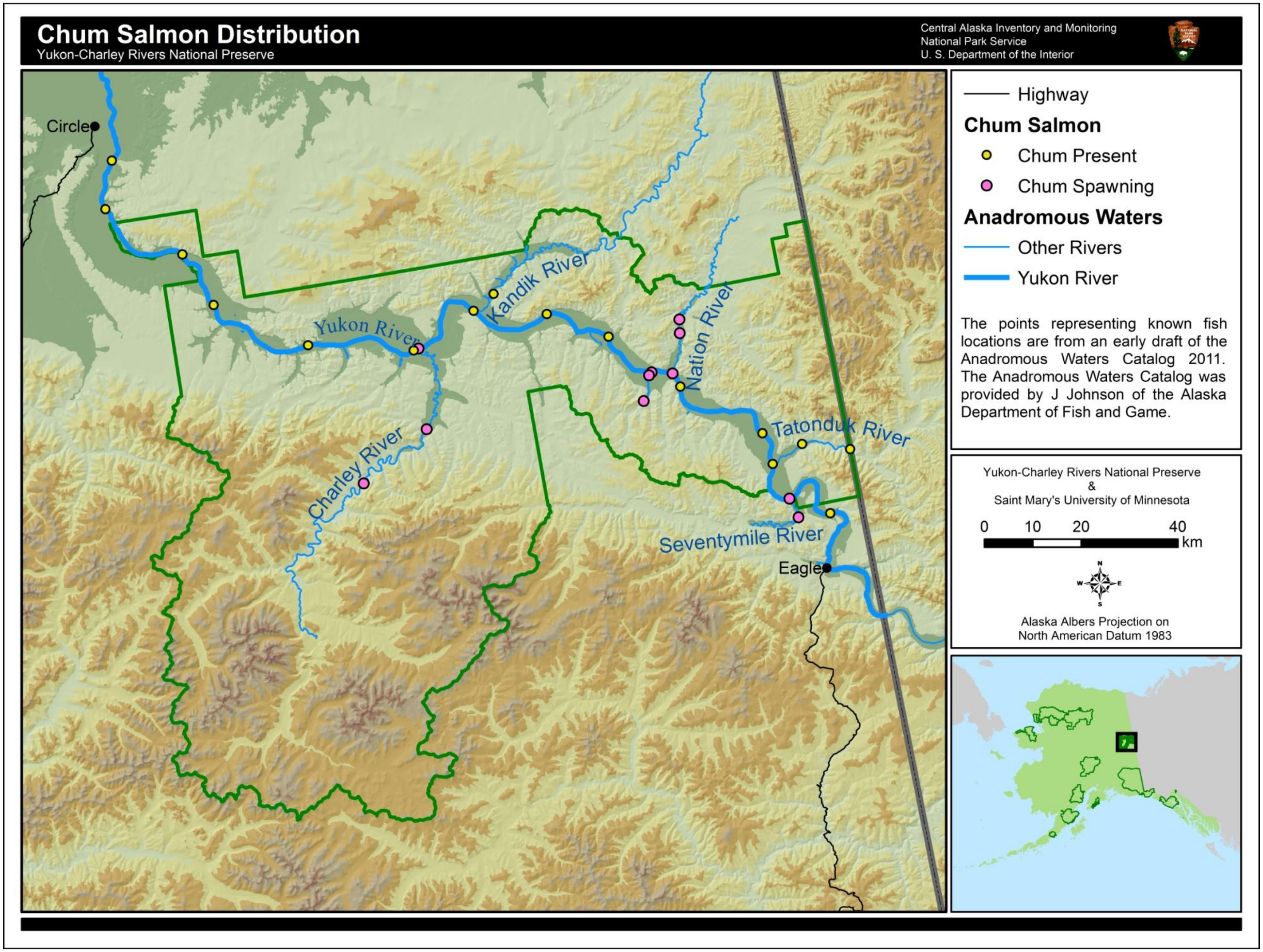


Plate 17. Presence and rearing locations of chum salmon within YUCH (Johnson 2011).

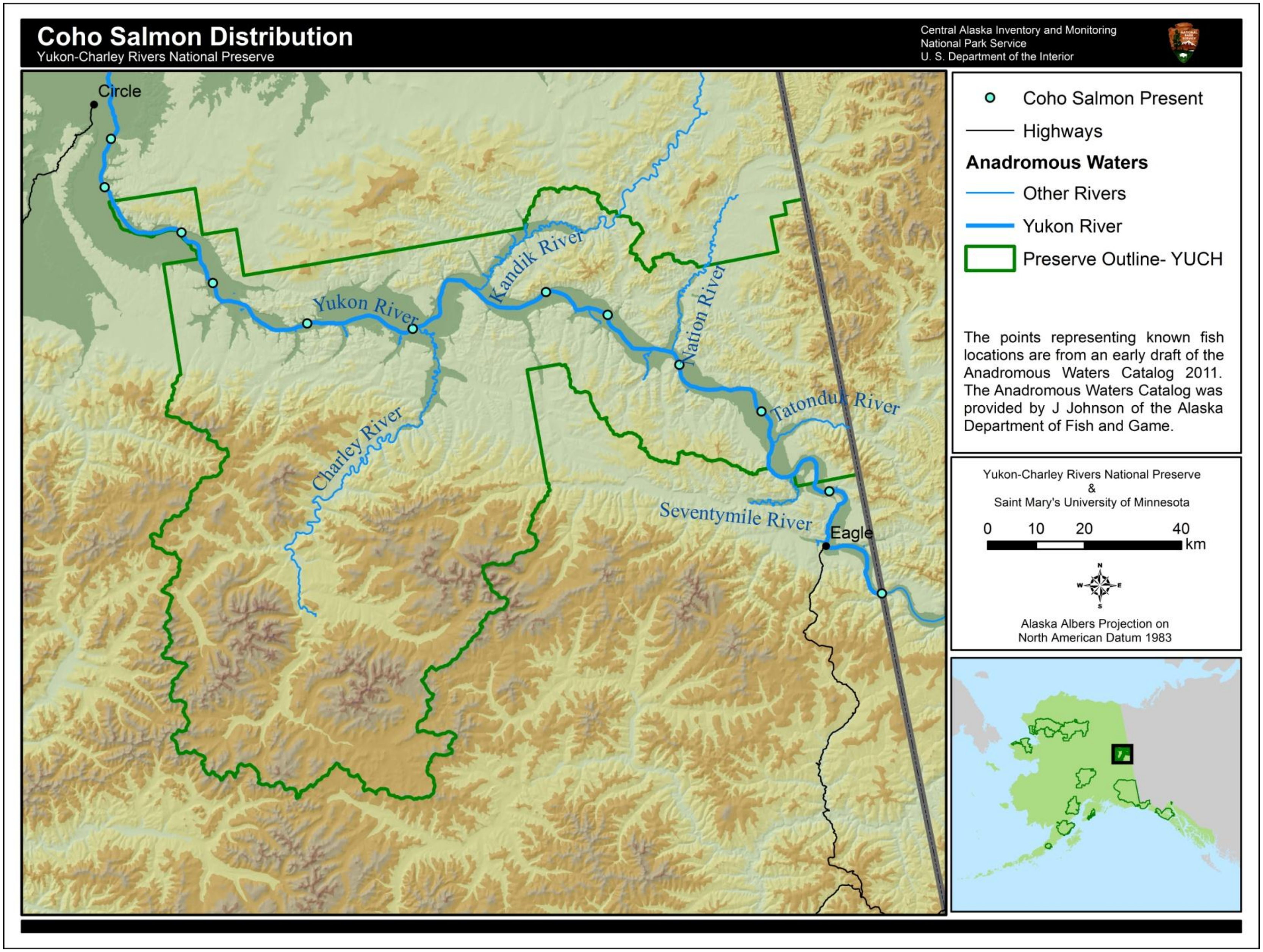


Plate 18. Presence locations of coho salmon with YUCH (Johnson 2011).

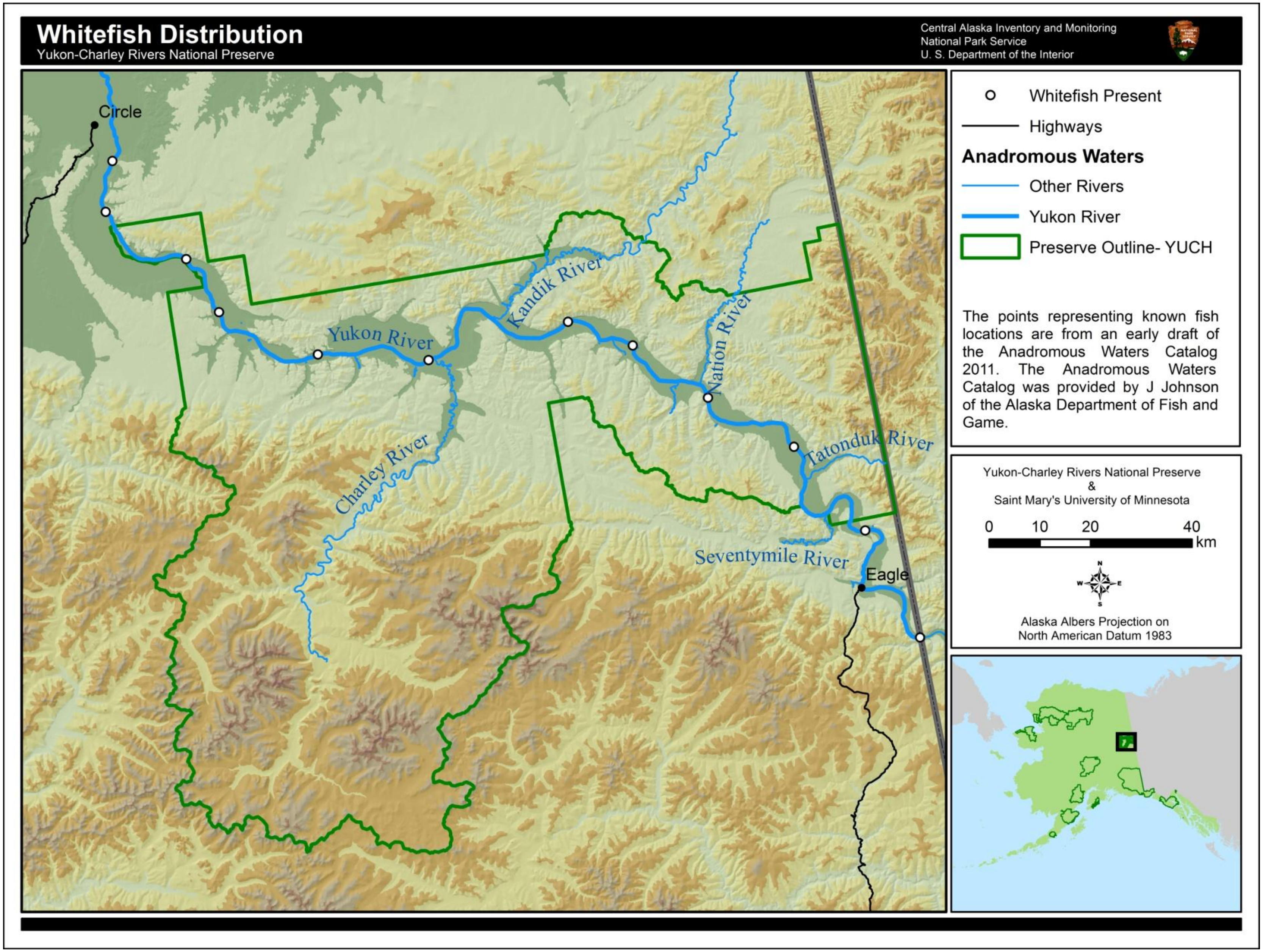


Plate 19. Presence of whitefish locations within YUCH (Johnson 2011).

4.16 Wood Frogs and Boreal Toads*

* During initial project scoping, project stakeholders identified wood frogs and boreal toads as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data are not summarized nor condition assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

Six amphibian species are native to Alaska, including the wood frog (*Rana sylvatica*) and the boreal toad (*Anaxyrus boreas boreas*), also known as the western toad (ADF&G 2011). Five out of the six native amphibians are found primarily in the southeast panhandle of Alaska and the coastal areas of the Prince William Sound (Hodge 1976, Anderson 2004, MacDonald 2010). The wood frog is the only amphibian found north of the Arctic Circle, and is distributed widely across Alaska (MacDonald 2010). The wood frog is commonly associated with interior forests of Alaska, and utilizes a variety of vegetation types, including grassy meadows to open forest, muskeg, and tundra (MacDonald 2010). The ability of the wood frog to withstand freezing is essential to its survival in YUCH; 65% of the water in the frog's body becomes ice during the winter when it hibernates (MacDonald 2010).

Photo 27. Boreal toad (ADF&G photo)

Photo 28. Wood frog (ADF&G photo by J.R. Hopkins).

The boreal toad is a common amphibian in southeast Alaska, and has been found as far north as Prince William Sound (Broderson and Tessler 2008). The toad is primarily a terrestrial species, found near freshwater in woodlands, meadows, wetlands, or marshes. Boreal toads prefer permanent or temporary water bodies with a sandy bottom for breeding (Broderson and Tessler 2008). According to the NPS certified species list for YUCH, only the wood frog has been documented in the preserve.

Amphibians act as key indicator species for ecosystems as they are especially susceptible to ecological changes, such as an introduction or increase of toxins in the environment, due to their permeable skin (Smith and Keinath 2007).

Because amphibians have very specific habitat requirements, they may be especially sensitive to threats posed by habitat change and climate change.

Measures

- Distribution
- Mutation rates

Reference Conditions/Values

The reference condition for wood frogs and boreal toads in YUCH is population abundance and distribution that is within the range of natural variability.

Data and Methods

There are no data specifically related to wood frogs or boreal toads in YUCH.

Current Condition and Trend

<u>Distribution</u>

There have been no estimates on the abundance and distribution of the wood frog or boreal toad within YUCH. Larsen (pers. comm., 2011) notes that abundance estimates may be very difficult to attain. The status of the boreal toad appears to be stable in Alaska overall; however, the species has declined significantly throughout its range in the contiguous United States (Broderson and Tessler 2008). There is concern that boreal toad populations in Alaska may currently be experiencing similar declines (MacDonald 2010).

The wood frog is a broadly distributed amphibian in Alaska and is the most common frog species in the state (Broderson and Tessler 2008, MacDonald 2010). The wood frog is monitored by the AKNHP's Alaska Wood Frog Monitoring Project, a volunteer-based (citizen science) program intended to assess wood frog status in southcentral and interior Alaska (AKNHP 2011).

According to GIS data from the AKNHP, three elemental occurrences (EOs) of wood frogs fall within YUCH. Surveys first occurring in 2001 documented wood frogs 200 km northeast of Delta Junction, Slaven's Cabin, Coal Creek, Yukon River, Andrew Creek Flats; Coal Creek, McGregor Cabin; and at the mouth of Coal Creek across from Woodchopper road.

<u>Mutation Rates</u>

Trust and Tangermann (2002) found abnormalities in Alaska National Wildlife Refuge amphibians; the abnormalities included missing, shrunken, or misshapen limbs, or abnormal eyes. Expected abnormality rates for wild populations of wood frogs are 0-2% (Ouellett 2000). The Trust and Tangermann (2002) study found higher rates; overall, 8.6% of sampled frogs were abnormal in the Kenai National Wildlife Refuge. Reasons for these abnormalities are unclear and are under further research. No information is available on abnormalities of wood frogs within YUCH.

<u>Threats and Stressor Factors</u>

During initial project scoping, YUCH resource specialists identified habitat change and climate warming as global threats to wood frogs and boreal toads in YUCH. Climate warming may contribute to shifts in natural processes that could impact the abundance and distribution of wood frogs and boreal toads in YUCH.

Additionally, the chytrid fungus *Batrachochytrium dendrobatidis* has been recently reported in wood frogs on the Kenai Peninsula in southern Alaska (MacDonald 2010). The lethal fungus is a potentially significant threat to amphibians in YUCH if it becomes introduced to the preserve.

The cause of physical abnormalities found in frogs sampled in Alaskan National Wildlife Refuges is unknown; a variety of hypotheses exist including chemical contaminants, parasites, ultraviolet radiation, predators, extreme temperatures during development, or a combination of these factors (Broderson and Tessler 2008).

Data Needs/Gaps

A survey of YUCH herpetofauna is needed to provide baseline data on the abundance and distribution of wood frogs and boreal toads in the preserve.

Overall Condition

Because this is a placeholder component, SMUMN GSS staff did not assess the condition of wood frogs and boreal toads in YUCH.

Sources of Expertise

John Burch, YUGA Wildlife Biologist, CAKN

Amy Larsen, YUGA Aquatic Ecologist, CAKN

Literature Cited

Anderson, B. C. 2004. An opportunistic amphibian inventory in Alaska's national parks 2001-2003. National Park Service, Inventory and Monitoring Program, Anchorage, Alaska.

Alaska Department of Fish and Game (ADF&G). 2011. Reptiles and amphibians. Online. (http://www.adfg.alaska.gov/index.cfm?adfg=animals.listreptiles). Accessed 26 July 2011.

Alaska Natural Heritage Program (AKNHP). 2011. Conservation status report – *Rana sylvatica*. Online. (http://aknhp.uaa.alaska.edu/services/aknhp.cfc?method=downloadSpeciesReport&elcode= AAABH01200). Accessed 20 December 2011.

Broderson, K,. and D. Tessler. 2008. Frogs and toads. Online. (http://www.adfg.alaska.gov/static/education/wns/frogs_and_toads.pdf). Accessed 27 July 2011.

Hodge, R. P. 1976. Amphibians and reptiles in Alaska, the Yukon, and Northwest Territories. Alaska Northwest Publishing Company, Anchorage, Alaska.

MacDonald, S. O. 2010. The amphibians and reptiles of Alaska: a field handbook. University of Alaska Museum, Fairbanks, Alaska.

Ouellet, M. 2000. Amphibian deformities: Current state of knowledge. *In* Ecotoxicology of Amphibians and Reptiles. Ed. D.W. Sparling, G. Linder and C.A. Bishop. SETAC Press, Pensacola, Florida.

Smith, B. E., and D. A. Keinath. 2007. Northern leopard frog (*Rana pipiens*): A technical conservation assessment. U.S. Forest Service, Rocky Mountain Region, Golden, Colorado.

Trust, K. A., and H. Tangermann. 2002. National malformed amphibian study. FY2000: Kenai National Wildlife Refuge, annual progress report. U.S. Fish and Wildlife Service, Anchorage, Alaska.

4.17 Native Plant Communities

Description

Yukon-Charley Rivers National Preserve contains a diverse landscape that supports a wide variety of temperate, boreal, and arctic plant species, due to its unique geology, hydrology, and strong continental climate. These factors, along with the vital role played by fire, create a complex mosaic - a "virtual patchwork quilt" – of plant communities across the preserve (Larsen et al. 2004, p. 1). Along the Yukon River, steep bluffs are home to a unique steppe community with many rare and endemic species. South of the river there is an area of rolling hills covered with forests typical of the northern boreal forest or "taiga" biome, consisting of spruces and several hardwood species. Sites with poor drainage are too wet for trees and support tussock-forming sedges and grasses with plants more characteristic of northern Alaska. Rugged mountains dominated by shrub and alpine tundra exist south of the preserve's rolling hills and north of the Yukon River.

Photo 29. Taiga and wetlands near the Yukon River in YUCH National Preserve (NPS photo by A. Larsen).

Fire is the dominant natural disturbance in the preserve and is of critical importance in the development and succession of its boreal forests. At least 70% of YUCH is subject to periodic wildfires with nearly all ignitions coming from lightning (Larsen et al. 2004). These fires release trapped nutrients which leads to higher primary production rates and increased reproductive rates in vascular plants. The removal of surface organic material also allows the ground to warm, lowering the permafrost table and causing an increase in overall ecosystem productivity that can last for 25 to 50 years (Larsen et al. 2004). Burned areas are rapidly colonized by early successional herbaceous species. Within a few years early successional trees such as willow, aspen, and birch appear. Over time spruce trees become reestablished, although in some areas birch and aspen stands will remain. Flooding is also an important source of disturbance in the floodplains of the Yukon River and its tributaries (Larsen et al. 2004).

The glacial history of YUCH contributes greatly to an understanding of its native plant communities. Most of the preserve escaped the Pleistocene glaciations, which peaked roughly 25,000 years ago. Evidence suggests that only 20% of the Yukon-Tanana Uplands around the headwaters of the Charley River were glaciated (Larsen et al. 2004). As a result, the preserve is known to contain many plant species endemic to Beringia, the ice-free land mass that stretched from present-day eastern Siberia to western Canada until 15,000 years ago. YUCH also supports a number of species endemic to the Alaska-Yukon area.

For the purpose of vascular plant research, the preserve can be divided into three physiographic regions: river floodplain, Ogilvie Mountains, and Yukon-Tanana Uplands (Figure 55; Larsen et al. 2004). The river floodplain consists of the floodplain of the Yukon River and its major tributaries. Vegetation in this region is strongly influenced by seasonal flooding, erosion, and deposition. The Ogilvie Mountains region includes all land north of the river floodplain, while the Yukon-Tanana Uplands covers the land south of the river floodplain.

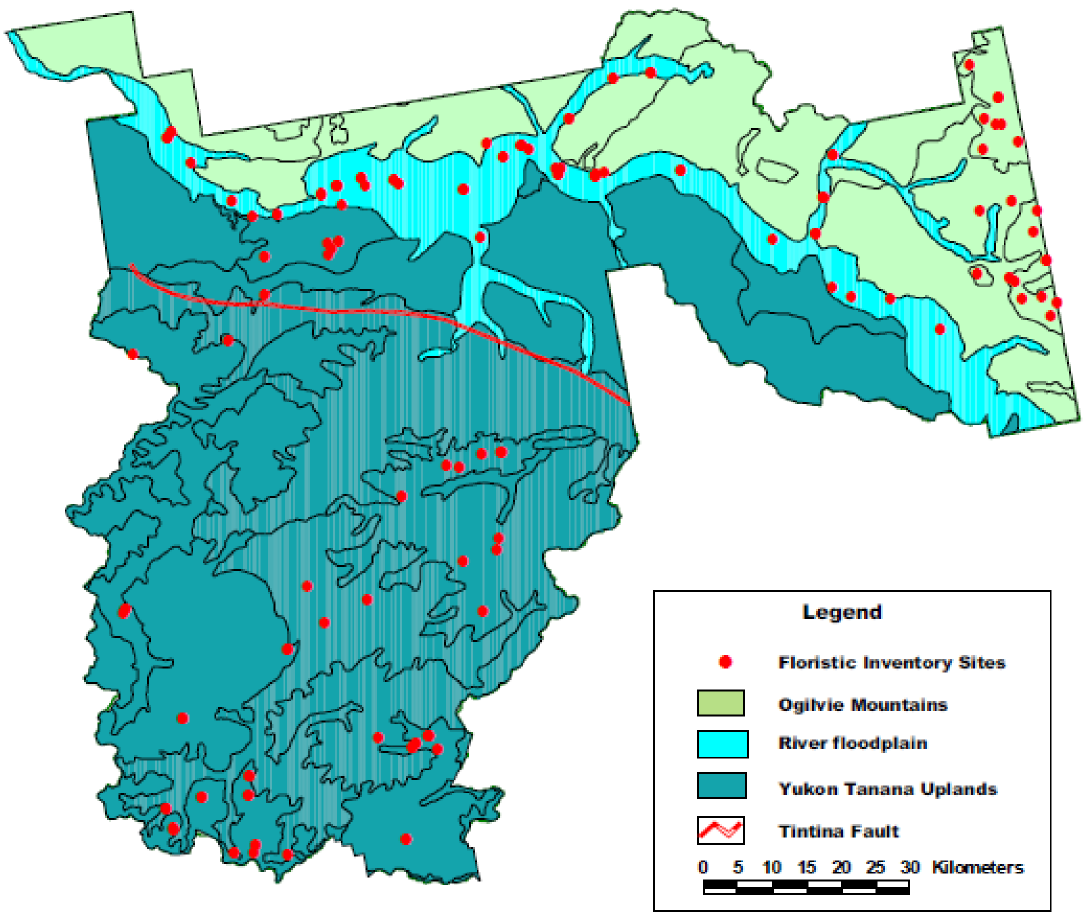


Figure 55. The three physiographic regions of YUCH and sites inventoried in 2002 (Larsen et al. 2004).

Measures

- Plant species composition as measured in vegetation monitoring program
- Status of rare and unique species
- Species distribution
- Summary of landcover by ecological subsection

Reference Conditions/Values

In 2002, all the existing floristic data for YUCH was compiled into a database so that gaps could be identified and addressed with inventory fieldwork. The inventory that followed provided the most comprehensive record of the preserve's native plant communities and will be used as the reference condition for our assessment.

Data and Methods

YUCH and CAKN staff provided the initial vascular plant inventory report (Larsen et al. 2004) and other relevant literature.

USFS forest health protection reports for Alaska were obtained online, and GIS datasets (AKDNR 2010) representing documented forest damage by agent (insect or disease) are summarized for select pests. These data were created from ocular estimates of damage agents during state-wide aerial surveys in the months of July and August.

Current Condition and Trend

<u>Plant Species Composition as Measured in Vegetation Monitoring Program</u>
Species richness is known to be high in YUCH. The 2002 inventory recorded 551 species and 27 subspecies, including 227 newly documented taxa. This brought the total number of vascular plant species known in the preserve to 631, plus 43 known subspecies, for a total of 674 known taxa (Larsen et al. 2004). In comparison, Denali National Park (three times the size of YUCH) has 816 documented taxa, while Wrangell-St. Elias National Park at five times the size of YUCH has 887 documented taxa. The most species rich families within the preserve are Cyperaceae with 73 species, Asteraceae with 56 species, and Poaceae with 46 species (Larsen et al. 2004).

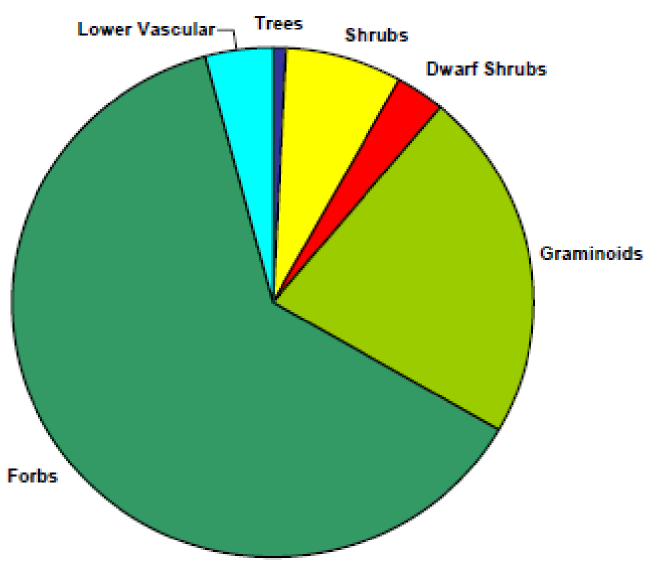


Figure 56. Percentage of YUCH's vascular flora occurring in six different growth forms (Larsen et al. 2004).

Trees were found to make up just 1% of the total vegetation at YUCH (Figure 56). Shrubs and dwarf shrubs comprised a slightly higher 8%. The dominant growth form was forbs, making up 62% of total vegetation, with graminoids at 22% and lower vascular plants comprising the remaining 4% (Larsen et al. 2004).

Six floristic elements have been identified within the preserve; numbers in parentheses indicate percent of total vegetation (Figure 57; Larsen et al. 2004):

> 1) Circumpolar species (31.4%) – these plants occur on all polar land masses including Europe, Asia, Greenland, and North America. The group can be further divided into four categories: boreal species, arctic/alpine species, species that occur in both boreal and arctic habitats, and exotic species.
> 2) Incompletely circumpolar species (16.4%) – this group is found in boreal areas of polar land masses in Asia and North America but not in Europe and Greenland.
> 3) North American species (22.5%) – these plants are generally restricted to North America. Within this group there are some species found only in the western mountains (called Cordilleran species) and some that are typically limited to the Pacific coastal area.
> 4) Alaska-Yukon endemic species (5.4%) – these species are found only in Alaska and northwestern Canada.
> 5) Amphiberingian species (23.3%) – this group is known only from parts of North America and northern Asia that were part of Beringia.
> 6) Amphiatlantic species (0.7%) – these species occur in North America, Greenland, and Europe, but have not been found in Asia.

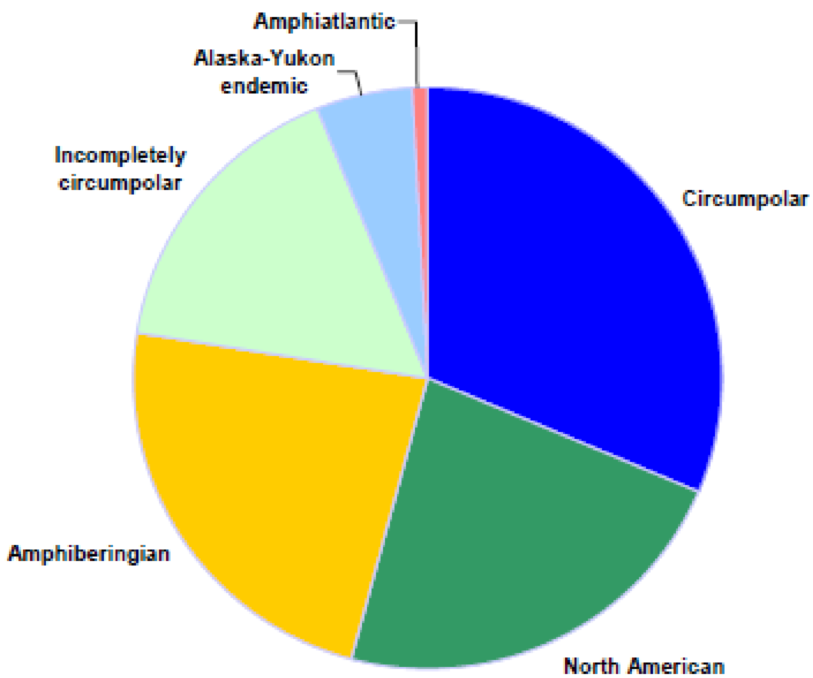


Figure 57. Percentage of YUCH's vascular flora in each of six floristic elements (Larsen et al. 2004).

Major range extensions of 200 km or more were documented for 19 of the collected plant species, with minor range extensions (70-199 km) for an additional 20 species. Sixty percent of these range extensions were for wetland species (Photo 30).

Photo 30. *Sagittaria cuneata* (left) and *Scirpus validus* (right) are just two of the wetland species with range extensions, 200 and 180 km respectively, as a result of the YUCH vascular plant inventory (NPS photos by A. Larsen).

Status of Rare and Unique Species

The 2002 inventory collected 19 new plant species recognized as rare in Alaska by the Alaska Natural Heritage Program, bringing the total number of known rare species within YUCH to 49 (Appendix 25). In comparison, Denali National Park has recorded 52 rare species and Wrangell-St. Elias contains 69 rare species. Fifteen of the new species are considered globally imperiled (Larsen et al. 2004). Fourteen of the new species were wetland plants, an area that had previously been greatly understudied.

Rare species were found to be distributed throughout the preserve: 26.1% in the Ogilvie Mountain region, 34.7% in the river floodplains, and approximately 39.2% in the southern Yukon-Tanana Uplands (Larsen et al. 2004). Of the six floristic elements, North American species made up the greatest portion of rare species with 39.6%. Alaska-Yukon endemics comprised 22.9% of rare species. The remaining rare species were incompletely circumpolar (14.6%), amphiberingian (10.4%), circumpolar (8.3%), and amphiatlantic (4.2%). Surveyors noted that North American species and Alaska-Yukon endemics comprised a much higher percentage of rare plants than of total plant species (Larsen et al. 2004).

Thirty-nine Alaska-Yukon endemic species have been recorded in YUCH. In comparison the much larger Wrangell-St. Elias National Park has recorded only 19 Alaska-Yukon endemics. Of the Alaska-Yukon endemics recorded in the preserve, 20 occurred in the Ogilvie Mountains, 22 in the Yukon-Tanana Uplands, and just five in the river floodplain. Fifty-one amphiberingian endemics have been collected in the preserve. The much larger Denali National Park has 52 recorded amphiberingian endemics. Of the amphiberingian endemics in YUCH, 32 species occurred in the Ogilvie Mountains, 41 in the Yukon-Tanana Uplands, and six in the river floodplain. The scarcity of endemic species in the preserve's river floodplains is attributed to that landscape's youth compared to the other two regions and its frequent disturbances (Larsen et al. 2004).

Species Distribution (rare and endemic)

Forty species within the preserve have a state heritage rank of S3 or below (rare or imperiled in Alaska). Based on inventories at 135 unique sites, 14 of these species were found in a single physiographic region and 16 were distributed across multiple ecological regions. Inventory sites containing species with a state rank of less than S3 in the inventory data are displayed in Plate 20. Location information was not available for the remainder of the rare species (14 in total) found in the preserve prior to the 2002 inventory. This representation only shows the primary sites where rare and endemic species have been found by plant inventory efforts. Rare plant species by their nature are difficult to locate and to understand changes in their distribution.

Summary of Landcover by Ecological Subsection

In 1999, the NPS Inventory and Monitoring Program developed a baseline ecological map of the preserve, dividing it into 14 ecological subsections (Swanson 2001). The subsections divided sharply along the Tintina Fault. Nine subsections are found north of the fault, four to its south, and one straddles the fault line. A summary of landcover types (including vegetation) by ecological subsections in Swanson (2001) is included in Chapter 4.1.

Threats and Stressor Factors

Invasive and Non-native Plants (seed sources, vectors for spread, effects of climate change)

The first report of introduced plant species in the Yukon-Charley Rivers area came in 1976 (Larsen et al. 2004). At this time two species were observed in disturbed areas along the Yukon that are still present in the preserve today: *Polygonum aviculare* and *Plantago major*. An exotic plant survey conducted by the U.S. Geological Survey in 2002 found five non-native species around developed areas of the preserve: *Chenopodium album*, *Matricaria discoidea*, *Plantago major*, *Taraxacum officinale*, and *Tripleurospermum inordorum* (McKee 2002). *P. major* was found at disturbed sites throughout the preserve while distribution of the other species was spotty. These areas were resurveyed in 2005. One species, *Tripleurospermum inordorum* (also known as *T. perforata*), was not relocated, but the other four had increased in abundance and distribution (Heys and Bauder 2005). Several new invasive species were also found, including *Crepis tectorum* (Photo 31); however, no non-native plants were found more than 5 meters from a trail edge or developed area (Heys and Bauder 2005).

Surveys in 2008 and 2010 led to the discovery of four more invasive species, bringing the total number of invasive species known within the preserve to 15 (Table 33; Passmore and Sherman 2010). Of most concern was the discovery of the particularly aggressive *Vicia cracca* in 2010 (Photo 31). This species has the potential to disturb the growth of native vegetation throughout YUCH, and the vine's ability to climb could harm the historical buildings within the preserve (Passmore and Sherman 2010).

Photo 31. Narrowleaf hawksbeard (*Crepis tectorum*) (left) and bird vetch (*Vicia cracca*) (right) in YUCH (NPS photos).

Table 33. Non-native invasive species documented in YUCH, with dates of first documentation and Alaska invasiveness rankings (Passmore and Sherman 2010, Larsen et al. 2004).

Scientific name	Common name	First documented	Invasiveness ranking
Plantago major	Common plantain	1976	44
Polygonum aviculare	Prostrate knotweed	1976	45
Taraxacum officinale	Common dandelion	2002	58
Chenopodium album	Common lambsquarter	2002	37
Matricaria discoidea	Pineapple weed	2002	32
Bromus inermis ssp. *inermis*	Smooth brome grass	2005	62
Crepis tectorum[1]	Narrowleaf hawksbeard	2005	54
Capsella bursa-pastoris	Shepherd's purse	2005	40
Lepidium densiflorum	Common pepperweed	2005	25
Stellaria media	Common chickweed	2005	42
Elymus repens	Quackgrass	2005	59
Poa annua	Annual bluegrass	2008	46
Rumex acetosella	Common sheep sorrel	2008	51
Trifolium hybridum	Alsike clover	2008	57
Vicia cracca	Bird vetch	2010	73

[1] The ranking of *Crepis tectorum* was scheduled to be reconsidered in the fall of 2010 due to field observations of its invasiveness. Invasiveness rankings listed here are according to the Alaska Exotic Plant Information Clearinghouse (AKEPIC 2010) database.

During the 2010 field season, an NPS exotic plant management team (EPMT) surveyed 44.5 ha (110 ac) of YUCH, finding a total of 4.6 ha (11.3 ac) infested with invasive plants and treating 0.54 ha (1.34 ac) of these infestations (Passmore and Sherman 2010). Inventory efforts have focused on the Coal Creek drainage OHV trails, primarily during the 2005 field season. Other EPMT survey efforts focused on several locations (e.g., public use cabins and take-outs along the

Yukon River) during 2008. In 2010, EPMT inventory and treatment efforts focused on three areas: Coal Creek Camp, Slaven's Roadhouse, and public use areas along the Yukon River corridor (Passmore and Sherman 2010). However, Passmore and Sherman (2010) noted reduced effectiveness of float surveys on the Yukon River due to flooding and debris.

Invasive plants may be introduced to the preserve by natural sources such as wildlife or rivers, but they are more likely transported by human activities (e.g., boating, dog sledding, sport hunting and subsistence activities) (Passmore and Sherman 2010). Within the preserve, invasive species are currently found in areas most frequently utilized by visitors, such as airstrips and public cabins. Airstrips are an area of increasing concern since many of the visitors arriving by plane depart from Fairbanks, which is increasingly infested with invasive plant species (Heys and Bauder 2005).

Annual average air temperatures and precipitation are predicted to increase in the preserve over the next century (SNAP et al. 2009). However, evapotranspiration is also expected to increase, resulting in overall drier conditions. Warmer temperatures are also likely to contribute to a longer growing season. These changes may favor non-native plants over native species that are adapted to the current climatic conditions in the preserve.

Willow Leaf Blotch Miner (Micrurapteryx salicifoliella)

The 2009 forest conditions survey found that willow leaf blotch miner (WLM) activity nearly doubled from the previous year statewide (USFS 2010). In reviewing forest damage GIS data from the USFS's aerial survey efforts, WLM damage covered approximately 770 ha (1,900 ac) in YUCH during 2007 surveys, 2,600 ha (6,500 ac) in 2009, and 6,300 ha (15,500 ac) in 2010 (the area was not surveyed in 2008 due to inclement weather). Most of the activity was detected along the Yukon River in the preserve; however, it is important to note that the survey flight-lines vary from year to year. Damage from WLM is typical in interior Alaska and is characterized by relatively large year-to-year population fluctuations. Studies have been initiated or proposed to research the effects this insect may be having on different willow species, as well as any secondary ecological effects or natural enemies. Since willow is an important browse source for moose, one of the major concerns is how the defoliated branches compare in their nutritional value to normal willow branches. Evidence suggests that felt-leaf willow, one of the major browse species, is not significantly impacted by leaf blotch miner (USFS 2010).

Spruce Beetles

The spruce beetle (*Dendroctonus rufipennis*) has been identified as the most significant mortality agent of white spruce in interior Alaska (USFS 2009). According to the forest damage GIS data, the area of detected (via aerial surveys) spruce beetle damage in YUCH has increased in recent years. In 2007, more than 2,000 ha (5,000 ac) of beetle activity was observed along the Yukon River in YUCH. An aerial survey of YUCH did not occur in 2008, but in 2009, the estimated damage area increased to 11,250 ha (27,800 ac). Finally, in 2010 the damage area was approximately 13,500 ha (33,500 ac). In interior Alaskan spruce forests, the spruce beetle often works in concert with the northern spruce engraver beetle (*Ips perturbatus*). At high populations, however, *Ips* will readily attack healthy trees (USFS 2010). In 2009, northern spruce engraver beetle activity declined in Interior Alaska, but evidence of damage was reported in the preserve. A similar increase in area of detected *Ips* beetle damage occurred in YUCH in recent years, with approximately 890 ha (2,200 ac) in 2007, 970 ha (2,400 ac) in 2009, and 3,900 ha (9,800 ac) in

2010. Spruce engraver beetles "generally attack trees that are stressed as a result of drought, flooding, mechanical damage, soil compaction, windthrow or fire scorching" (USFS 2009, p. 29). Both *D. rufipennis* and *I. perturbatus* are native to Alaska and were collected in the Yukon-Charley area as early as 1974 (Gara and Holsten 1976).

Data Needs/Gaps

During the 2002 vascular plant inventory, two previously unknown bluff communities were found along smaller streams within the preserve (Larsen et al. 2004). This discovery highlights the need to explore smaller watersheds for rare and unique and plant species.

In the interest of providing early detection of invasive plant species, Passmore and Sherman (2010) recommended surveying several high traffic areas that were not visited during the most recent field season, including the entire ATV trail system surrounding Slaven's Roadhouse and Coal Creek, Woodchopper Roadhouse, Woodchopper Creek mining area, 22 Mile Cabin, and the Charley River.

Overall Condition

The three quantifiable measures for this component (plant species composition, status of rare and unique species, and species distribution) were all assigned *Significance Levels* of 3 by YUCH staff, indicating they are all important in understanding the condition of native plant communities.

Plant Species Composition

The vascular plant inventory by Larsen et al. (2004) provided excellent baseline data that can be used to detect any change in the preserve's native plant communities in the future. Long-term vegetation monitoring plots are being established within the preserve and will soon be available for comparison to this baseline data. At this time there is no indication that this measure is of concern within the preserve, and it is therefore assigned a *Condition Level* of 0

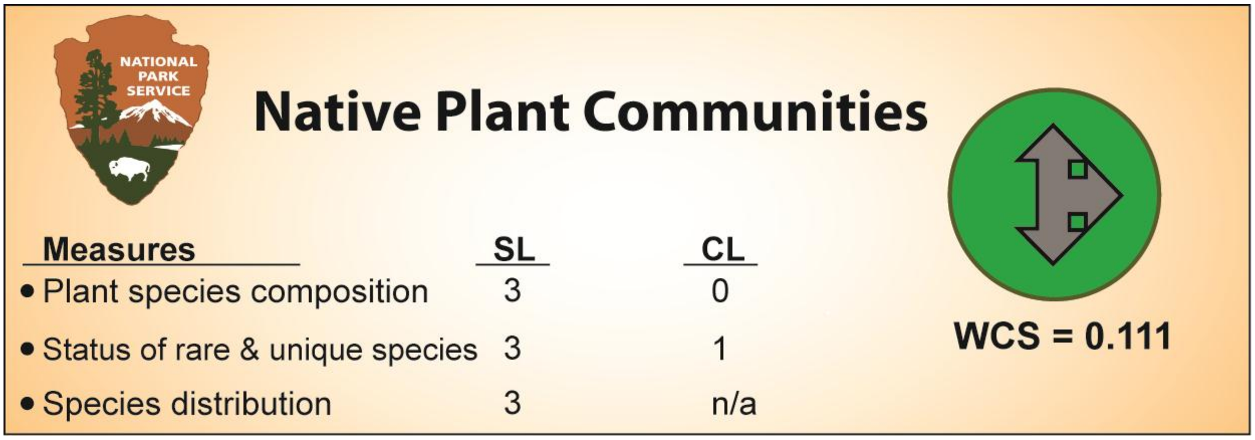
Status of Rare and Unique Species

YUCH supports a relatively high number of rare and endemic plant species, including several that are considered globally imperiled. While there is no evidence that these species are declining, their rarity and value as endemics make them a slight management concern. This measure is assigned a *Condition Level* of 1.

Species Distribution

While location information is available for many species in YUCH, including rare and endemic plants, it is difficult to assess the overall condition of native plant community distribution within the preserve. SMUMN GSS analysts did not assign a *Condition Level* for this measure.

Weighted Condition Score
The Weighted Condition Score (WCS) for native plant communities is 0.111, indicating overall low concern. Since recent monitoring data is not yet available for comparison with the 2002 inventory, the trend for this component is unknown.



Sources of Expertise
Primary sources of expertise for this assessment were Amy Larsen, aquatic ecologist for YUGA, and Carl Roland, botanist with CAKN.

Literature Cited

Alaska Exotic Plant Information Clearinghouse (AKEPIC). 2010. Alaska exotic plant information clearinghouse database. Alaska Natural Heritage Program, University of Alaska, Anchorage. Online. (http://akweeds.uaa.alaska.edu/). Accessed 2010.

Alaska Department of Natural Resources (AKDNR). 2010. Forest insect and disease conditions in Alaska shapefiles in cooperation with U.S. Forest Service, Alaska Region, State and Private Forestry, Juneau, Alaska.

Gara, R., and E. Holsten. 1976. Final report of the Yukon-Charley River entomological survey. Pages 262-281 *in* The environment of the Yukon-Charley Rivers area, Alaska. S. B. Young, ed. The Center for Northern Studies, Wolcott, Vermont.

Heys, J., and P. Bauder. 2005. BAER invasive plant survey, Yukon-Charley Rivers National Preserve, Coal and Woodchopper Creek watersheds: 2005 fieldwork report. National Park Service, Anchorage, Alaska.

Larsen, A., C. Rector, C. Roland, and M. Cook. 2004. Results of an inventory of the vascular plants of Yukon-Charley Rivers National Preserve. National Park Service Inventory and Monitoring Program, Central Alaska Network, Fairbanks, Alaska.

McKee, P. 2002. Exotic plants in Alaska national parks: 2002 field season report. U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Passmore, C., and M. S. Sherman. 2010. Invasive and exotic species management for Yukon-Charley Rivers National Preserve: 2010 summary report. Natural Resource Data Series NPS/YUCH/NRDS—2010/103. National Park Service, Fort Collins, Colorado.

Scenarios Network for Alaska Planning (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 10 November 2011.

Swanson, D. 2001. Ecological subsections of Yukon-Charley Rivers National Preserve. National Park Service, Alaska Region Inventory and Monitoring Program, Anchorage, Alaska.

U.S. Forest Service (USFS). 2009. Forest health conditions in Alaska – 2008. U.S. Forest Service, Alaska Region, Juneau, Alaska.

U.S. Forest Service (USFS). 2010. Forest health conditions in Alaska – 2009. U.S. Forest Service, Alaska Region, Juneau, Alaska.

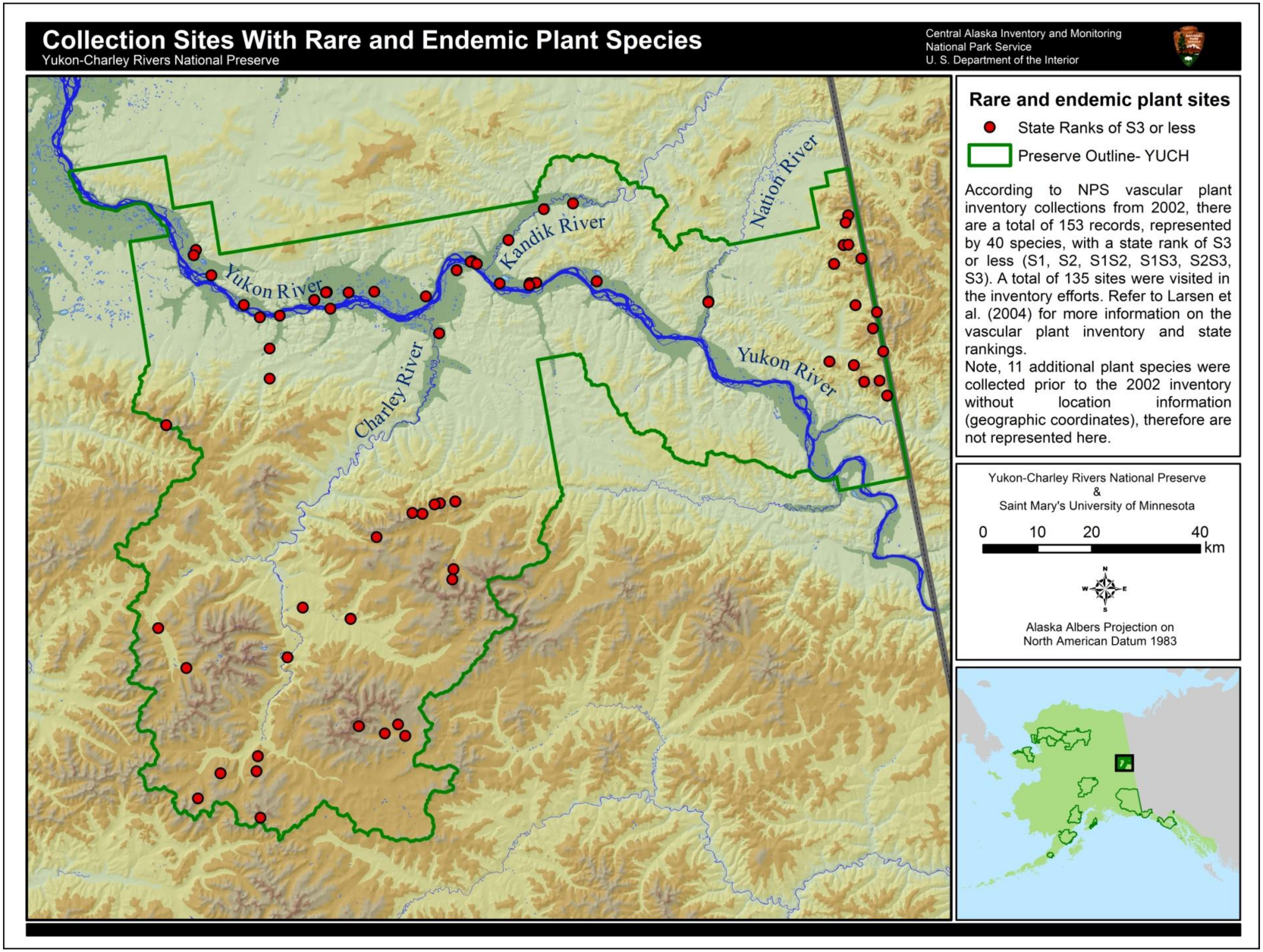


Plate 20. Rare plant taxa site locations from the 2002 vascular plant inventory (Larsen et al. 2004).

4.18 Steppe Community

Description

Steppe communities are found primarily on the steep, south-facing bluffs of YUCH's rivers. The preserve contains the most extensive system of steppe bluffs and one of the largest collections of endemic and disjunct plant taxa for its size in the state of Alaska. Due to their small size, limited range, and possible ancient affiliation, these communities are considered a "subject of critical botanical concern" (Larsen et al. 2004, p. 7). Their existence was not known in the scientific community until geologist Hosford Shacklette described the distinctive flora of Eagle Bluff in 1960. Similar bluffs were found along the Yukon and Charley Rivers and studied by Steve Young in the mid-1970s. It was suggested that these communities were relicts of Pleistocene Beringia, a theory supported by their similarity to pollen assemblages found in Pleistocene sediments (Young 1976) and to modern Siberian steppe communities. However, more recent research suggests that these are not exact Beringian communities due to localized species competition and changes in microclimate over time, but that they still offer a unique "window into the biogeographic history of the area" (Larsen et al. 2004, p. 35).

The earliest researchers theorized that steppe communities were limited to small sites with southern exposures by their intolerance for colder soil temperatures. While environmental variables such as soil temperature and moisture availability may affect some species, the current consensus is that steppe community distribution is limited by its poor competitive ability, particularly for light (Wesser and Armbruster 1991, Lloyd et al. 1994, Roland 1996). Steppe species are able to survive at sites with high light and low moisture levels that are not tolerated by other vegetation types (Wesser and Armbruster 1991). Fire has also been identified as a possible key factor in the maintenance of steppe communities because of its ability to limit forest encroachment. Evidence of this can be seen at Montauk Bluff, which was covered in steppe vegetation when it was visited in 1990. Yet a 1956 USGS quad map, prior to a major wildfire on Montauk in 1969, showed the area as forested (Larsen et al. 2004).

Photo 32. Steppe community on Kathul Mountain in YUCH (NPS photo).

An extensive study of bluffs along the Yukon River and its tributaries within the preserve by Carl Roland determined that the distribution of steppe communities is primarily determined by topography (Roland 1996). His study sites on average had a slope of 34°, an elevation of 481 m, and an equivalent latitude (EQ) of 33°. The EQ measure reflects the amount of solar radiation received by combining the influences of slope and aspect, and indicates that these sites receive as much sun as a flat surface at 33° latitude (for comparison, cities at this latitude include Phoenix and Atlanta). Roland's results suggest that EQ is perhaps the best predictor of steppe community distribution and composition, due to the fact that they are generally limited to sites with high sun exposure. Evidence of fire was also found at every site. Soils were generally sandy and on average 13% of the area was bare ground or rock cover. The average cover by vascular plants was just 26% with moss and lichen covering 58%, although the prevalence of these nonvascular plants varied greatly between sites. On average only 2.6% of the bluff area was shaded (Roland 1996).

Roland (1996, p. 37) found that EQ, elevation, shading, soil organic matter content, and soil texture were "the strongest predictors of community composition" at his bluff study sites. Species richness particularly increased as EQ and elevation increased. Hot, dry sites at lower elevations had fewer species and were dominated by bunch grasses and sage brush. Higher elevations supported more species overall, including some tundra species, and a more significant lichen component. Soil characteristics such as texture and organic matter content influence vegetation because they affect the soil's capacity to hold moisture. However, soil characteristics were also found to be significantly linked with EQ, making it "difficult to disentangle the contributions of microclimate and soil qualities in producing the trends described within the vegetation" (Roland 1996).

Roland's (1996) results also showed that species richness and, to some degree, the community composition of bluff sites were strongly influenced by the habitat diversity or heterogeneity of a site, as measured by its elevational extent (the difference between the site's highest and lowest points). Communities with a greater elevational extent are likely to have more ecological niches and therefore support a greater number and variety of plant species. Species composition was additionally influenced, although to a lesser extent, by the principles of island biogeography. Bluffs with more potential habitat area (size of the 'island') generally have more plant species while more isolated bluffs (distance from other 'islands') have fewer species (Roland 1996).

Measures

- Spatial locations (size, number, and composition)
- Number of unique sites
- Unique species composition

Reference Conditions/Values

The information presented in the "current condition and trends" section of this document, while representing the current understanding of steppe communities, is nearly two decades old and can therefore serve as a reference condition for future assessments. Very little research has been conducted in these communities in the past 15 years to update earlier survey efforts, and therefore no more recent information was available to address the selected measures.

Data and Methods

Preserve staff provided a vascular plant inventory report (Larsen et al. 2004), journal articles, and several unpublished reports. Carl Roland's thesis on steppe communities (Roland 1996) was obtained from the Alaska Resources Library (ARLIS).

SMUMN GSS used GIS data to model potential steppe community locations in YUCH. The model was based on previous work by Knuckles and Wesser (1992), which used elevation, slope, and aspect as factors to predict potential steppe community locations. Areas of suitable elevation were extracted from a 10 m DEM, and aspect and slope rasters were developed from the DEM. Areas fitting all three requirements were identified using the raster calculator tool in ArcGIS 10. Existing non-digital map data from Wesser and DeVoe (1987) and Roland (1996) were converted to GIS files by georectifying individual maps and then digitizing survey points within those maps. This information gives a rough location, as the original maps were small in scale. However, this information is the best available for the assessment. Further work may be required to refine this location information.

Current Condition and Trend

Spatial Locations

Knuckles and Wesser (1992) developed a GIS model to identify potential steppe communities in YUCH based on three factors: south-facing aspect (130 to 252°), steep slopes (29 to 45°), and elevations less than 880 m, as well as previous research by Wesser (1991), Wesser and Armbruster (1991), Wesser and DeVoe (1987), Edwards and Armbruster (1989), Roland (1990, 1991), and others. The model incorporating slope, aspect and elevation was recreated using an updated (2007) 10 m DEM. Plate 21 displays a portion of YUCH with potential steppe community sites based on the slope, aspect, and elevation model. Based upon field surveys, Knuckles and Wesser (1992) concluded that the overall accuracy of the GIS model was 50.1%, if aspen/woodland and steppe classes were considered a success of the model; however, if the model could be updated to eliminate drainages less than 2 km wide, the accuracy could improve to 74.9%. There has been no preserve-wide investigation of steppe community locations. Additional steppe surveys may refine the model in the future to include environmental determinants for soils and vegetation classes. Refer to Wesser and DeVoe (1987) for some further environmental characteristics of sites containing steppe species.

Number of Unique Sites

The number of individual, unique steppe community sites in the preserve is unknown. Along with descriptions of steppe sites in the aforementioned literature, the slope, aspect, and elevation criteria presented in Knuckles and Wesser (1992) provides a starting point for locating steppe communities across the preserve. Figure 58 illustrates the largest patch meeting the criteria of the GIS model (Knuckles and Wesser 1992), Biederman Bluff along the south facing bluffs of the Yukon River in the central portion of the preserve.

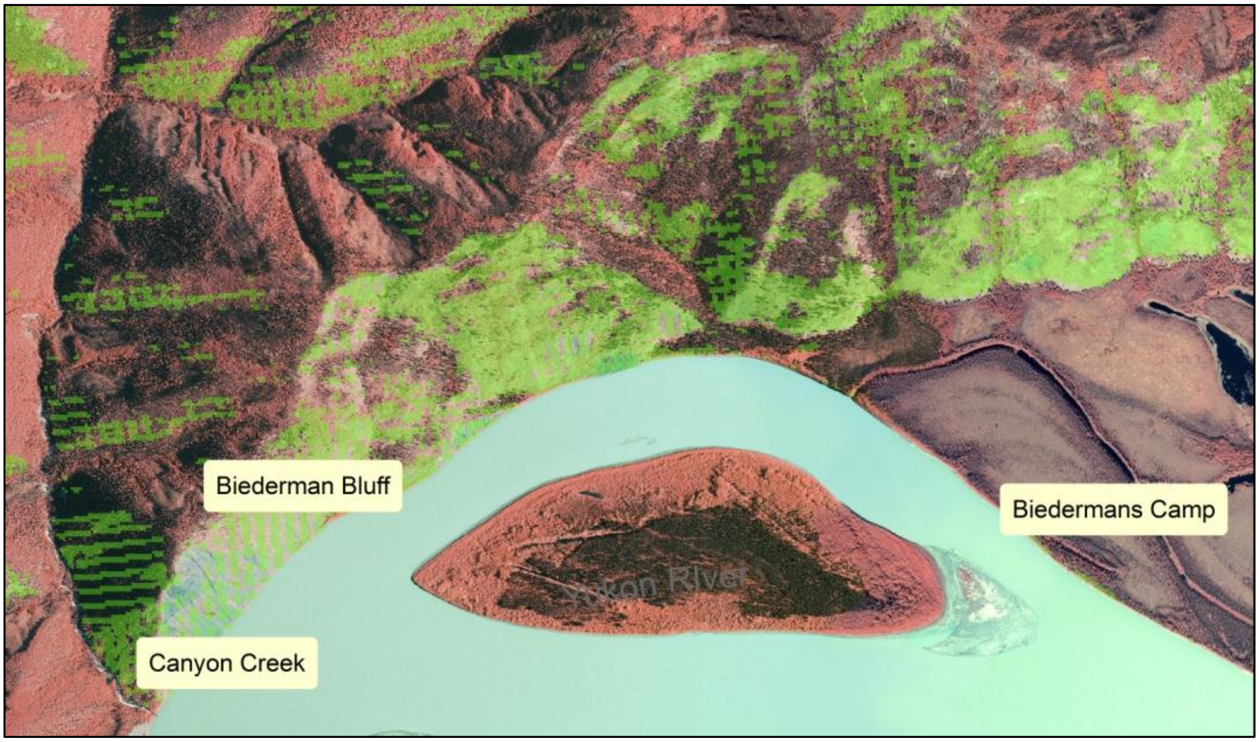


Figure 58. Biederman Bluff represents the largest contiguous patch fitting the Knuckles and Wesser (1992) GIS model. Areas in light green represent potential steppe locations based upon the three parameters (slope, aspect, elevation).

GPS locations of some steppe communities were obtained through field surveys in Knuckles and Wesser (1992). The coordinates were preserved on a datasheet obtained from the YUCH museum curator, Christopher Houlette. With assistance from Joel Cusick of the Alaska Regional NPS office, the coordinates were imported to a GIS file. These locations are displayed in Plate 22. The precision of these coordinates are unclear due to missing system documentation. Other locations identified in Wesser and DeVoe (1987) and in Roland (1991, 1996) were identified on USGS 1:63,000, and 1:250,000 topological maps. These maps (scanned, georeferenced to the appropriate USGS digital raster graphics (DRG) and point locations extracted) are also presented in Plate 22.

Unique Species Composition

Roland's (1996) study of steppe communities included nine bluffs along the Yukon River in Alaska, ten bluffs along the Charley River south of the Yukon, and three bluffs each on the Kandik and Tatonduk Rivers north of the Yukon. The author used several "indicator taxa" to identify potential sites, including the sagebrushes *Artemisia frigida* and *A. alaskana*, the grasses *Agropyron spicatum* and *Calamagrostis purpurascens*, the sedges *Carex supina* and *C. obtusata*, and forbs including *Potentilla hookeriana*, *P. pennsylvanica*, *Penstemon gormanii*, and *Pulsatilla patens*. Species diversity was highest on the Yukon River bluffs where a total of 93 vascular plant species were found with an average of 40 species per bluff. Fifty-six of the plant species were categorized as "generally restricted" (GR), meaning that they occur almost exclusively in dry, open, and generally treeless microclimates. On average, the Yukon bluffs contained 23 GR species per site. Diversity was lowest on the Charley River sites, where the average number of species per bluff was 23, with only 13 on average being GR. This may be due to the fact that bluffs along the Charley River generally have less of an elevational extent and are smaller in total area than sites along the Yukon and its northern tributaries. Species composition along all the Yukon tributaries appears to be a ‘subset’ of the Yukon bluff species, although the Charley River contains a different subset than the northern tributaries. In fact, three species were found along the Charley that were not found at any other study sites (Roland 1996). The distribution of rare plants on selected steppe bluffs in or near the preserve is presented in Table 34.

Table 34. Distribution of rare plant species on Yukon River bluffs and in the Charley, Kandik, and Tatonduk River sites (Roland 1996, Larsen et al. 2004).

Species	Eagle	Calico	Tatonduk	Montauk	Nation	Kathul	Biederman	Woodchopper	Eureka Creek	Charley River	Kandik River	Tatonduk River
Campanula aurita										x		
Cryptantha shackletteana	x	x										
Douglasia arctica						x	x					
Draba murrayi	x		x	x	x	x	x	x	x		x	x
Eriogonum flavum	x	x				x		x				
Erysimum asperum	x	x		x		x	x	x	x		x	x
Festuca lenensis						x						x
Minuartia yukonensis	x					x	x	x	x			x
Phacelia mollis											x	
Phacelia sericea	x					x	x					
Phlox hoodii	x							x				x
Podistera yukonensis						x		x				
Smilacina stellata				x	x	x		x				

The flora of the steppe communities can be divided into four biogeographic groups: widespread (common in circumpolar areas worldwide), amphiberingian (found in parts of Asia and North America that were once part of Beringia), North American (restricted to North America), and endemic (found only in Alaska and the Yukon Territory) (Roland 1996). On the Yukon River bluffs, North American species were most dominant, comprising 35.9% of the overall composition. The remaining species were widespread (28.3%), amphiberingian (19.6%), and Alaska-Yukon endemic (16.3%). At the Kandik and Tatonduk sites, widespread species made up a slightly higher percentage of the total composition than North American species. Amphiberingian numbers were similar to the Yukon sites, but endemics actually comprised a higher overall percentage of species (about 20%) along these northern tributaries than on Yukon bluffs. Distribution among biogeographic groups was noticeably different for the Charley River sites. Here, a much higher 41% of species were considered widespread, and fewer amphiberingian species were found (Figure 59, Roland 1996).

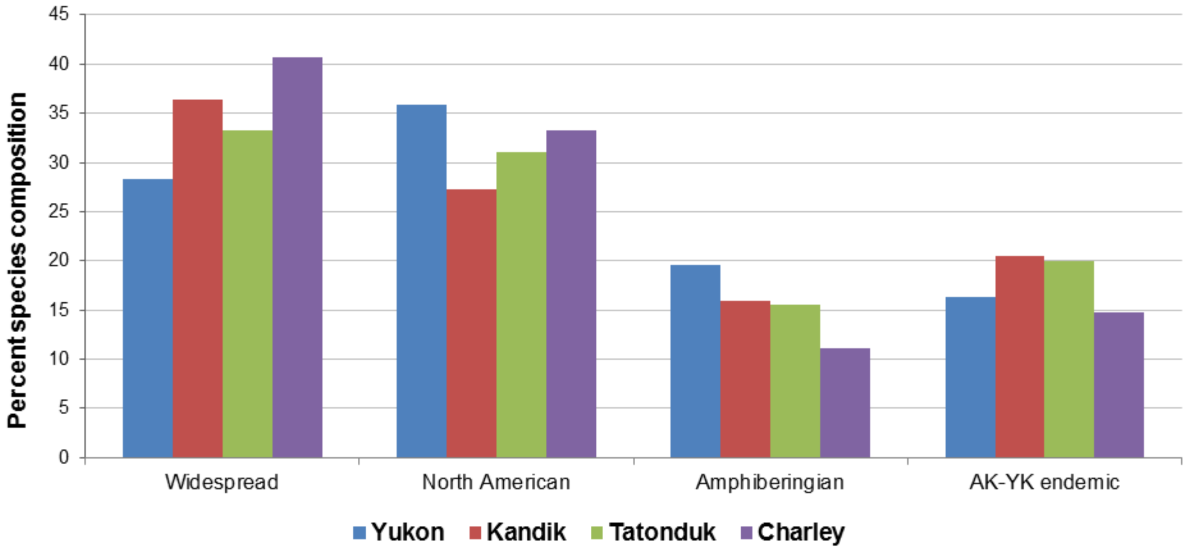


Figure 59. Percentage of bluff floras from four biogeographic categories by study drainage (Roland 1996).

The four biogeographic groups appeared to respond differently to physical variables (Roland 1996). For example, nearly half of the widespread species were more abundant at lower elevations while amphiberingian and endemic species tended to increase in abundance at higher elevations. North American species did not seem affected by changes in elevation. In general, the amphiberingian species seemed to prefer the cooler microclimates of higher elevations and higher equivalent latitudes. Bluff isolation affected only amphiberingian and endemic species, with the number of these species at a site decreasing as the distance to the nearest bluff increased. Total potential habitat area affected only amphiberingian species, with smaller habitats supporting fewer species. When considered together, the negative effects of habitat area and bluff isolation suggest that amphiberingian species are more vulnerable to localized extinction and are unlikely to recolonize a site once eliminated. This is further supported by the fact that amphiberingian species were also the rarest of the biogeographic groups, with 58% of these species found at less than five of the study sites (Roland 1996).

One Alaska-Yukon endemic of the steppe communities worthy of mention is *Cryptantha shackletteana*. There is still some dispute as to whether *C. shackletteana* is a unique species or a variety of *C. spiculifera*, whose range lies 2000 km south of the Alaska populations (Parker 1995). Whether a species or a variety, this plant has been found at only two sites worldwide – Calico and Eagle Bluffs. It is considered critically imperiled at both the global and state level. In 1995, the population at each site was estimated to be at least 1,000 individuals (Parker 1995). However, the populations may have been higher since some of the species' preferred habitat – rocky areas with minimal soil development – was inaccessible. Other steppe community plants considered globally imperiled are *Podistera yukonensis, Draba murrayi Eriogonum flavium* var. *aquilinum,* and *Phacelia mollis* (Photo 33).

Photo 33. *Cryptantha shackletteana* on Calico Bluff, *Draba murrayi* along the Tatonduk River, *Eriogonum flavum* var. *aquilinum* on Eagle Bluff, and *Podistera yukonensis* on Kathul Mountain (photos by C. Parker).

Threats and Stressor Factors

Climate Change

Any changes in temperature or precipitation are likely to affect soil temperatures and moisture levels, which will in turn impact steppe communities (Roland 1996). Wesser and Knuckles (1990) suggest that steppe communities may be useful as barometers of climate change. The warmer, drier conditions predicted for Alaska over the next century may help maintain the drought tolerant steppe communities, particularly if drier conditions contribute to increased wildfire frequency. However, steppe species that favor cooler, higher elevation microclimates (e.g., amphiberingian and some Alaska-Yukon endemics) may be negatively impacted by warmer temperatures, leading to an overall decrease in species diversity.

Forest Encroachment
Roland (1996, p. 94) noted that his "personal observation of well-developed aspen forest on very steep, directly south-facing slopes suggests that given enough time (i.e., lack of disturbance events) aspen forest may be able to propagate itself across most south-facing bluff surfaces." While some steppe sites may be too warm, too dry, or too rocky for trees to survive, forest encroachment is a serious threat on many bluffs (Photo 34). The relationship between species richness and potential habitat area, particularly for amphiberingian species, as well as elevational extent suggests that forest encroachment would significantly impact steppe community composition. As habitat shrinks, populations will become smaller and more vulnerable to localized extinctions. As discussed earlier, fire appears to be a vital process in reducing forest competition and maintaining open areas for steppe species.

Erosion and Flooding Events
Erosion, flooding, and other physical disturbances have the potential to wipe out significant steppe communities on the river bluffs. According to Roland (1990, p. 52), "The steep slopes and friable metamorphic parent material, combined with undercutting by the Yukon River, makes rockslides and other geomorphic activity a common occurrence on the bluffs", particularly Biederman, Nation, and Montauk Bluffs (Photo 34).

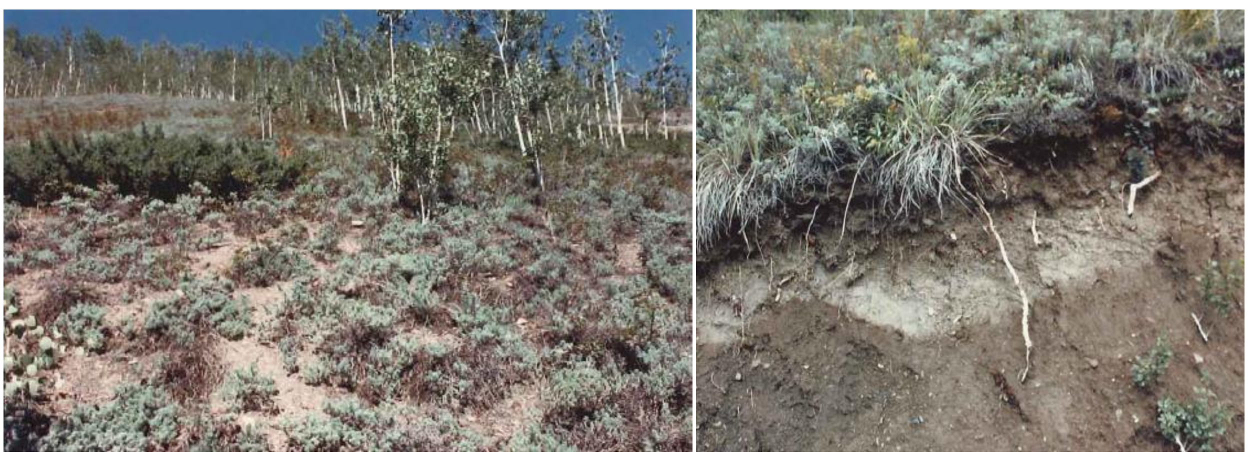


Photo 34. The first stages of forest encroachment on Tatonduk Bluff (left) and erosion at Montauk Bluff (right) (NPS photos).

Human Use
Since several bluffs along the Yukon are easily accessible from the river, disturbance from hiking is a concern (Parker 1995). The open nature of these bluffs and the potential scenic views at their summits can be particularly appealing to hikers. Most steppe sites have sandy soils or rubble slopes that are easily disturbed.

Invasive Plants
Since most steppe species are thought to be poor competitors (Lloyd et al. 1994), they may be particularly vulnerable to invasive species. Invasive plants are often tolerant of poor conditions and may be able to survive and compete with steppe species on the warm, dry bluff sides where many of the native competitors cannot. Currently there is no evidence that non-native species have invaded steppe communities.

Data Needs/Gaps

Roland (1996) noted that, "The role of nonvascular plants in organizing plant community structure is understudied. Nonvascular plants, however, probably have important effects on the community ecology of subarctic steppe." Researchers believe that moss and lichen coverage influence the vascular plant community by reducing the amount of bare ground available for colonization and by insulating the soil. This insulation effect delays soil warming in the spring, potentially shortening the growing season, and may increase soil moisture levels by preventing evaporation (Lloyd et al. 1994).

Other research interests related to steppe communities include its role in ecological succession, the role of natural disturbance in maintaining plant community structure, and its importance for grazing animals (Roland 1990). More information could also be gathered on endemic plant species within the community, including the effect of fire on their distribution, how large a population must be to remain viable, and how these species disperse (Roland 1990).

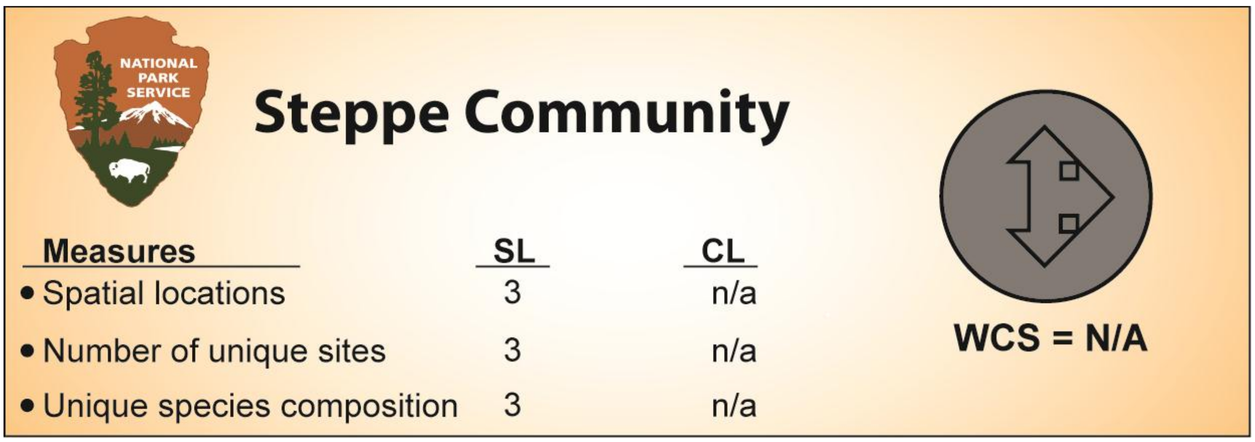
Photo 35. Conducting a vegetation survey on Kathul Mountain (Roland 1990).

Researchers have suggested that steppe communities in the upper Yukon could be valuable indicators of climate change, due to their sensitivity to "subtle environmental gradients" (Roland 1990). Kathul Mountain (Photo 35) is perhaps the most researched steppe bluff community (Young 1976, Batten et al. 1979, Roland 1990, Lloyd et al. 1994, Parker 1995, and Roland 1996) and could potentially serve as an index site for the study of climate change and steppe communities. Vegetation sampling plots were established on Kathul Mountain as part of the CAKN monitoring program in 2007.

Known steppe community locations should be compared to the GIS model of potential locations to test for accuracy. The model could be used to identify new steppe community sites within YUCH.

<u>Overall Condition</u>
YUCH staff assigned all three measures a *Significance Level* of 3. However, due to a lack of recent data for comparison with the baseline data presented here, *Condition Levels* could not be assigned at this time. The information presented in this assessment could serve as synthesis of valuable baseline data for future assessments. Presently there is no evidence for an elevated concern, but generally the status of steppe communities in unknown.

Weighted Condition Score
A Weighted Condition Score could not be calculated for this component since *Condition Levels* could not be assigned for any of the measures. The current condition of steppe communities in YUCH is therefore unknown with an unknown trend.



Sources of Expertise
Primary sources of expertise for this assessment were Carl Roland, botanist with CAKN, and Amy Larsen, aquatic ecologist for YUGA.

Literature Cited

Batten, A., D. Murray, and J. Dawe. 1979. Threatened and endangered plants in selected areas of the BLM Fortymile Planning Unit, Alaska. Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska.

Edwards, M., and W. Armbruster. 1989. A tundra-steppe transition on Kathul Mountain, Alaska, U.S.A. Arctic and Alpine Research 21:296-304.

Knuckles, P., and S. Wesser. 1992. Aerial survey of arctic steppe sites in Yukon-Charley Rivers National Preserve based on geographic information system modeling. Research and Resource Management Report Series 92-03. National Park Service, Fairbanks, Alaska.

Larsen, A., C. Rector, C. Roland, and M. Cook. 2004. Results of an inventory of the vascular plants of Yukon-Charley Rivers National Preserve. National Park Service, Central Alaska Network, Fairbanks, Alaska.

Lloyd, A., W. Armbruster, and M. Edwards. 1994. Ecology of a steppe-tundra gradient in interior Alaska. Journal of Vegetation Science 5:897-912.

Parker, C. 1995. Status and trends survey of category 2 plants in the Yukon-Charley Rivers National Preserve, Alaska. National Park Service, Washington, D.C.

Roland, C. 1990. Arctic steppe survey: Yukon River sites. Research and Resource Management Report Series 90-04. Unpublished report. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Roland, C. 1991. Arctic steppe community: a survey of Yukon-Charley Rivers National Preserve (Charley and Kandik Rivers). Research and Resource Management Report Series 91-04. Unpublished report. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Roland, C. 1996. The floristics and community ecology of extrazonal steppe in the Yukon and Kolyma River drainages. Thesis. University of Alaska, Fairbanks, Alaska.

Wesser, S. D. 1991. The effects of light and moisture on two species from contiguous communities of south-facing bluffs in interior Alaska, U.S.A. Arctic and Alpine Research 23(1):99-103.

Wesser, S. D., and W. S. Armbruster. 1991. Species distribution controls across a forest-steppe transition: a causal model and experimental test. Ecological Monographs 61(3):323-342.

Wesser, S. D., and D. L. DeVoe. 1987. Survey of the vegetation of some south-facing bluffs in Yukon-Charley Rivers National Preserve. Research and Resource Management Report Series 87-03. Unpublished report. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

Wesser, S. D., and P. Knuckles. 1990. Arctic steppe: snapshot of the past or glimpse of the future? Park Science 10(4):22-23.

Young, S. 1976. The environment of the Yukon-Charley Rivers area, Alaska. Center for Northern Studies, Wolcott, Vermont.

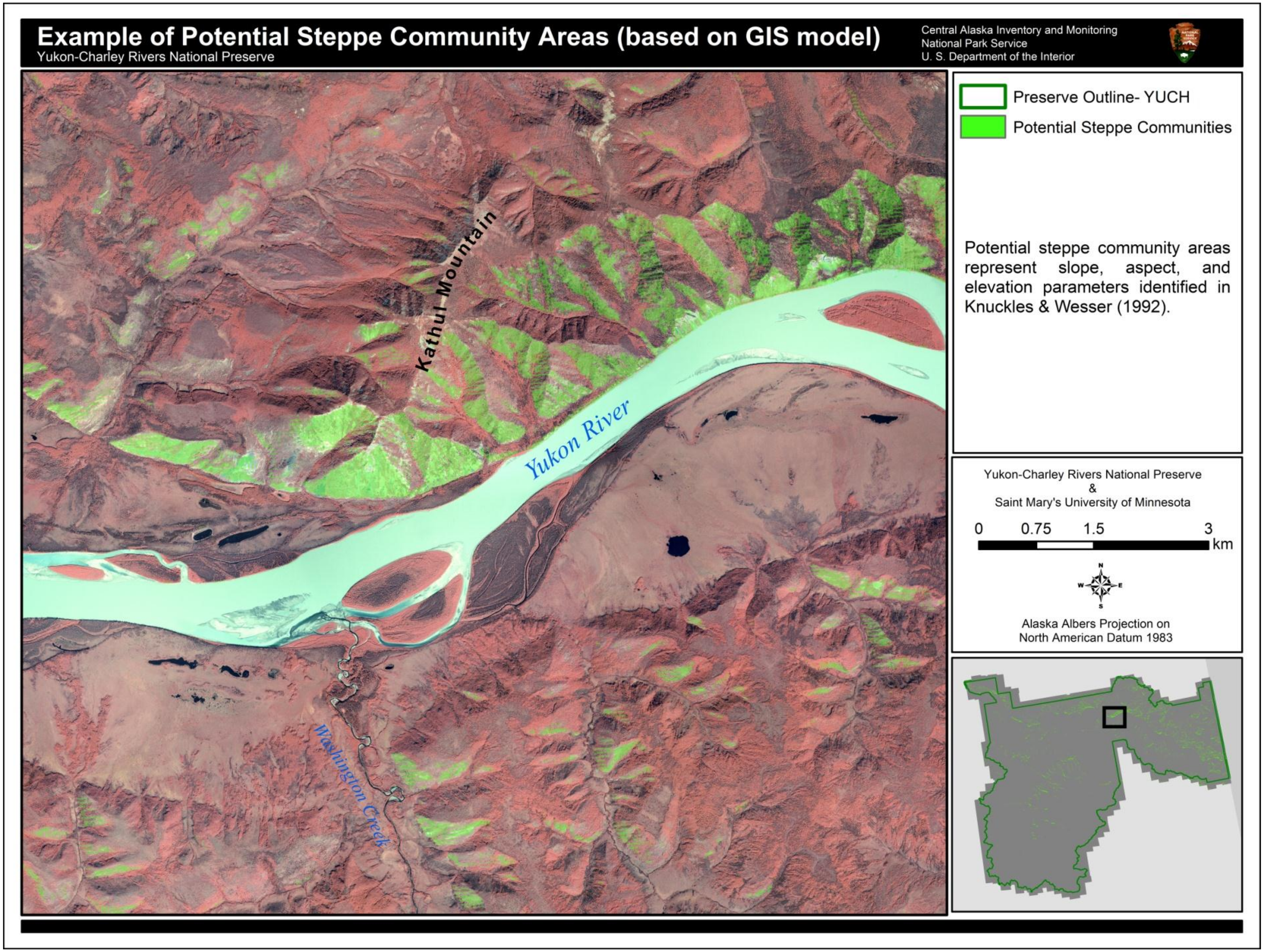


Plate 21. Potential steppe community locations based on variables described in Knuckles and Wesser (1992).

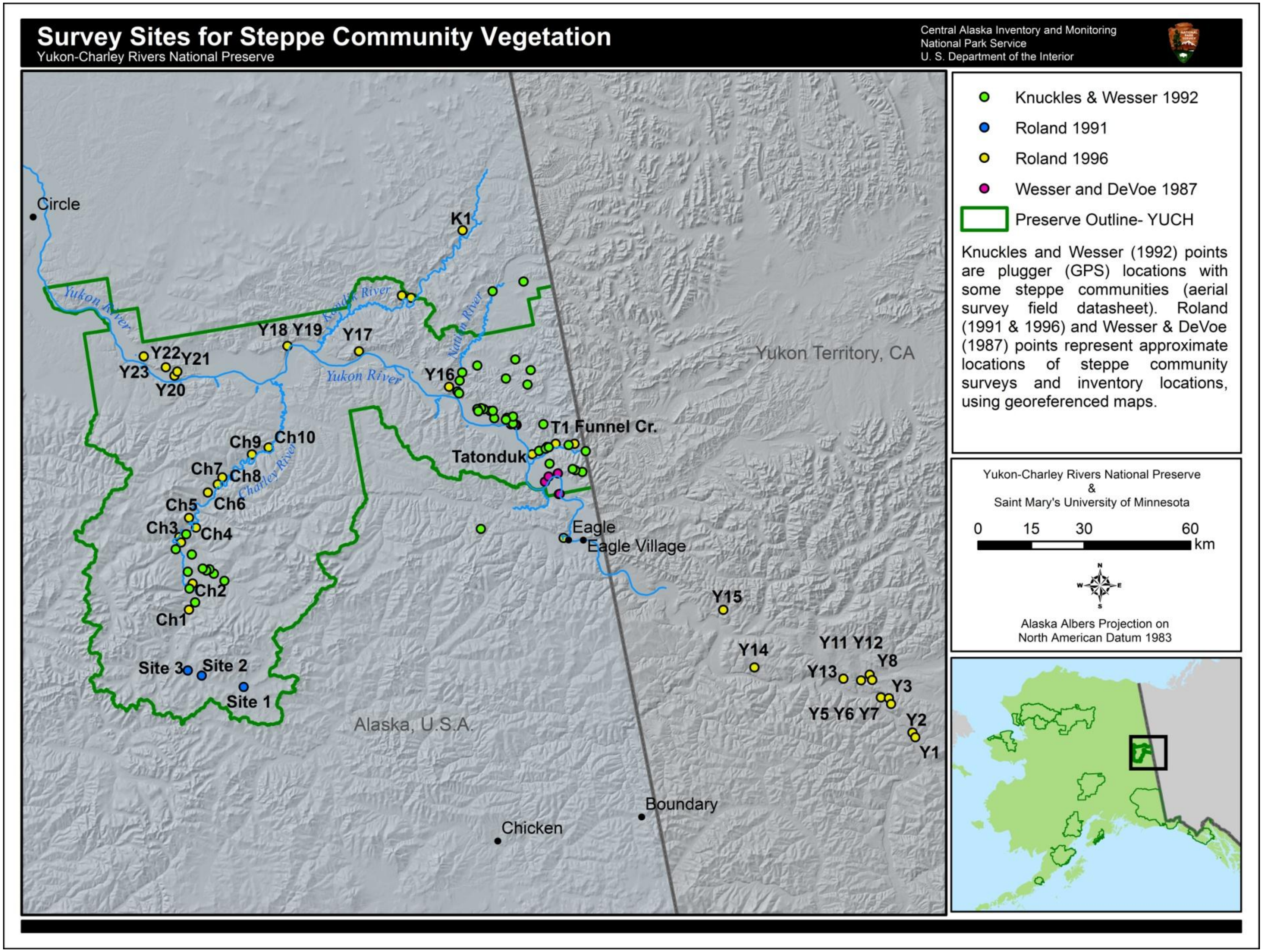


Plate 22. Floristic survey or study sites for steppe communities (Wesser and Devoe 1987, Knuckles and Wesser 1992, Roland 1991, 1996).

4.19 Water Quality (Chemical and Biological Integrity)

Description

Water quality is a Vital Sign for the Central Alaska Network (CAKN) and eventually will be assessed by monitoring water chemistry and macroinvertebrates present in aquatic systems. Macroinvertebrates are a stand-alone Vital Sign in the network as well (MacCluskie and Oakley 2005). This assessment addresses water chemistry parameters (chemical properties, nutrients, and heavy metals) and macroinvertebrates in YUCH water bodies, specifically rivers and streams.

Photo 36. The Charley River in YUCH (NPS Photo).

The Yukon and Charley Rivers are the two major water bodies that flow through the preserve, in addition to a number of smaller tributaries that feed them. The Charley River is designated as a Wild and Scenic River (Brabets 2001) (Photo 36). YUCH also has numerous shallow lakes within its boundaries; these are addressed in Chapter 4.2, Lake Ecosystem Function.

Monitoring water quality in YUCH is important for a number of reasons. Residents in the region utilize rivers for drinking water (Brabets et al. 2000), mining, agriculture, recreation, and fishing (YRITWC 2002). The variety of fish and wildlife species present in YUCH require suitable water quality for their survival (Brabets et al. 2000). The protection of biological integrity is an important component of the enabling legislation of YUCH, which states that the preserve should: “maintain the environmental integrity of the entire Charley River Basin, including streams, lakes, and other natural features, in its undeveloped natural condition for public benefit and scientific study; to protect habitat for, and populations of, fish and wildlife” (ANILCA, section 201(10)).

Macroinvertebrates are indicators of water quality. Monitoring the presence or absence and abundance of various macroinvertebrate species is important, as water chemistry parameters alone do not provide enough information to assess the biological integrity of water bodies (Simmons 2010). Karr and Dudley (1981, p.56) define biological integrity as “the ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region.” Subarctic rivers and streams, such as those found in YUCH, generally have low species diversity and abundance relative to temperate streams (Wagener and LaPerriere 1985). Invertebrate densities are considered a good indicator of water quality in subarctic streams where placer mining is occurring (Wagener and LaPerriere 1985). Aquatic insects are also important food sources for fish and bird species (NPS 2010). Data regarding macroinvertebrates in YUCH water bodies are mainly restricted to lakes; see Chapter 4.2 for further discussion.

Standard chemical water quality parameters addressed in this assessment include dissolved oxygen, fecal coliform, pH, conductivity, turbidity, and water temperature. Fish and zooplankton absorb or “breathe” dissolved oxygen from the water to survive (USGS 2010, EPA 2010a). As the amount of DO drops, it becomes more difficult for aquatic organisms to survive (USGS 2010). The concentration of DO in a water body is closely related to water temperature; cold water holds more DO than does warm water (USGS 2010). However, in YUCH, most streams or rivers typically have lowest DO concentrations during the winter because ice eliminates the exchange of oxygen between water and the atmosphere (CAKN, Trey Simmons, Aquatic Ecologist, pers. comm., 2012).

Fecal coliforms are various gram-negative bacteria that are found in the feces of mammals. Fecal coliform is most commonly used to assess the level of fecal bacteria contamination in water (USGS 2009, EPA 2010b). *E. coli* is one species in this group commonly used to measure fecal contamination of water bodies.

pH is a measure of the level of acidity or alkalinity of water and is measured on a scale from 0 to 14, with 7 being neutral (USGS 2010). A pH of less than 7.0 indicates acidity, whereas a pH greater than 7.0 indicates alkalinity. Aquatic organisms have a preferred pH range that is ideal for growth and survival (USGS 2010). Added chemicals and nutrients in water can change the pH and harm aquatic organisms. Therefore, monitoring pH can be useful for detecting natural and human-caused changes in water chemistry (USGS 2010).

Specific conductance is a measure of the ability of water to conduct electrical current, which depends largely on the amount of dissolved solids in the water (USGS 2010). Water with low amounts of dissolved solids (such as purified or distilled water) will have a low specific conductance, while water with high amounts of dissolved solids (such as salt or other minerals) will have a much higher specific conductance (USGS 2010). Specific conductance is an important water quality parameter to monitor as high specific conductance can indicate high levels of dissolved solids, which can render water unsuitable for drinking or aquatic life (USGS 2010).

Turbidity assesses the amount of fine particle matter (such as silt, plankton, microscopic organisms, or finely divided organic or inorganic matter) that is suspended in water by measuring the scattering effect they have on light that passes through water (USGS 2010); the more light that is scattered, the higher the turbidity measurement. The suspended materials that make water turbid can absorb heat from sunlight, increasing the water temperature in waterways and reducing DO concentrations (USGS 2010). Turbid waters can decrease plant and algae photosynthesis, further contributing to decreased DO concentrations (USGS 2010). Suspended particles also irritate and clog the gill structures of many fish or amphibians (USGS 2010).

Water temperature greatly influences water chemistry and aquatic organisms. In addition to affecting the ability of water to hold oxygen, water temperature also affects biological activity and growth within a system (USGS 2010). All aquatic organisms, from fish to insects to zoo- and phytoplankton, have an optimal temperature range for existence (USGS 2010). As temperature increases or decreases past this range, the variety of species and number of individuals able to live in the system eventually decreases. In addition, higher temperatures allow some compounds or pollutants to dissolve more easily in water, which can increase toxicity to aquatic life (USGS 2010).

Nutrient concentrations, including dissolved organic carbon (DOC), nitrates, and phosphates, are another important water quality factor considered in this assessment. Nutrients are chemical elements which are essential for plant and animal survival, but can become contaminants at higher concentrations in water (Mueller and Helsel 2009). Nitrates and phosphorus are two common nutrient contaminants in water bodies (Mueller and Helsel 2009). Nitrogen occurs naturally in soils and thus in surface waters, but is increased by human inputs such as sewage, fertilizers, and livestock waste. High levels of phosphorus are a concern for surface water quality because it can lead to eutrophication (EPA 2009).

Heavy metals pose a threat to water quality in YUCH. Atmospheric deposition of mercury and pollution from historic mining are two major sources of heavy metals in the preserve. In water, mercury is converted to methylmercury, a neurotoxin that is biomagnified in the aquatic food web (USGS 2011). However, it is quite likely that many of the waters are naturally metalliferous, similar to those in Wrangell St. Elias National Park, due to the high concentrations of metals in stream and river substrate and bedrock in the preserve (Eppinger et al. 2000).

Measures

- Standard water chemistry parameters including dissolved oxygen, fecal coliform, pH, specific conductance, temperature, and turbidity
- Observed vs. expected macroinvertebrate species
- Presence and concentration of nutrients including dissolved organic carbon, nitrates, and phosphates
- Presence and concentration of heavy metals

Reference Conditions/Values

In much of Alaska, CAKN in particular, the water quality is very good in comparison to the lower 48 states due to the lack of human influence on the landscape (NPS 2011b). National drinking water standards articulate many chemical parameters that, in excess, could harm people. However, the Clean Water Act also recognizes the importance of the “biological integrity of the Nation’s waters.” In the case of YUCH, most of surface and groundwater in the preserve rarely experiences human use. Therefore, assessing water quality according to biological integrity is reasonable. Biological integrity is measured in water bodies around the world through monitoring the status of aquatic macroinvertebrates (NPS 2011b). CAKN intends to monitor water bodies in its units using analytical tools that interpret the results of macroinvertebrate samples; this will assist the development of a reference condition for network parks in the form of a range of natural variability. Currently, the range of natural variability for biological and chemical water quality parameters in YUCH is largely unknown, which makes assessing water quality in the preserve difficult.

Data and Methods
In 1995, the NPS published the results of surface water quality data retrievals for YUCH using five EPA national databases: Storage and Retrieval (STORET) water quality database management system, River Reach File (RF3), Industrial Facilities Discharge (IFD), Drinking Water Supplies (DRINKS), and Water Gages (GAGES). This retrieval resulted in 2,534 observations for 137 separate parameters in and around YUCH. Twenty-two monitoring stations were included in the analysis, six of which were located within YUCH boundaries (NPS 1995). The vast majority of samples were collected from the Yukon River upstream of YUCH at the USGS gauging station in Eagle, AK. Six sample sites within YUCH boundaries were included in the report; however, these were all one-time sample events.

Brabets et al. (2000) includes water quality data collected in the Yukon River Basin between 1976 and 1996, including water temperature, specific conductance, pH, and dissolved oxygen.

Schuster et al. (2010) reports on an ongoing USGS water quality study of the Yukon River Basin, and includes results of water quality sampling from 2006-2008. The most relevant sampling location to the preserve is the Eagle, AK station.

Current Condition and Trend

<u>Observed vs. Expected Macroinvertebrates</u>
Macroinvertebrates will be the primary indicators used by CAKN to assess the biological integrity of flowing waters (NPS 2011b). To date, data and literature regarding this measure in YUCH are minimal. Recently, CAKN finalized the monitoring protocol for macroinvertebrates in the network and preliminary data collection began in 2011. Future assessments should incorporate data collected using the new protocol for assessing water quality. Two primary indices are available to evaluate the biological integrity of water bodies utilizing measurements of macroinvertebrates: the Index of Biological Integrity (IBI) and the River Invertebrate Prediction and Classification System (RIVPACS) (Simmons 2010). Simmons (2010) considers the RIVPACS index, which uses observed vs. expected abundance measurements, as more appropriate for Alaskan ecosystems.

O’Brien and Huggins (1976) collected macroinvertebrates from eight streams and rivers in YUCH, including the Yukon and Charley Rivers, observing a minimum of 30 different species of macroinvertebrates (Appendix 28), including mayflies, stoneflies, snails, and clams.

Lloyd et al. (1987) observed a lower abundance of macroinvertebrates in turbid Alaskan streams northwest of the preserve compared to less-turbid reference streams in the region.

<u>Water Chemistry Parameters and Nutrients</u>
Macroinvertebrate abundance and diversity often correlate to water chemistry parameters, such as dissolved oxygen, pH, specific conductance and nutrients (e.g., dissolved organic carbon [DOC], nitrates, and phosphates). Generally, the water quality in YUCH is good, with the exception of areas exposed to mining (NPS 1995). YUCH has numerous flowing water bodies that are nearly pristine due to their remoteness and the lack of human influence with no water quality data. Other sites within the preserve are compromised because of past mining activities; these sites are discussed in the threats and stressors section of this assessment. The Yukon River is the most sampled water body in the area, with the majority of sampling taking place at Eagle,

AK. Due to the sparse collections of data for the preserve as a whole, water chemistry and nutrient data are presented for the Yukon River at Eagle, AK. However, this site provides limited insight to the water quality in YUCH as a whole, and the water quality data for the site at Eagle are not necessarily representative of conditions throughout the Yukon River in the preserve.

Yukon River at Eagle, AK

NPS (1995) analyzed the water quality data for the preserve through 1995, including data collected at Eagle, AK. Prior to 1995, chemistry parameters rarely exceeded EPA standards (Table 35). Dissolved copper exceeded EPA drinking water standards on one sampling occasion prior to 1995 (NPS 1995). pH did not meet EPA standards for aquatic life on two occasions. Schuster et al. (2010) examined 34 pH measurements at Eagle, AK between 2006 and 2008; the average pH was 7.9, with a minimum value of 7.1 and a maximum of 8.7.

Turbidity exceeded EPA standards for aquatic life on multiple occasions prior to 1995. However, the Yukon River is glacial-fed and high turbidity is natural in these types of waters. Schuster (2003) found that turbidity measurements from 2001 at the same location examined by NPS (1995) were variable and exceeded EPA standards on occasion as well. In general, lower turbidity occurs under ice cover and during the summer (except after rainstorms), high turbidity occurs during high flows from snow and ice-melt and rainstorms, with peaks typically during the spring ice-break-up.

No EPA or AKDEC standards exist for specific conductance. Schuster et al. (2010) measured specific conductance 23 times on the Yukon River at Eagle, AK from 2006 to 2008. The mean specific conductance was 211 µS/cm, with a maximum of 272 µS/cm (Schuster et al. 2010).

Standards for nutrient parameters (DOC, phosphates, nitrates) have not been established. Schuster et al. (2010) measured DOC and nitrate 23 times between 2006 and 2008 at the Eagle, AK station. The average DOC concentration was 5.9 mg/L, with a maximum of 19.4 mg/L (Schuster et al. 2010). The mean nitrate concentration of this sampling effort was 4 µeq/L. Few phosphate or phosphorus samples have been collected in or around YUCH (two phosphorus samples were collected from the Yukon River at Eagle, AK in 1978). Elevated levels of phosphorus in water can cause accelerated plant and algae growth, low dissolved oxygen levels, and death of invertebrates, fish and other aquatic animals (EPA 2011).

Table 35. Summary of water quality observations on the Yukon River at Eagle, AK (NPS 1995).

Parameter	Std. Type	Std. Value	Total Obs	Exceed Standard	Prop. Exceeding
Turbidity, Jackson Candle Units	Other-Hi Lim.	50	7	4	0.57
Turbidity, Hach Turbidimeter	Other-Hi Lim.	50	2	1	0.50
Oxygen, Dissolved	Fresh Acute	4	1	0	0.00
pH	Other-Hi Lim.	9	38	0	0.00
	Other-Lo Lim.	6.5	38	2	0.05
Nitrate Nitrogen, Dissolved as N	Drinking Water	10	24	0	0.00
Nitrate plus Nitrate, total 1 DET.	Drinking Water	10	2	0	0.00
Chloride, total in water	Fresh Acute	860	28	0	0.00
Sulfate, total	Drinking Water	400	29	0	0.00
Arsenic, total	Fresh Acute	360	1	0	0.00
	Drinking Water	50	1	0	0.00
Barium, total	Drinking Water	2000	1	0	0.00
Cadmium, total	Fresh Acute	3.9	0	0	0.00
	Drinking Water	5	0	0	0.00
Chromium, total	Drinking Water	100	1	0	0.00
Copper, total	Fresh Acute	18	1	1	1.00
	Drinking Water	1300	1	0	0.00
Lead, total	Fresh Acute	82	0	0	0.00
	Drinking Water	5	0	0	0.00
Nickel, total	Fresh Acute	1400	1	0	0.00
	Drinking Water	100	1	0	0.00
Silver, total	Fresh Acute	4.1	0	0	0.00
	Drinking Water	50	1	0	0.00
Zinc, total	Fresh Acute	120	1	0	0.00
Selenium, total	Fresh Acute	20	1	0	0.00
	Drinking Water	50	1	0	0.00
Fecal coliform, MF	Other-Hi Lim.	200	1	0	0.00
Nitrate nitrogen, dissolved	Drinking Water	44	26	0	0.00
Uranium	Drinking Water	20	1	0	0.00

Presence and Concentration of Heavy Metals

One copper measurement collected on the Yukon River in 1974 at Eagle measured 50 μg/L, which exceeded the EPA acute freshwater criterion of 18 μg/L (NPS 1995). Additional heavy metal samples have been collected sporadically in YUCH, but no long-term data are available.

LaPerriere et al. (1985) measured heavy metal concentrations in several streams northwest of YUCH where gold mining was occurring. Arsenic, lead, zinc, and copper were found in elevated concentrations compared to un-mined reference streams (LaPerriere et al. 1985).

Threats and Stressor Factors

Legacy Effects of Past Mining and Current Mining Activities

Historic gold mining occurred on Woodchopper and Coal Creeks, which are tributaries of the Yukon River, in the early-to-mid 1900s. Mining was accomplished by using placer techniques and dredging (Beckstead 2003). The Coal Creek dredge operated from 1936 to 1957 (NPS 2011a). The greatest threat posed by both historic and current mining in and around YUCH is the potential to harm fish-spawning areas in rivers and streams (Brabets et al. 2000). The Coal Creek mining operation was declared a Superfund site by the EPA and cleanup was completed in 1998 (Brabets et al. 2000). During the NPS (1998) environmental impact study, Woodchopper, Coal, Sam, Ben, and Fourth of July Creeks contained zinc levels over 1986 EPA criteria. However, these levels were above the criteria upstream and downstream, but not within past mining activity areas in the study. Although these creeks may contain heavy metals and high levels of sediments (NPS 2011b), the present status of legacy effects of past mining activities is unknown. The most notable mine-tailings-derived sediment input was in Coal Creek; NPS (1998, p. 61) noted, "sediment input from the previously mined area has substantially reduced the suitability of downstream habitat for aquatic organisms." Lesser effects of tailing-derived sediment inputs were noted by NPS (1998) for the other aforementioned creeks with past mining activity.

Wagener and LaPerriere (1985) studied the effects of gold placer mining in several Alaskan streams (Faith Creek, Chatanika River, Birch Creek, Mammoth Creek, Ketchem Creek) northwest of the preserve. Turbidity, non-filterable residues, and settleable solids were higher in mined streams than in non-mined reference streams. Invertebrate density and biomass were significantly lower in mined streams compared to reference locations (Wagener and LaPerriere 1985). One stream (Ptarmigan Creek) was measured prior to mining and again after mining occurred; after mining, there was a significant increase in turbidity and settleable solids and a decrease in invertebrate density and biomass (Wagener and LaPerriere 1985). It is important to note that these results represent conditions during active mining; it is likely that disturbances caused by mining may subside after mining activities cease.

Heavy metals released into streams as a result of placer mining are likely to have long-term impacts on water quality. Arsenic, cadmium, mercury, lead, zinc, and copper are metals commonly associated with gold that can be released during placer mining (LaPerriere et al. 1985). LaPerriere et al. (1985) found significantly elevated levels of arsenic, lead, zinc, and copper below placer mining operations at both current and historic mines.

There is an active gold mining operation located on Woodchopper Creek in the preserve (Simmons, pers. comm., 2011). According to Tom Liebscher, YUCA Chief of Natural and

Cultural Resources (pers. comm., 2011), the mining operation on Woodchopper Creek has been active sporadically and has some local impacts on water quality but is not a major concern at this time. As the price of gold has risen substantially in recent years and may continue to rise, this is an ongoing concern for water quality in YUCH. Also, if cyanide heap leaching were employed at the mining operation, there would be increased concern for water quality (Liebscher, pers. comm., 2011).

Effects of Climate Change
Average air temperatures in YUCH are projected to rise approximately 1°F per decade (SNAP et al. 2009). Climate change may influence the distribution of permafrost, level of glacial runoff, and biogeochemical fluxes in the Yukon River basin (Brabets et al. 2000). Increased permafrost thawing is expected to increase nutrient, sediment, and carbon loading in Arctic water bodies, which will have both positive and negative effects on water quality (Wrona et al. 2006). Changes in natural chemical and physical properties of water could alter migration patterns of salmon, as well as moose and waterfowl (Schuster 2010). Rising water temperatures in YUCH water bodies are another likely result of climate change (NPS 2010).

Increased Development
There are three small communities near YUCH: Eagle, Eagle Village, and Circle, AK, totaling only a few hundred people together. Increased development in these communities or in any industry surrounding the preserve could negatively impact water quality. Development activities such as logging, road construction, and infrastructure development can negatively impact water quality (NPS 2011b). According to Trey Simmons (pers. comm., 2011), the most likely threat posed by traditional development would occur on the Yukon River upstream of the preserve, in Canada.

Effluent Discharge from Dawson
Dawson, Canada is located on the Yukon River, about 150 km (90 mi) upstream of YUCH. The population is roughly 1,300 people. Currently, Dawson is responsible for one billion liters of wastewater input into the Yukon River each year. This wastewater is preliminarily screened; many small sewage particles remain when wastewater is transferred to the river. Following direction from the Yukon Territorial Court, Dawson implemented a project to develop a wastewater treatment plant. The new wastewater treatment plant should be complete and operational by spring of 2012 (Government of Yukon 2012).

Floaters/Rafters Causing Degradation of Riparian Corridor
Rafting and float trips are a tourist draw on the Yukon and Charley Rivers in the preserve. Damage can occur to riparian corridors (vegetation and river banks) where people enter, exit, and camp along the rivers, potentially impacting water quality. Currently, this potential threat is of low concern in the preserve; however, if the popularity of such activities were to increase in the future, so would the threat of riparian habitat and water quality degradation (Simmons, pers. comm., 2011).

Administrative and Research Activities
There are a number of administrative and research-related activities in YUCH that could cause disturbance and potentially impact water quality. Potential fuel spills or leaks from OHVs, boats, helicopters, and airplanes may present localized threats to water quality. The septic system and

airstrip at the Coal Creek administrative building pose a minor potential threat to water quality, and ATV traffic by researchers and preserve staff could negatively impact a newly discovered Chinook salmon rearing site in the area (Simmons, pers. comm., 2011).

Airborne Contaminants
Airborne mercury deposition is a threat to water quality within the preserve. China is the largest emitter of mercury from fossil fuel combustion; these pollutants can reach Alaska via trans-Pacific transport in windblown dust (Macdonald et al. 2004). Mercury contamination is caused by airborne deposition originating from coal combustion, waste incineration, mining, and natural sources (EPA 2010c). In water, mercury is converted to methylmercury, a neurotoxin that is biomagnified in the aquatic food web (EPA 2010c).

Chlorinated pesticides, including HCH, HCS, DDT, toxaphene, and chlordanes have been detected in the Arctic, and it is believed that these chemicals are transported globally in the atmosphere (Brabets et al. 2000). These compounds become concentrated in the fat of fish and mammal species (Brabets et al. 2000). No data exist on the presence or concentration of these compounds in YUCH water bodies.

Oil and Gas Exploration
Oil and gas exploration are concerns in the Nation and Kandik River basins because the State of Alaska owns these river beds within the preserve and associated development rights (Brabets 2001). The NPS is concerned with two potential impacts associated with oil and gas exploration: temporary access across preserve land and possible development within the preserve (Brabets 2001). Oil and gas extraction create the potential for leaching of drilling waste from proposed reserve pits (NPS n.d.). Wastewater and fuel spills are additional potential threats to water quality, and turbidity may increase because of gravel removal (NPS n.d.). There is also 29,317 ha (72,443 ac) of proposed oil and gas exploration area located between the western boundary of the preserve and just east of Central and northeast of Circle, AK (Plate 23, AK DNR DOG 2010).

Data Needs/Gaps
There is a lack of long-term water quality monitoring within YUCH boundaries; many of the measurements used to assess water quality in the preserve were taken in Eagle, AK. These measurements do not account for any inputs to water bodies within YUCH boundaries. Most of the sampling stations represented in NPS (1995) were one-time or single-year intensive sampling efforts. Multi-year studies are necessary to determine long term trends in YUCH water quality.

There is no well-developed methodology for measuring macroinvertebrate community health in Alaskan ecosystems (Simmons 2010). Development of a suitable macroinvertebrate index for the area would allow long-term trends of community health (biological integrity) to be established. It is important to collect macroinvertebrate data on undisturbed reference streams in the preserve to determine expected levels of diversity and abundance for future comparison; the study by O'Brien and Huggins (1976) provides some idea of the species composition in some YUCH streams.

The history of gold mining on Coal and Woodchopper Creeks was addressed in Beckstead (2003), but potential environmental implications of this activity were not discussed. The present impacts of past mining activity have not been revisited since the 1980s. The threat posed by atmospheric deposition of mercury and anthropogenic chemicals also has not been quantified in YUCH water bodies.

<u>Overall Condition</u>

The measures used in this assessment were macroinvertebrates, water chemistry, presence and concentration of nutrients, and presence and concentration of heavy metals; the *Significance Levels* of these measures are 3, 1, 1, and 2, respectively. Due to insufficient data, the *Condition Level* is undefined for all measures. However, due to the remoteness of the park and the limited anthropogenic influences, water quality is likely in a natural state for most of the preserve. There are particular areas in the park where mining or other anthropogenic stressors altered the water quality, but the prevalence of these areas is limited. The implementation of monitoring in the future should provide the data necessary to detect changes in water quality in the preserve, along with the ability to define condition in the future.

Sources of Expertise

Trey Simmons, CAKN Aquatic Ecologist

Thomas Liebscher, YUGA Chief of Natural & Cultural Resources

Literature Cited

Alaska Department of Natural Resources, Division of Oil and Gas (AKDNR DOG). 2010. Crooked-Creek Circle Basin proposed. Online. (http://dog.dnr.alaska.gov/Programs/ExplorationLicenseAreas.htm#circle). Accessed 1 November 2011.

Beckstead, D. 2003. The world turned upside down: a history of mining on Coal Creek and Woodchopper Creek, Yukon-Charley Rivers National Preserve, Alaska. National Park Service, Fairbanks, Alaska.

Brabets, T. P., B. Wang, and R. Meade. 2000. Environmental and hydrologic overview of the Yukon River Basin, Alaska and Canada. Water-resources investigations report 99-4204. U.S. Geological Survey, Anchorage, Alaska.

Brabets, T. P. 2001. Hydrologic data from Nation, Kandik, and Yukon Rivers, Yukon-Charley Rivers National Preserve, Alaska. Open-File Report 01–295. U.S. Geological Survey, Anchorage, Alaska.

Environmental Protection Agency (EPA). n.d. Appendix F: national EPA water quality criteria summary. Environmental Protection Agency, Washington, D.C.

Environmental Protection Agency (EPA). 2009. Phosphorus. Online. (http://www.epa.gov/agriculture/ag101/impactphosphorus.html). Accessed 6 May 2011.

Environmental Protection Agency (EPA). 2010a. Dissolved oxygen. Online. (http://www.epa.gov/caddis/ssr_do_int.html). Accessed 26 April 2011.

Environmental Protection Agency (EPA). 2010b. Fecal bacteria: What are fecal bacteria and why are they important? Online. (http://water.epa.gov/type/rsl/monitoring/vms511.cfm). Accessed 24 March 2011.

Environmental Protection Agency (EPA) 2010c. Mercury: basic information. Online. (http://www.epa.gov/mercury/about.htm). Accessed 21 April 2011.

Environmental Protection Agency (EPA). 2011. Phosphorus. Online. (http://water.epa.gov/type/rsl/monitoring/vms56.cfm). Accessed 22 November 2011.

Eppinger, R. G., P. H. Briggs, D. Rosenkrans, and V. Ballestrazze. 2000. Environmental Geochemical Studies of Selected Mineral Deposits in Wrangell-St. Elias National Park and Preserve, Alaska. U.S. Geological Survey Professional Paper 1619. U.S. Geological Survey, Reston, Virginia.

Government of Yukon. 2012. Dawson wastewater treatment project. Online. (http://www.dawsonwastewater.ca/hottopics.html). Accessed 20 February 2012.

Karr, J. R., and D. R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5(1):55-68.

LaPerriere, J. D., S. M. Wagener, and D. M. Bjerklie. 1985. Gold-mining effects on heavy metals in streams, Circle Quadrangle, Alaska. Water Resources Bulletin 21(2):245-252.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Fairbanks, Alaska.

Macdonald, R. W., T. Harner, and J. Fyfe. 2004. Arctic mercury deposition and its relationship to climate change. Online. (http://www.akcontaminants.org/blog/?p=478). Accessed 1 December 2011.

Mueller, D. K., and D. R. Helsel. 2009. Nutrients in the nation's waters—too much of a good thing? Online. (http://pubs.usgs.gov/circ/circ1136/circ1136.html#WHATARE). Accessed 25 March 2011.

National Park Service (NPS). 1995. Baseline water quality data inventory and analysis: Yukon-Charley Rivers National Preserve. Technical Report NPS/NRWRD/NRTR-95/53. National Park Service, Water Resources Division, Fort Collins, Colorado.

National Park Service (NPS). 2010. Rivers & streams climate change resource brief. October 2010, No. 72. National Park Service, Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). 2011a. Coal Creek dredge. (http://www.nps.gov/yuch/planyourvisit/coalcreekdredge.htm). Accessed 9 November 2011.

National Park Service (NPS) 2011b. Streams & rivers resource brief. February 2011, No. 72. Alaska Region Inventory & Monitoring Program. National Park Service, Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). n.d. Nation River project, Yukon-Charley National Rivers Preserve. Unpublished report. National Park Service,Yukon Charley Rivers National Preserve, Alaska.

O'Brien, W. J., and D. G. Huggins. 1976. A limnological investigation of the lakes and streams of the Charley River area. Pages 282-321 *in* The environment of the Yukon-Charley Rivers area, Alaska. S. B. Young, editor. The Center for Northern Studies, Wolcott, Vermont.

Scenarios Network for Alaska Planning (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 10 November 2011.

Schuster, P. F. 2003. Water and sediment quality in the Yukon River Basin, Alaska, during water year 2001. Open-File Report 03-427. U.S. Geological Survey, Denver, Colorado.

Schuster, P. F., K. B. Maracle, and N. Herman-Mercer. 2010. Water quality in the Yukon River

Basin, Alaska, water years 2006-2008. Open-File Report 2010–1241. U.S. Geological Survey, Reston, Virginia.

Simmons, T. 2010. A history of the concept of biological integrity and its use in the assessment of water quality. Unpublished report. National Park Service, Central Alaska Network, Fairbanks, Alaska.

U.S. Geological Survey (USGS). 2009. What are bacteria? Online. (http://ga2.er.usgs.gov/bacteria/bacteria.cfm). Accessed 8 February 2011.

U.S. Geological Survey (USGS). 2010. Common water measurements: USGS water science for schools. U.S. Geological Survey. Information from "A Primer on Water Quality" by Swanson, H. A., and H. L. Baldwin, U.S. Geological Survey, 1965. Online. (http://ga.water.usgs.gov/edu/characteristics.html). Accessed 1 October 2010.

U.S. Geological Survey (USGS). 2011. Mercury in stream ecosystems. National Water Quality Assessment Program. Online. (http://water.usgs.gov/nawqa/mercury/). Accessed 27 January 2011.

Wagener, S. W., and J. D. LaPerriere. 1985. Effects of placer mining on the invertebrate communities of interior Alaska streams. Freshwater Invertebrate Biology 4(4):208-214.

Wrona, F. J., T. D. Prowse, J. D. Reist, J. E. Hobbie, L. M. J. Levesque, and W. F. Vincent. 2006. Climate change effects on aquatic biota, ecosystem structure and function. Ambio 35(7):359-369.

Yukon River Inter-Tribal Watershed Council (YRITWC). 2002. Yukon River unified watershed assessment. Yukon River Inter-Tribal Watershed Council, Alaska Region Office, Anchorage, Alaska.

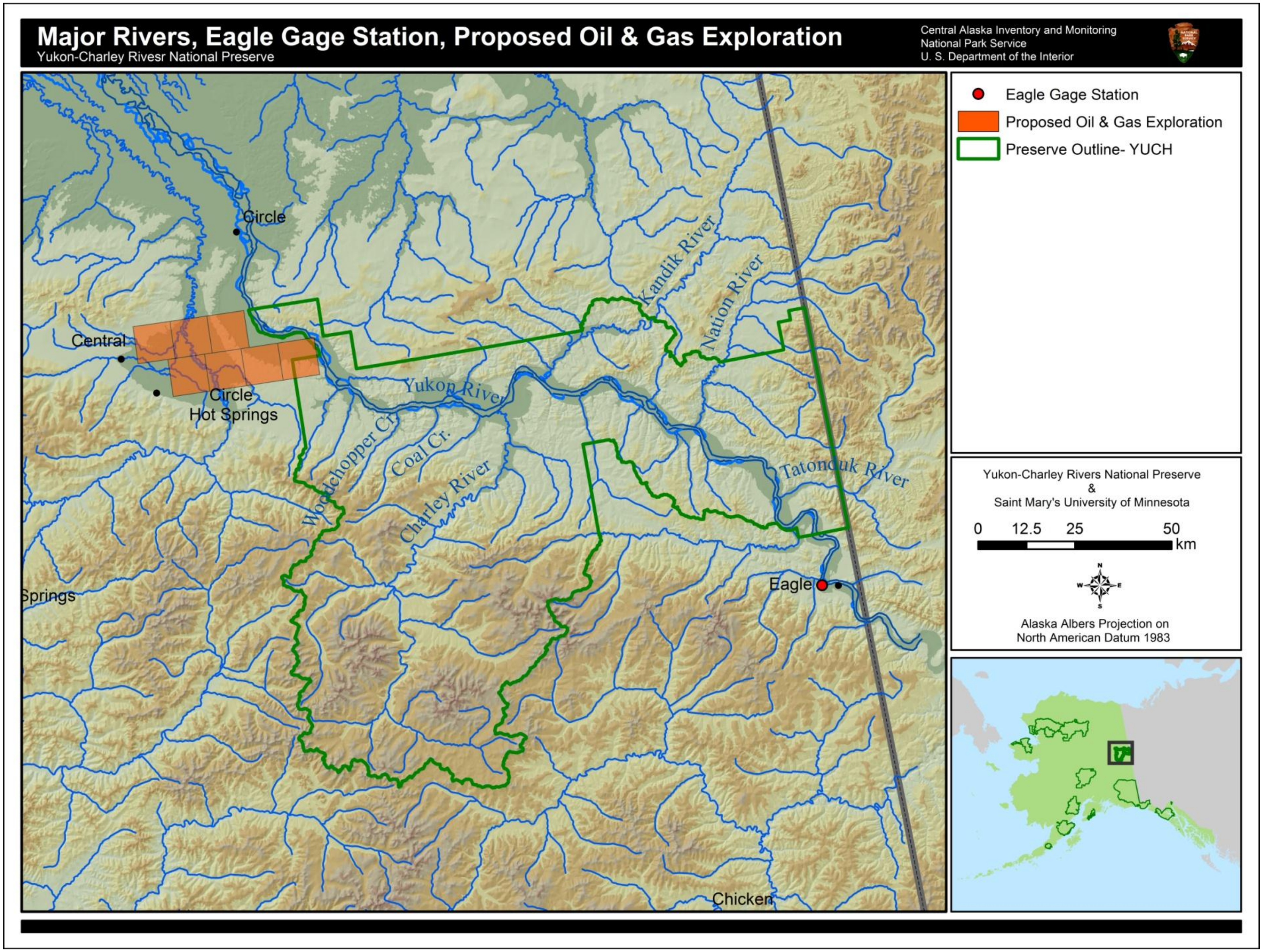


Plate 23. Eagle, AK gage station and major rivers in YUCH (AKDNR DOG 2010).

4.20 Air Quality*

* During initial project scoping, project stakeholders identified air quality as a placeholder component. These components are recognized in the assessment as an important resource for the preserve, but little or no data exist to examine its current condition. Thus, data are not summarized nor condition assessed. Rather, a brief overview of the component and a description of potential measures, threats, and stressors are provided for the primary purpose of inclusion in a future assessment when appropriate data are available.

Description

Air pollution can significantly affect natural resources and their associated ecological processes. In particular, air pollution can influence water quality and soil pH, compromise plant health and distribution, accelerate the decay of geologic or cultural features, and impair the visibility and air quality within parks (NPS 2007). Consequently, air quality in parks and wilderness areas is protected and regulated through the 1916 Organic Act and the Clean Air Act of 1970 (CAA) and the CAA's subsequent 1977 amendments, which specify protection for parks and wilderness areas. The Clean Air Act defines two distinct categories of protection for natural areas, Class I and Class II airsheds. The CAA also establishes that current visibility impairment in Class I areas must be remedied and future impairment prevented (EPA 2008). To comply with CAA and NPS Organic Act mandates, the NPS established a monitoring program that measures air quality trends in many park units for key air quality indicators, including atmospheric deposition, which affects ecological health through acidification and fertilization; ozone, which affects native plant communities and human health; and visibility, which affects how well and how far visitors can see park landscapes (NPS 2009).

The CAA designates YUCH as a Class II airshed, a classification that allows for some degradation of air quality from the existing condition (NPS 1985). YUCH has several important resources that may be impacted negatively by changes in air quality, which are identified by CAKN as Air Quality Related Values (AQRVs) (CAKN 2011). AQRVs such as visibility, vegetation, surface waters, soils and fish, and wildlife are considered sensitive to air pollution and may be adversely impacted by air pollutants and atmospheric deposition of nitrogen, sulfur oxides, and heavy metals (CAKN 2011). Although YUCH is located in the remote interior basin of Alaska, there are sources of pollution, both regional and global, that increase the potential for decreased air quality in the preserve (NPS 1985).

Local/Regional Sources

In the winter, the interior Alaska region often experiences extended periods of little air movement and extreme temperature inversions; these extended periods in combination with cold temperatures and minor emissions from wood smoke or development, can cause localized pollution (NPS 1985). In summer, hot, dry weather patterns encourage both large and small-scale wildfires to burn across YUCH and the surrounding region (NPS 2006). Although these fires have many ecological benefits to the interior Alaska landscape, the smoke from wildfires periodically impacts air quality and visibility in the preserve (NPS 1985).

Global Sources

Some air pollution affecting interior Alaska comes from international sources beyond the reach of the CAA (NPS 2010a). Pollutants originate from a variety of emission sources including power plants, smelters, agriculture, and others across the Asian and European continents. Contaminants from these international sources reach interior Alaska via two transport mechanisms: Trans-Arctic transport in the form of Arctic Haze that brings pollutants over the North Pole and into Alaska, and Trans-Pacific transport in the form of airborne dust and aerosols (NPS 2010a). Arctic Haze deposits nitrogen and sulfur compounds, as well as heavy metals, in snow, water, and soils in Alaska (NPS 2008). Windblown particulates and dust from Asia and Europe periodically travel across the Pacific Ocean and settle in Alaska. While historically this is a natural event for the region, dust storms are expected to increase in frequency due to increased human-caused desertification in Asia, and the amount of airborne contaminants entering interior Alaska from international sources are expected to increase as global development continues (AKDEC 2002).

Measures

- Atmospheric deposition of mercury
- Atmospheric deposition of nitrogen
- Atmospheric deposition of sulfur
- Visibility

Reference Conditions/Values

Where adequate data exist or where data can be interpolated between sites, the NPS Air Resources Division has established an approach for rating air quality conditions in national parks, which are based on current NAAQS, ecosystem thresholds, and visibility improvement goals (NPS 2010b). Typically these standards are identified as the reference condition for air quality in condition assessments. However, because no data will be summarized, nor will the condition of air quality be assessed, reference condition is not specified here.

Data and Methods

To date, there are no long-term air quality monitoring stations located in or near YUCH, nor have any studies on air quality been conducted in the preserve. Thus, there are not monitoring data available to assess air quality condition in YUCH. The IMPROVE database contains stacked filter unit data for aerosols and particulate matter at Eagle from 1986 to 1993. No data exist for this beyond 1993.

The Alaska Department of Environmental Conservation drafted a regional air quality plan for Alaska, which addressed air quality concerns for Class I airsheds (AKDEC 2002). However, this plan does not specifically mention actions intended for management of air quality in YUCH. Additionally, the NPS (2010c) Annual Performance and Progress Report on air quality in national parks provided insight into air quality conditions for the greater interior Alaska Basin. Lastly, Landers et al. (2008) conducted a study of the transport and ecological impacts of airborne contaminants in western national parks. Air quality contaminant sampling was completed for air, snow, vegetation, fish and sediment resources in several Alaskan parks. YUCH was not included in this study, but sampling did occur at Denali National Park and Preserve (DENA) (located approximately 290 km to the west of YUCH), and these results were used to gain insight into the air quality of the greater interior Alaska Basin.

Current Condition and Trend

Atmospheric Deposition of Mercury
To date, no current or historical deposition data are available for YUCH.

Atmospheric Deposition of Nitrogen
To date, no current or historical deposition data are available for YUCH.

Atmospheric Deposition of Sulfur
To date, no current or historical data are available for deposition or concentration of sulfur in or near YUCH.

Visibility/Arctic Haze
To date, aerosol and visibility data exist for 1986 to 1993 from Eagle, Alaska, approximately 8 kilometers (13 m) from YUCH.

Air Quality in the Region
Though DENA is located quite a distance west of YUCH (290 km), it supports air quality monitoring stations whose data may provide some insights into the air quality of the greater interior Alaska Basin. NPS (2010c) reports that air quality conditions in DENA for ozone, visibility, and wet deposition of nitrogen and sulfur are good with a stable trend. When sampling fish from two lakes in DENA, Landers et al. (2008) found mercury concentrations that exceeded contaminant health thresholds for mammals and piscivorous birds and concentrations of historic-use semi-volatile organic compounds (SOCs) that exceeded contaminant health thresholds for subsistence fishers. Though DENA is a considerable distance from YUCH, it is possible that YUCH experiences similar contamination levels through atmospheric deposition.

Threats and Stressor Factors
During initial project scoping, YUCH resource specialists identified the following regional and global threats to YUCH's air quality:

- Intercontinental/international sources of emissions reaching interior Alaska via two pathways: Trans-Arctic transport (e.g., Arctic Haze) and Trans-Pacific transport (e.g., windblown dust and aerosols from other continents) of contaminants such as sulfur and nitrogen oxides, and heavy metals.
- Increasing global and local development will add to the total emission sources and the pollutants carried into YUCH.
- Arctic Haze events, though periodic, reduce visibility, impair viewsheds, and contribute to deposition of contaminants in water, snow and soils.
- Climate change/warming may contribute to shifts in natural processes that may impact air quality. Warmer average temperatures may contribute to an increase in the natural gaseous release from thawing permafrost, as well as contribute to an increase in the frequency and intensity of wildfires (increased wildfire smoke).

Data Needs/Gaps

The CAA mandates the protection of natural and cultural resources of national parks (EPA 2008) and the NPS established a national air monitoring program to comply with these mandates. Although no data for core air quality parameters are available for YUCH, NPS (1985) considers air quality within YUCH to be excellent. The YUCH General Management Plan (1985) states that air quality monitoring will be established at strategic locations in YUCH to gather baseline data and to monitor for potential degradation. To date, no long-term air quality monitoring stations have been established in or near YUCH (the nearest stations are located in DENA approximately 290 km to the west). Because higher than expected levels of mercury and SOCs have been found in DENA, it may be necessary to begin monitoring these contaminants in YUCH.

Overall Condition

There is a lack of monitoring sites in or near YUCH that capture deposition and concentration data for the specified measures of this component. Thus, it is not possible to assess the condition of air quality for YUCH at this time.

Sources of Expertise

Andrea Blakesley, Environmental Protection Specialist, Denali National Park & Preserve; Maggie MacCluskie, National Park Service Inventory & Monitoring Program Manager, Central Alaska Network.

Literature Cited

Alaska Department of Environmental Conservation (AKDEC). 2002. Draft regional haze in Alaska: Summary of scientific knowledge and its implications for Alaska's state implementation plan. Alaska Department of Environmental Conservation, Juneau, Alaska.

Central Alaska Network (CAKN). 2011. Sensitive air quality related values of Central Alaskan Network Parks. Online. (http://www.nature.nps.gov/air/permits/aris/networks/docs/caknFinalAqrvList.pdf). Accessed 20 June 2011.

Environmental Protection Agency (EPA). 2008. Air and radiation: Clean Air Act Title I. Online. (http://epa.gov/oar/caa/title1.html#ic). Accessed 13 June 2011.

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). EPA/600/R-07/138. U.S. Environmental Protection Agency, Office of Research and Development, Western Ecology Division, Corvallis, Oregon.

National Park Service (NPS). 1985. Yukon-Charley Rivers National Preserve, Alaska: General management plan, land protection plan, Charley Wild River management plan, and wilderness suitability review. National Park Service, Washington, D.C.

National Park Service (NPS). 2006. Yukon-Charley Rivers National Preserve – Environmental factors. (http://www.nps.gov/yuch/naturescience/environmentalfactors.htm). Accessed 22 June 2011.

National Park Service (NPS). 2007. Explore air: Effects of air pollution. (http://www.nature.nps.gov/air/AQBasics/effects.cfm). Accessed 16 June 2011.

National Park Service (NPS). 2008. Denali National Park and Preserve air quality overview. (http://www.nature.nps.gov/air/permits/aris/dena/?CFID=5760339&CFTOKEN=96316879). Accessed 24 June 2011.

National Park Service (NPS). 2009. Air quality monitoring and access to data. (http://www.nature.nps.gov/air/monitoring/index.cfm). Accessed 16 June 2011.

National Park Service (NPS). 2010a. Air quality in Denali National Park and Preserve. (http://www.nps.gov/dena/naturescience/airquality.htm). Accessed 24 June 2010.

National Park Service (NPS). 2010b. Rating air quality conditions. Air Resources Division, Natural Resources Program Center. Online. (http://www.nature.nps.gov/air/Planning/docs/20100112_Rating-AQ-Conditions.pdf). Accessed 10 November 2011.

National Park Service, Air Resources Division (NPS) 2010c. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, Colorado.

4.21 Hydrology

Description

Thirteen sub-basins, representing eight major tributaries and lowland areas, combine to form the Yukon River Basin. YUCH is located in the East Central Yukon Drainage Basin, which encompasses an area of 7.1 million ha (17.5 million ac) (Brabets et al. 2000). The preserve includes approximately 260 km (160 mi) of the Yukon River between Eagle and Circle, AK (Larsen et al. 2004).

Photo 37. Yukon River looking downstream in the preserve (NRCS photo).

YUCH includes four primary watersheds (other than the Yukon River itself): the Charley, Kandik, Nation, and Tatonduk River watersheds (Plate 24). The Charley River, protected under the Wild and Scenic Rivers Act, flows northwest and its entire watershed is contained within YUCH boundaries. Aside from the Yukon River, the Charley River basin is the largest watershed within the preserve, draining 440,300 ha (1.2 million ac). The Kandik, Nation, and Tatonduk Rivers originate in Canada and flow southwest into the Yukon River. The Kandik River flows 132 km (82 mi) and drains approximately 310,800 ha (768,001 ac), the Nation River flows a distance of 80 km (49.7 mi) and drains 233,100 ha (576,000 ac) and the Tatonduk River flows for 97 km (60.3 mi) and drains 349,700 ha (867,124 ac).

Enabling legislation specifies that one purpose of YUCH is to "maintain the environmental integrity of the entire Charley River Basin in its undeveloped natural condition for public benefit and scientific study" (ANILCA §§ 201(10)). Furthermore, the General Management Plan for YUCH states that the NPS "proposes to manage the shorelines of these rivers to protect their primitive or, in the case of the Yukon, their natural characters, with no new development on federal land" (NPS 1985, p. 55).

The only active USGS stream gage near the preserve is located on the Yukon River at Eagle, AK (approximately 19.3 km [12 mi] upstream of the preserve boundary) (NPS 2009a), and therefore this assessment focuses on the Yukon River. During most years, the Yukon River begins to freeze in October, with ice reaching a thickness of approximately 1.2 to 2.4 m (4 to 8 ft). Ice breakup usually occurs in April, and is complete by May (Previsic and Bedard 2008). The breakup of ice has the potential to be very destructive, with large chunks of ice scouring the bottom of the river (Previsic and Bedard 2008), and forming ice dams, which can cause flooding from the backup of flowing water.

CAKN is interested in developing a protocol for monitoring stream flood frequency and discharge, pending the availability of necessary resources (Simmons, pers. comm., 2011). These

Vital Signs are highly relevant in YUCH, and monitoring would be designed to determine long-term trends. Snowpack is also a Vital Sign in YUCH, and monitoring in conjunction with climatic variables will help quantify this ecological driver of the preserve's ecosystems (MacCluskie and Oakley 2005).

Measures

- Discharge
- Snowpack
- Ice freeze-up/break-up
- Flood frequency
- Flood magnitude

Reference Conditions/Values

The reference condition for general hydrologic river function in YUCH is a hydrologic regime driven by natural processes. The parameters of what is considered a "natural" hydrologic regime in YUCH are not well characterized. However, the relatively long period of discharge records at Eagle, AK, historic flood (stage height) data, and snowpack data provide some indication of the range of natural variability in these parameters for at least the main stem of the Yukon River. Climate change is expected to alter the primary drivers of the hydrologic regime, such as patterns of precipitation (summer rainfall, winter snowpack), and the timing and duration of snowmelt and river freeze-up and break-up. This would, in turn, alter the hydrologic regime as well, including the timing, frequency, and magnitude of high flow events. In addition, melting permafrost is expected to affect the hydrology of the preserve by altering the importance and connectivity of subsurface and surface hydrologic flow paths. Therefore monitoring hydrologic parameters is important for detecting changes caused by climatic changes.

Data and Methods

The USGS (2011) water data for Alaska website provided peak flow, stage height, and discharge data from stream gage station 15356000, located on the Yukon River at Eagle, AK, from 1950 to 2010. Data are current as of 31 January 2011. USGS (2011) also provided discharge from stream gage station 15388060 on the Kandik River from 1994 to 2001 and stream gage station 15388030 on the Nation River from 1991 to 2003.

NRCS (2011) provided the average snow water equivalent (SWE) and snow depth (1989 to 2009) from the Mission Creek SNOTEL (SNOwpack TELemetry) Station 41P06, retrieved on 18 February 2011.

NOAA (2011) provided the historical flood crest data for the Yukon River at Eagle, Alaska (stream gaging station 15356000), as well as flood stage and action stage levels.

Eagle resident, John Borg continued a collection of historic ice freeze-up and break-up dates for the Yukon River from 1897 to 2011 (Borg 2011).

Current Condition and Trend

Discharge

Discharge monitoring in the Yukon River Basin began in the late 1940s and early 1950s when streamflow gaging stations were established (Brabets et al. 2000). Discharge has been measured for the Yukon River at Eagle since 1951. A hydrograph based on the mean monthly discharge over this period is shown in Figure 60. Peak discharge occurs in the spring, typically in early June, and then decreases gradually until December. December through April constitutes the baseflow period for the Yukon River, with low flows dominated by groundwater input. This is a typical hydrograph for a snowmelt dominated river, although flows in the Yukon remain relatively high throughout the summer due to substantial inputs from glacial rivers.

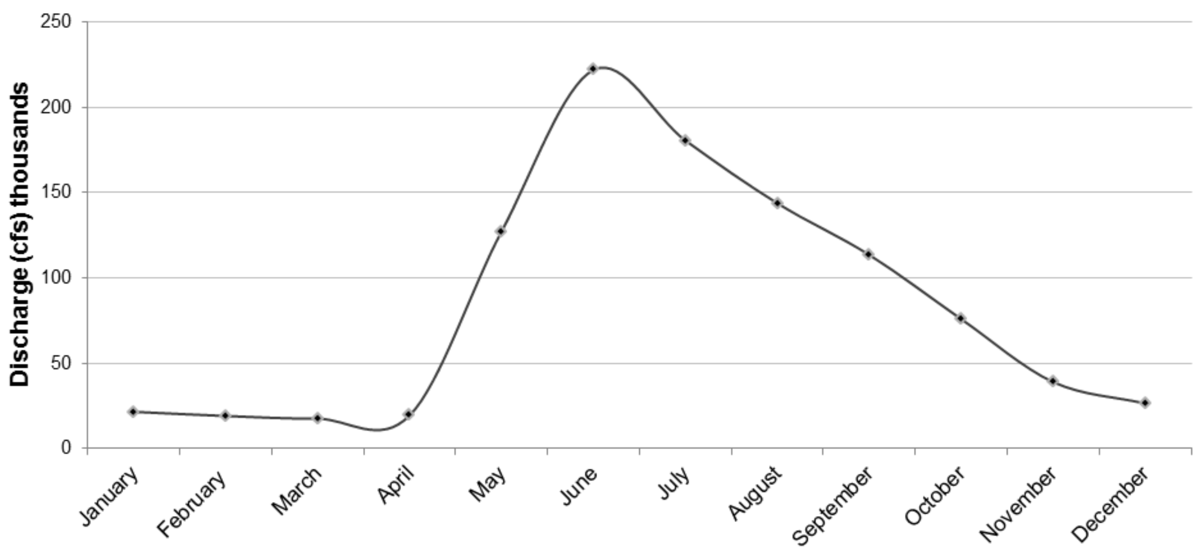


Figure 60. Mean monthly discharge of the Yukon River at Eagle from 1951 to 2009 (USGS 2011).

Mean annual discharge from 1952 to 2009 (1951 was only measured for ~6 months) averaged 85,000 cfs, with minimum and maximum annual means of 24,000 and 110,000 cfs, respectively (Figure 61). A least squares linear regression showed no statistically significant linear trend in the mean annual discharge over this period (F=1.135; alpha = 0.05; p = 0.291). This is consistent with the findings of Brabets and Walvoord (2009), who found no trends in mean annual discharge over a similar period. In a related study, Brabets and Walvoord (2009) examined long-term trends in seasonal flow at 21 sites throughout the Yukon River Basin, all of which had over 20 years of discharge data. They found a statistically significant increase both in winter flows (1 January to 31 March) and average April flows at the majority of these sites. Increased winter flow is presumed to be due to increased groundwater discharge to the stream rather than increased surface-water runoff, due to frozen surface conditions (Brabets and Walvoord 2009). For the Yukon River at Eagle, Brabets and Walvoord (2009) found statistically significant increases in May flows and flows during the fall recession (1 October to 31 December).

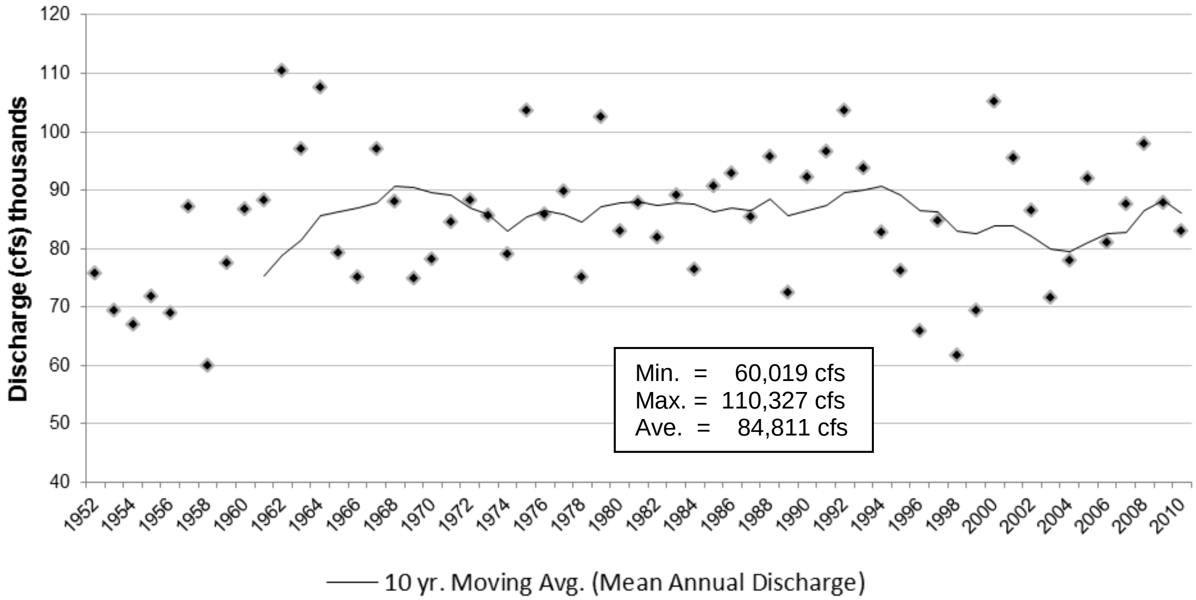


Figure 61. Mean annual discharge (cfs) of the Yukon River at Eagle from 1952 to 2010 (USGS 2011). Values based on mean monthly discharge for each year, shown with a ten-year moving average line.

The only other discharge data available within YUCH are from gages on the Nation (1991-2003) and Kandik (1994-2001) Rivers. Brabets (2001) conducted a study of discharge during the open water season (May-September) for these two sites. Hydrographs based on mean monthly discharge are similar for these two rivers, with a spring peak flow that recedes gradually through the summer (Figure 62). A second peak due to late summer rains occurs in August, followed by decreased flow into the fall. Although the short periods of record for these two rivers preclude an analysis of trends in discharge, these data could provide a baseline for comparison if gages are re-established in the future.

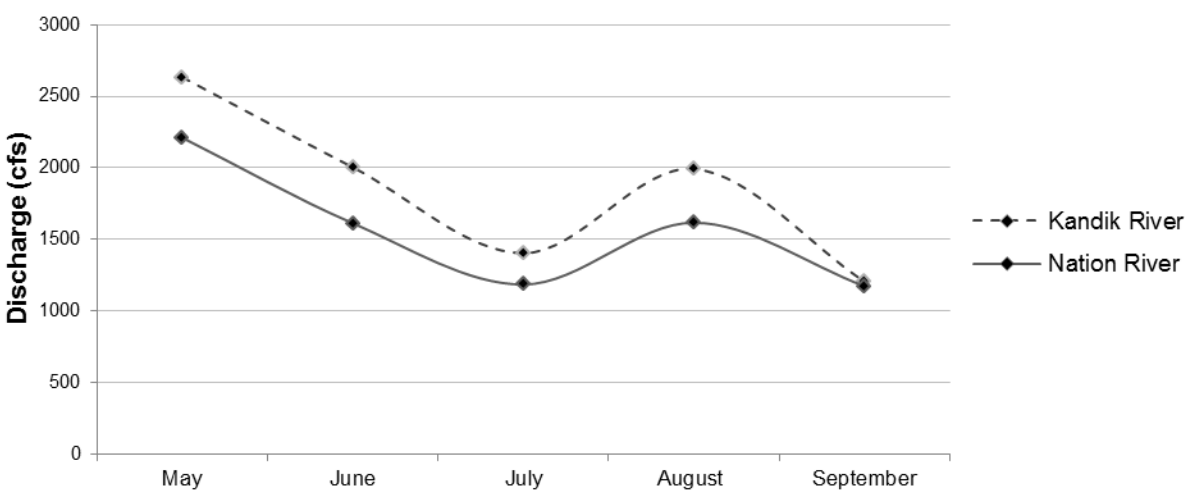


Figure 62. Average monthly discharge during the open water season for Kandik River (1994 to 2000) and Nation River (1991 to 2000) (Brabets 2001).

Snowpack

Seasonal snowpack is an important climatic feature in areas of high latitude due to its large influence on hydrology, as well as on vegetation and faunal communities (Sousanes 2008). As a driver of hydrologic regime, the most important measure of snowpack is its snow water equivalent (SWE), which is the amount of water contained within the snowpack (Sousanes 2008)

Few snowpack data are available for the preserve; however, a survey conducted from 2006-2007 by Sousanes (2008) reported that snow depths at Coal Creek were similar to those at the Mission Creek SNOTEL site near Eagle, suggesting that Mission Creek data are an adequate surrogate for snow conditions within the preserve. Based on the Mission Creek data, in a typical year, both snow depth and SWE in YUCH increase gradually from October through April, and decrease abruptly in May.

A visual examination of snowpack data for the Mission Creek SNOTEL site collected from 1989 to 2009 suggests that average snow depth and SWE remained relatively stable over this period (Figure 63). Average snow depth was 35.6 cm (14 in), and average SWE was 7.3 cm (2.9 in). The deepest snowpack occurred in 2004, when snowpack reached a depth of 56 cm (22 in). The shallowest snowpack (23.5 cm [9.2 in]) was recorded in 1999. The highest SWE (11.8 cm [4.6 in]) was recorded in 2000, and the lowest (3 cm [1.18 in]) in 1999. While these data are relevant to the local hydrology of Mission Creek, snowpack in the larger upstream portion of the Yukon River watershed, largely in Canada, is more relevant to the hydrology of the Yukon River as it enters the preserve near Eagle, AK.

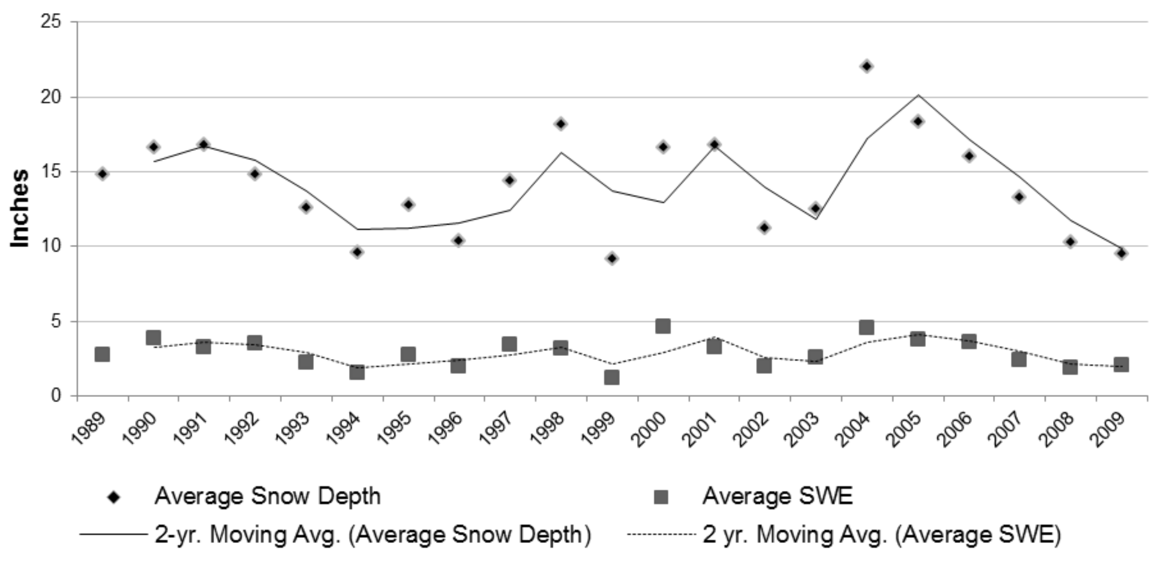


Figure 63. Mission Creek at Eagle average annual snow depth and snow water equivalent (SWE) from 1989 to 2009 (NRCS 2011). Shown with two-year moving average lines.

River Freeze-up/Break-up

Freeze-up has important ecological and social implications for a river system. After freeze-up, rainfall runoff will generally no longer increase the water supply in a system (Williams 1965); dissolved oxygen levels also generally decrease under the ice, with potential implications for overwintering fish. Freeze-up also marks the end of the Yukon River's navigation season for boats, while travel by snow machine and dogsled becomes possible. Heat exchange with the atmosphere, heat stored in the river, and any inflow of warm water determine when freeze-up occurs at a particular site (Williams 1965). Break-up, or when the ice cover of a river is cleared completely, marks the beginning of the on-water navigation season (Williams 1965). The timing of break-up is influenced by air temperature, wind velocity, and water currents (Williams 1965).

A recent study examined trends in the date of break-up on the Yukon River at Dawson City, Canada, located approximately 160 km (99.4 mi) upriver from Eagle (Bienek et al. 2011). Study findings, based on data from 1949 to 2008, indicate that break-up is occurring approximately 1.3 days earlier per decade. This study also found an identical rate of decrease in the breakup date for the Tanana River at Nenana and for the Kuskokwim River at Bethel, suggesting that breakup is occurring earlier across much of Alaska. At all of these sites, those variables found to correlate most with the date of break-up included April-May surface air temperatures and discharge.

John Borg, a long-time resident of Eagle, compiled an existing historical record and continued recording ice freeze-up and break-up dates (1897 to 2011) for the Yukon River at Eagle (Appendix 29) (Borg 2011). Analysis of these data indicate average freeze-up occurs around 19-20 November, with the earliest freeze-up occurring in 1930 (21 October, Figure 64). The latest freeze-up occurred on 1 January 2003, marking the first time in the period of record that a calendar year (2002) did not experience a freeze-up. No significant trends were detected in the freeze-up data. Break-up at Eagle occurs on average around 7 May. The earliest break-up occurred on 7 April 2006 and the latest on 19 May 1920. A regression analysis of the Eagle data indicates a significant shift in the break-up date from 1897 to 2011 (0.8 days earlier per decade, $p<0.001$) (Figure 65), which is similar to the shift found by Bienek et al. (2011). A second regression analysis restricted to data from a more recent time period (1948-2011) suggests that the rate of recession in the break-up date may be increasing (2.1 days earlier per decade, $p<0.001$).

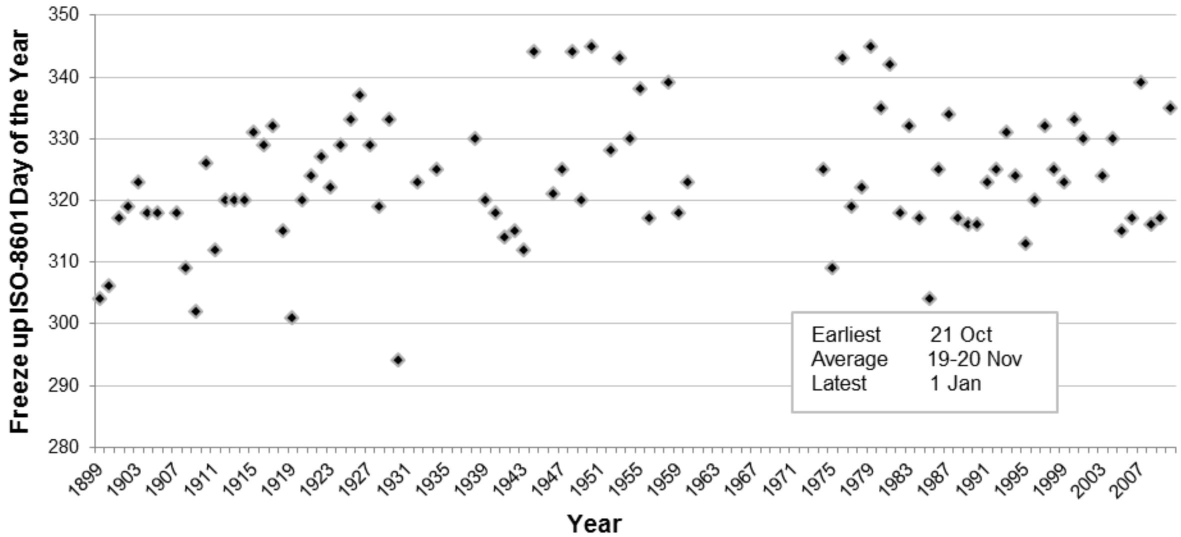


Figure 64. Dates of freeze-up on the Yukon River at Eagle, displayed as ISO-8601 day of the year (280 ≅ 7 October and 350 ≅ 16 December; including leap years). Note, multiple records (years) are missing from the freeze-up data, refer to Appendix 29. For 2002, freeze-up actually occurred on 1 January 2003 (Borg 2011).

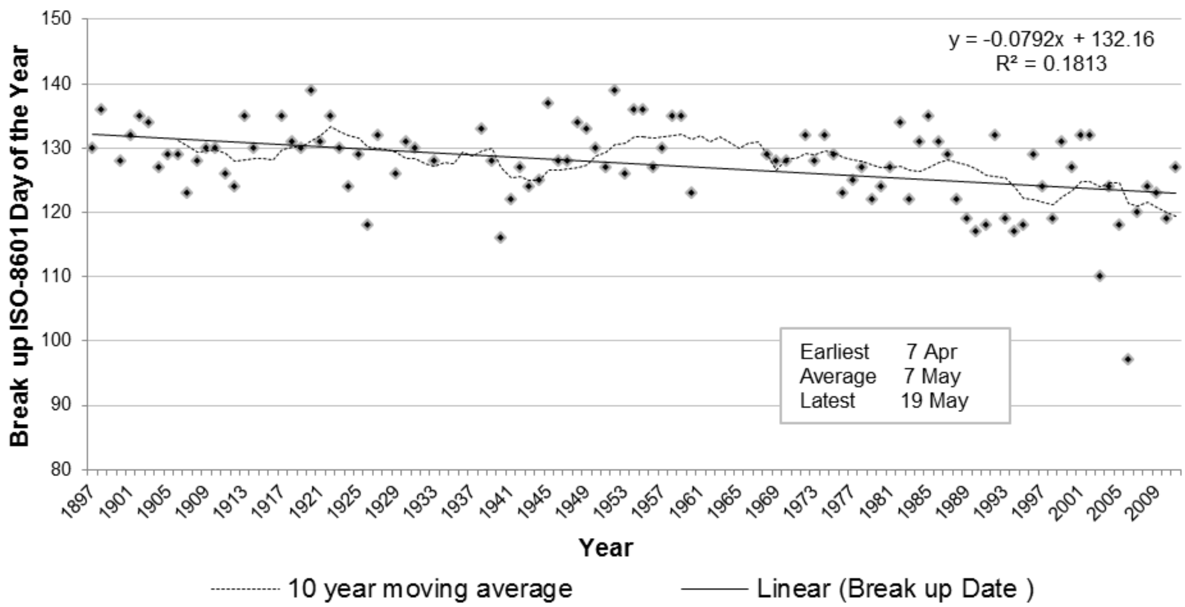


Figure 65. ISO-8601 day of the year (80 ≅ 30 March and 150 ≅ 30 May; including leap years) of ice break-up at Eagle (Borg 2011). Shown with linear trend line (solid) and with a ten-year moving average line (dashed). Note some years are missing in the available data (e.g., mid 1930s and early 1960s).

<u>Flood Frequency and Magnitude</u>

Jones and Fahl (1994) and Curran et al. (2003) conducted flood frequency analyses (statistical reoccurrence of peak flows) on the Eagle, Alaska gage data (Table 36). While this provides a baseline of flows (discharges) referred to as flood recurrence intervals at Eagle, it is unclear how these discharges may relate to other definitions of floods or characterizations of discharges (e.g., effective discharge) in river segments downstream in the preserve.

Table 36. Peak streamflow (cfs), estimated for given recurrence interval (years), for the Yukon River at Eagle. This table represents a portion of Table 4 in Curran et al. (2003).

Flood recurrence interval	Discharge (cfs) estimates (calculated in 1993)	Discharge (cfs) estimates (calculated in 2003)
2-year	289,000	282,000
5-year	360,000	353,000
10-year	411,000	403,000
25-year	477,000	468,000
50-year	531,000	520,000
100-year	581,000	573,000
200-year	639,000	628,000
500-year	719,000	705,000

A flood is typically defined as an event in which a river's discharge causes it to overtop its banks (NOAA 2005). In areas like the Yukon River Basin that experience a significant winter snowpack, there is generally a predictable and ecologically important high flow during the spring, which may not always be characterized as a flood according to the overtopping bank definition. For the Yukon River, this spring high flow typically results in the annual peak discharge and usually occurs in early to mid-June (Figure 60). Floods can also occur at less predictable times and with varying magnitudes (e.g., a late summer high flow caused by extreme rainfall), causing atypical stress on aquatic and riparian communities. An example of a peak flow event caused by rainfall runoff occurred on 30 August 2008 (282,000 cfs) on the Yukon River at Eagle.

Spring flooding also occurs from ice-jams (or ice dams), causing high stage heights accompanied by low discharge. Ice-jam floods have the potential to alter the river's morphology and riparian vegetation. Historical accounts of the occurrence of large ice jam floods are likely only recorded when they affect human property or communities such as the 2009 ice jam flood. This flood caused severe damage to the communities of Eagle Village and Eagle, AK (FEMA 2009) and reportedly scoured islands with mature spruce stands on the Yukon River within the preserve.

In general, bankfull discharge (flows that reach but do not necessarily overtop the banks) and effective discharge are important measures for understanding the morphological changes, and consequently, ecological changes that occur in a river and its riparian ecosystem over time. Effective discharge is the channel-forming flow of a stream or river in equilibrium, calculated from long-term measurements of flow and sediment transport. Bankfull discharge is often used interchangeably with effective discharge for alluvial streams with an observable floodplain, because the effective discharge of these stream types is often observed when a stream or river rises to its banks (FISRWG 1998, EPA 2011). In the case of the Yukon River, the bankfull discharge and effective discharge likely vary depending on the river section. In areas where the river is entrenched, "common stage indicators" located along the margins of the active river channel would determine bankfull discharge because of the absence of a discernible floodplain

(EPA 2011). Neither effective nor bankfull discharge for the Yukon River at Eagle are described in the literature.

Although not generally defined as floods per se, bankfull flows may have a critical influence on the river's morphology and aquatic and riparian communities due to their higher frequency of occurrence (generally every 1.5-2 years).

The estimated discharge with a two-year recurrence interval, as developed by Jones and Fahl (1994), is used here in conjunction with daily discharge data to provide insight into trends in magnitude and frequency of bankfull flows (equal to or exceeding 289,000 cfs at the Eagle gage) (Figure 66). During this 59-year period of record, discharge has exceeded or equaled this discharge 40 times. Nearly all of these flow events occurred in late May through late June; only three occurred after 26 June (20 July 1988, 22 July 1992, and 28 July 2001). Therefore, these peak flows generally occur during the predictable high flow periods due to snow melt. Given a simple 10-flood event moving average, the magnitude of flow events over 289,000 cfs appears to be decreasing over the period of record. The average frequency of events over 289,000 cfs is once every 1.5 years, though the discharge with a two-year recurrence interval was recalculated by Curran (2003) in 2003 and reduced slightly (Figure 67).

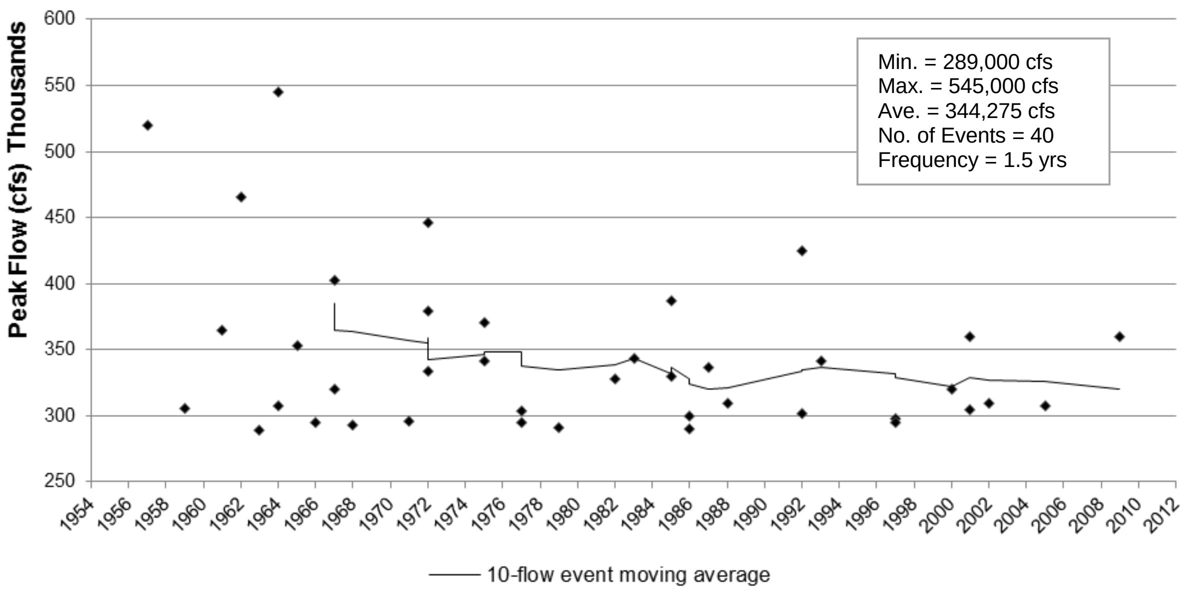


Figure 66. Peak discharge events (floods) above 289,000 cfs from 1950 to 2009 on the Yukon River at Eagle (USGS 2011). Notice that in several years multiple peak flow events occurred above 289,000 cfs.

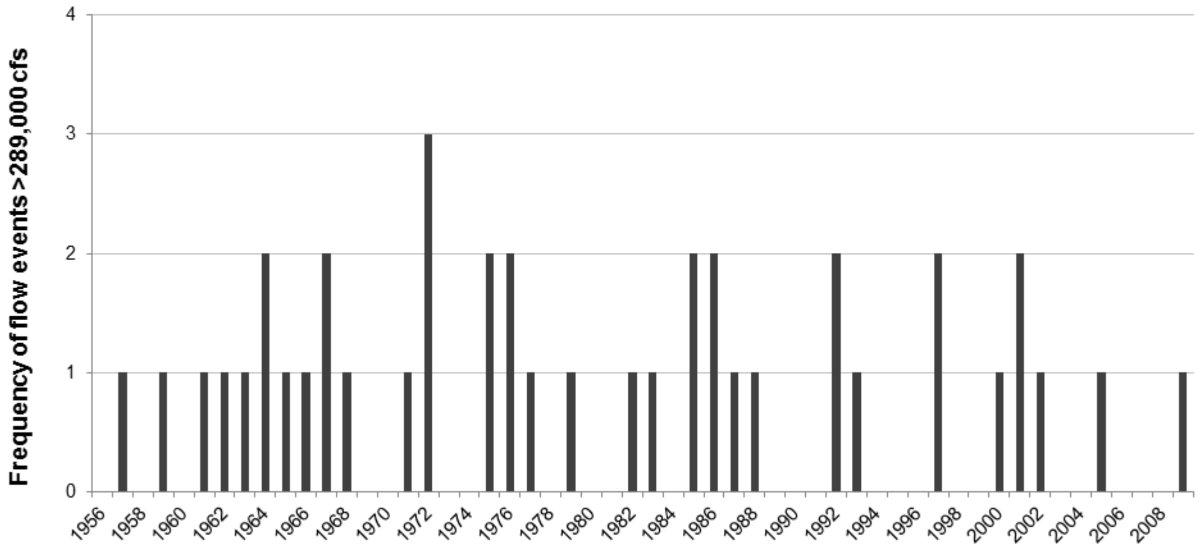


Figure 67. Number of flow events greater than 289,000 cfs by year on the Yukon River at Eagle (USGS 2011). Each flow event is counted when the average daily discharge rises to or exceeds 289,000 cfs, then drops below.

Other flood definitions are related to the river's effect on human activity or property. These include action stages and flood stages. Generally, the action stage is defined as the level at which some type of mitigation activity may be necessary in preparation for potential damage, and flood stage is defined as the gage height where hazards to property or human lives may occur (NOAA 2005). For the Yukon River at Eagle gage, NOAA defines a flood stage as 10.4 m (34 ft) and action stage at 9.4 m (31 ft). This flood stage is somewhat arbitrary (in an ecological sense) compared with effective discharge or bankfull flows for the Yukon River within the preserve. The NOAA flood stage presented here is primarily relevant to the protection of the communities of Eagle and Eagle Village. It does not define at what discharge the river's morphology is significantly affected as it flows through YUCH. However, given the high banks of the river at this gage, the discharge of the Yukon River during flood stage at Eagle is likely to represent a high magnitude flow event, one that may have significant effects on channel morphology and riparian vegetation, for much of the Yukon River in the preserve.

Peak flows (which typically are not considered floods at Eagle) generally occur around 11-12 June. The earliest date of peak flow occurred on 5 May, while the latest date of peak flow occurred on 30 August (Figure 68). Yearly peak flow ranges from 545,000 cfs (1964) to 189,000 cfs (1951), with an average of 299,100 cfs (Figure 69). Peak flows caused by rain events often occur in late summer, some with magnitudes large enough to represent the annual peak flow. However, all but two of the dates (1 August 1960 and 30 August 2008) represented here are from the spring peak flows (defined here as occurring before 1 August). The spring peaks for these two years occurred on 7 July 1960 and 22 July 2008. Additional analysis may prove useful in describing trends in the timing of seasonal peak flows due to snowmelt versus those caused by rain events, typically in late summer.

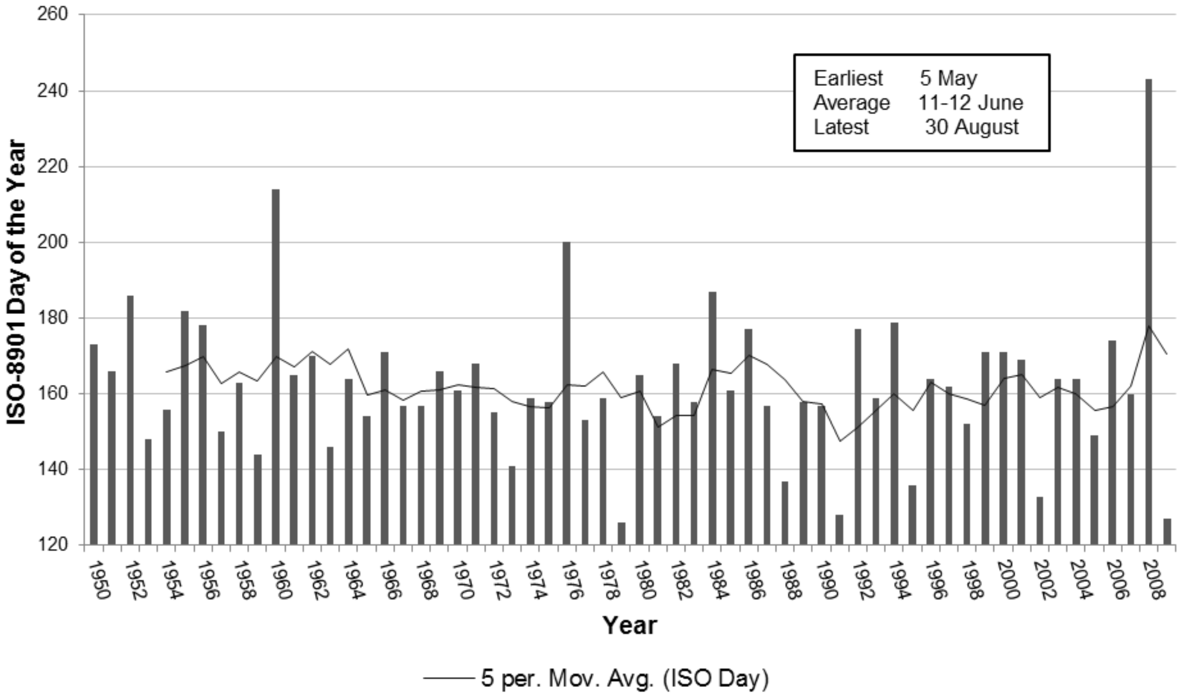


Figure 68. ISO-8601 day of the year (120 ≅ 29 April and 260 ≅ 17 September; including leap years) of peak streamflow by year (1951 to 2009) of the Yukon River at Eagle (USGS 2011).

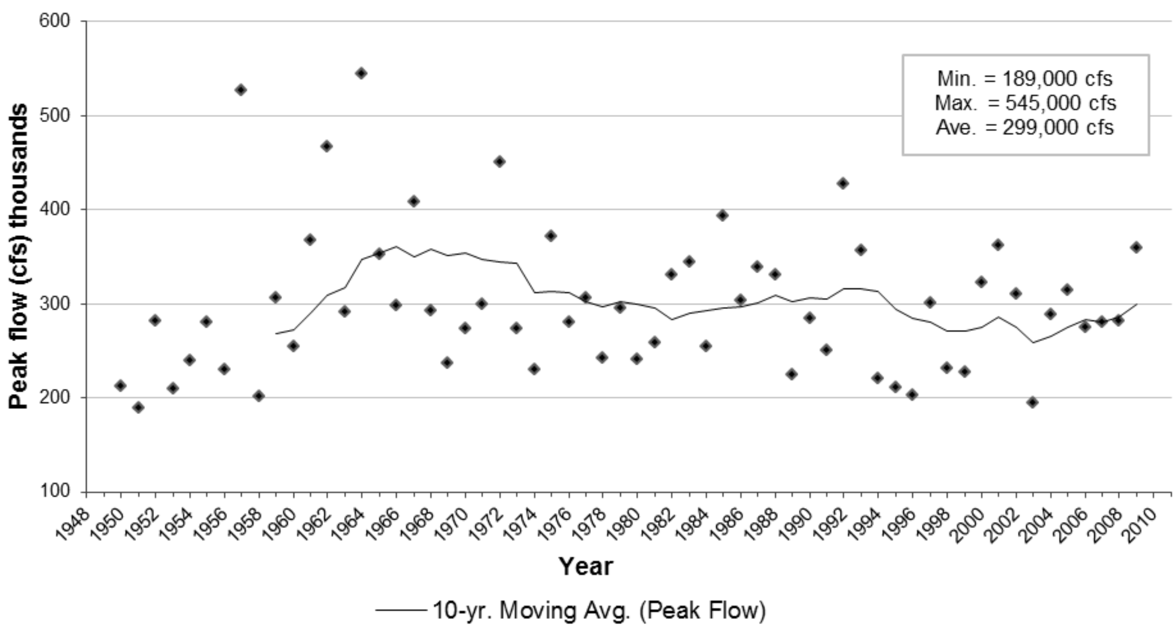


Figure 69. Peak streamflow (cfs) of the Yukon River at Eagle per year (1951 to 2009) (USGS 2011).

NOAA (2011) documented historical crests at the gaging site located on the Yukon River at Eagle. Figure 70 illustrates NOAA's defined flood stage and action stage in comparison to measured historical crests at Eagle from 1957-2007. According to NOAA's definition of a flood at Eagle, AK, only one year (1964) in this period of record has reached flood stage, and only two years (1957 and 1962) were above action stage. Historically, crests have occurred between 6 May and 1 August, and occur on average around 9 June (Figure 71); however, with additional analysis, trends in the timing of spring peaks could be separated from late summer peaks.

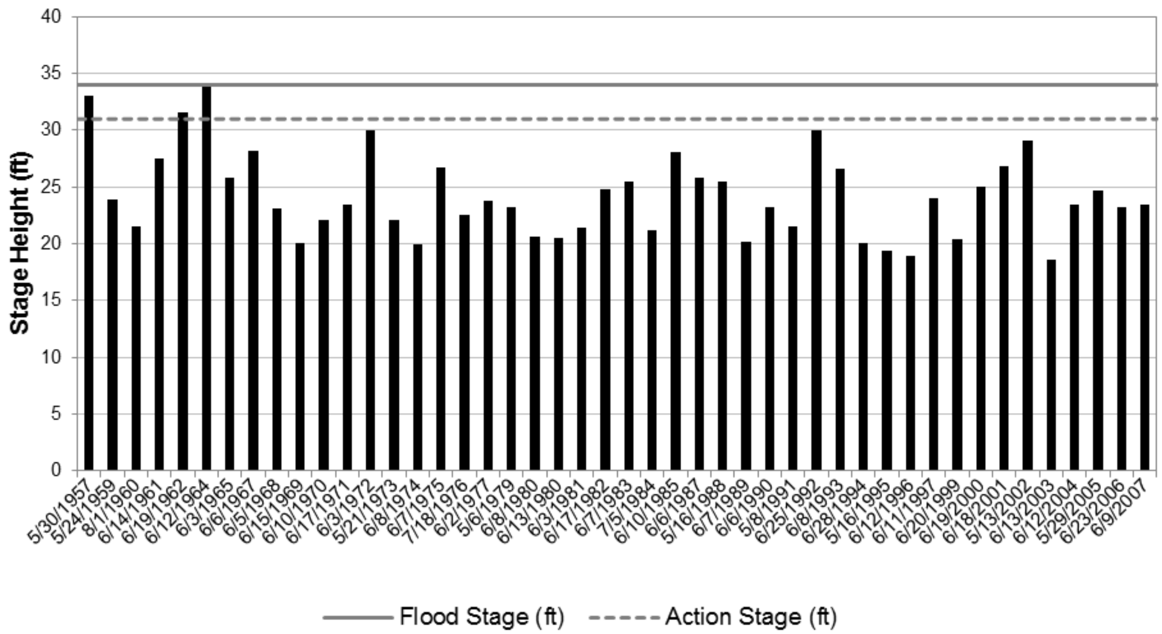


Figure 70. Historical crests defined by NOAA (2011), on the Yukon River at Eagle. NOAA (2011) defines flood stage and action stage as 10.4 m (34 ft) and 9.4 m (31 ft) respectively.

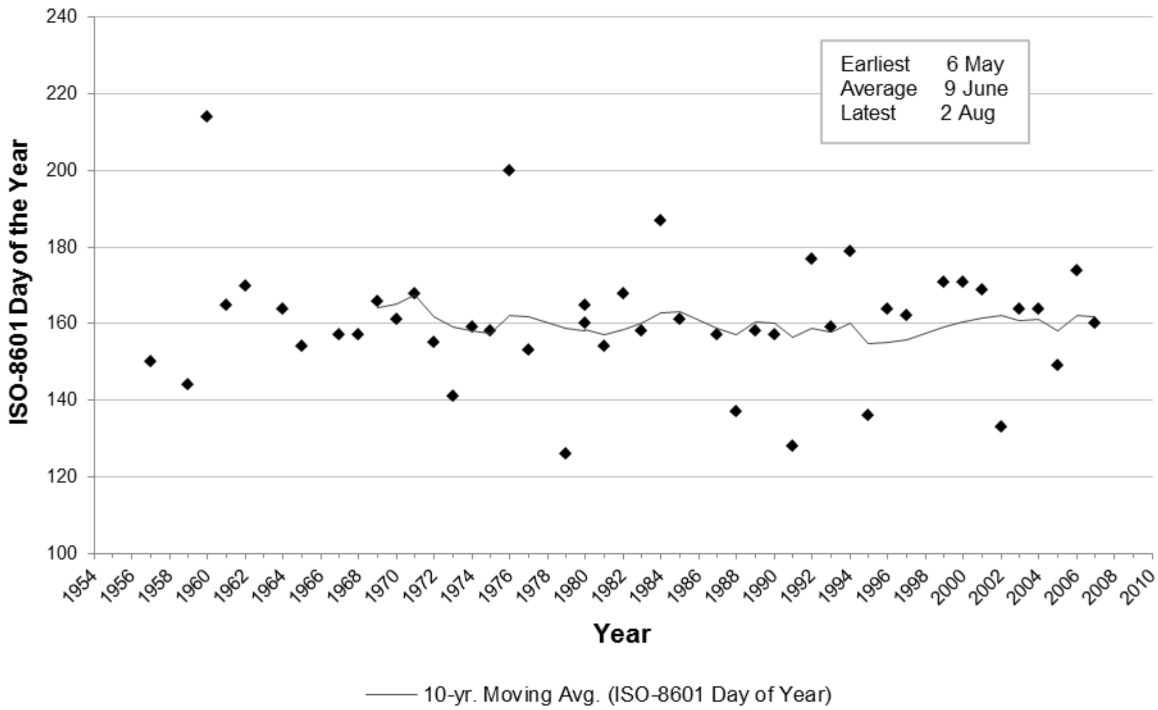


Figure 71. Timing of historical crests by ISO-8601 day of the year (100 ≅ 10 April and 240 ≅ 28 August; including leap years) for the Yukon River at Eagle (NOAA 2011). Shown with a ten-year moving average line.

Major flooding events that specifically affected the town of Eagle occurred in 1962, 1964 and 2009. The May 1962 flood on the Yukon River was the largest on record at Eagle. Ice-jams caused the river to reach a stage height of 10.95 m (35.94 ft) (FEMA 2009), inflicting damage to 70% of the town (AK DNR 2003).

Rapid snowmelt from large snowpacks located in the Yukon River Basin, exacerbated by rain on water-saturated snow in some places, contributed to the severity of a flood in June and July 1964 (Brabets et al. 2000). In Eagle, floodwaters reached a stage height of 10.3 m (33.85 ft) (FEMA 2009), causing damage to 60 % of the town (AK DNR 2003).

A combination of unusually large snowpack (up to 150% more than normal) and ice formation (up to 140% more than normal) on the Yukon River, along with many days of unseasonably warm weather, were contributing factors to the 2009 flood. These factors caused rapid melting and ice movement (NPS 2009b). During this event, Eagle and Eagle Village experienced significant damage to many homes, public facilities and infrastructure. In fact, on 11 June 2009, the U.S. Government declared the flood zone a major disaster (FEMA 2009).

<u>Threats and Stressor Factors</u>

Climate Warming

Climate change is expected to affect the hydrologic regime of YUCH in many ways, most directly through a rise in water temperatures. An increase in temperature could be problematic for many aquatic species. Salmon (*Oncorhynchus* spp.) are particularly sensitive to increased water temperatures, which could result in a reduced survival of eggs and fry, premature smolting, shifts in timing of emigration (possibly reducing marine survival), and increased risk of predation and disease. Higher temperatures also increase rates of respiration and metabolism in salmon, slowing the rate of growth (Richter and Kolmes 2005). Projections by SNAP et al. (2009) indicate average annual temperatures in YUCH are expected to rise by approximately 2.6ºC (4.6ºF) by 2040 and as much as 4.7ºC (8.4ºF) by 2080. This will also accelerate permafrost degradation, altering the connectivity of subsurface flowpaths (NPS 2011a, 2011b). This could cause streams to dry up, cause year-round flow in once seasonal streams, or cause more lakes to form or dry up (NPS 2011a, 2011b).

SNAP et al. (2009) projected a 20% increase in summer rainfall in YUCH; however, SNAP et al. (2009) also predict that this increase will not be enough to offset the increase in evapotranspiration caused by warmer temperatures and a longer growing season. Therefore, conditions are expected to become drier in the summer and fall and icier in the winter (SNAP et al. 2009). Shifts in the frequency and magnitude of precipitation such as snowpack and summer rains will change the frequency and magnitude of low and high flows. This will affect aquatic species that have adapted to historical flow patterns, and will alter the structure of river channels (NPS 2010).

Climate models also predict an increase in severe storms and flooding events. This will likely have negative effects on salmon. Increases in winter floods, especially, have the potential to wash away salmon eggs and scour gravel spawning beds (NWF 2011).

Mining activity

In 1901, Coal Creek became the first stream in the current preserve area to have a filed mining claim. In this area, soil, clay, and organics compose the placer deposit. This deposit accounts for the upper 1.5 to 3.1 m (5 to 10 ft) of depth. An alluvial gravel layer, which contains gold, is present at approximately 3.1 to 4.6 m (5 to 15 ft). Beneath the gravel lies bedrock. Typically, dredging operations disturbed the entire gravel layer as well as 0.31 to 0.61 m (1 or 2 ft) of bedrock (NPS 2011d). From the mid-1930s through the mid-1950s, miners used high-pressure water to separate the gold, which can produce a significant amount of outwash (e.g., gravel and sand). The outwash from the Coal Creek Dredge carried downstream to the Yukon River. The outwash from some claims are documented to have turned the Yukon River black (NPS 2011d). The increase in sediment affects hydrology by silting-in the streambed, which decreases the connection between the stream and groundwater (Bjerklie and LaPerriere 1985) and affects the complexity and availability of salmon habitat (Poole and Berman 2001). The Coal Creek Dredge removed 2,903 kg (3.2 tons) of gold during its 17 years of operation (NPS 2011c). Woodchopper Creek, located to the west of Coal Creek, also experienced placer mining activity (NPS 2011d).

In the early 1980s, the National Parks Conservation Association (NPCA) purchased the Coal Creek mining properties and donated the land to the NPS, which incorporated it into the preserve (NPS 2011d). The mining practices used in the 1900s had a severe impact on the watershed (Brabets et al. 2000). According to a memorandum written on 9 September 1991, mining has severely disturbed the streams of YUCH and has had a negative effect on the riparian areas along Coal and Woodchopper Creeks (Wagner and Sharrow 1991). Another concern associated with mining is the negative effect it may have on areas where fish spawn (Brabets et al. 2000). As a result, the EPA declared the Coal Creek area a Superfund site, and clean up was completed in 1998 (Brabets et al. 2000).

Data Needs/Gaps

There is very little information regarding hydrology (streamflow) within YUCH. The nearest USGS stream gaging site is located in Eagle, AK on the Yukon River, which is outside of the preserve. Historical daily mean discharge data recorded at Eagle cover a long period of record (1950 to 2010). Data available for the Kandik and Nation Rivers cover a very short period of record, and are only available for open water months. Repeated discharge measurements have not been recorded for the Charley River or any other Yukon River tributaries in the preserve.

Snow pack data are available from Mission Creek from 1989 to 2009; however, snow pack located near the headwaters of the Yukon River in Canada and the U.S. (upriver of the preserve) likely has a greater influence on the hydrologic regime of the Yukon River in YUCH.

While this assessment examined the timing of peak annual flows, predictable spring flows influenced by snowmelt are important to characterize and monitor and to separate from unpredictable floods (e.g., a late summer high flow event driven by extreme rainfall). In addition, there is little information regarding the natural frequency and severity of ice-jam floods. Both the late summer high flow events and ice-jam floods may have more consequential effects on aquatic and riparian communities than predictable spring flow peaks occurring after ice break-up is complete on the Yukon River. Flooding, though ecologically important, is not the only type of flow with important ecological implications. Streamflow timing and quantity, including both high and low flows, are important to the ecological integrity of a river system (Poff et al. 1997).

A thorough examination of the hydrologic regime should focus more closely on the precipitation inputs, to be able to understand the streamflow outputs (response to the inputs).

Overall Condition

Discharge

The measure of discharge was assigned a *Significance Level* of 3, as it is a fundamental hydrologic variable which has significant influence on many river conditions. For example, Poff et al. (1997) state that the timing and magnitude of high and low flows (discharges) influence in-stream and riparian habitat formation, extent, and distribution, which in turn affects the distribution, abundance, reproductive success and survival of aquatic and riparian species, as well as fish migration. Data collected from the Yukon River indicate that mean annual discharges have remained stable over the period of record. The period of record for the Kandik and Nation Rivers is too short to draw any discharge trend conclusions, and data do not exist for other tributaries in the preserve. No significant trends in the average annual discharge of the Yukon River were revealed in examining the daily discharge data from the gage at Eagle (1950 to 2010). However, increases in the discharge during winter, April, and May flows, as well as during fall recession were found to be statistically significant (Brabets and Walvoord 2009). Therefore, SMUMN GSS assigned discharge a *Condition Level* of 1.

Snowpack

The snowpack measure was assigned a *Significance Level* of 2. Snowpack is important as a precipitation input and its influence on discharge and on soil temperatures and therefore permafrost depth. Snowpack data are available from 1989 to 2009 at Mission Creek near YUCH. On average, snow pack reaches maximum depths in April. During this 20-year period, average annual snowpack reached a maximum depth of 56 cm (22 in), a minimum depth of 23.5 cm (9.2 in), and averaged 35.6 cm (14 in). SWE averaged 7.3 cm (2.9 ft) with a maximum of 11.8 cm (4.6 in) and a minimum of 3 cm (1.18 in). Snowpack at Mission Creek influences the hydrologic regime of Mission Creek itself, but may have very little effect on the Yukon River within the Preserve. However, snowpack in the Yukon River watershed upriver of the Preserve (largely in Canada) is likely to have more influence on the Yukon River within the Preserve and therefore more useful in understanding its relationship to discharge of the Yukon River. For these reasons, a *Condition Level* could not be assigned for this measure.

Ice Freeze-up/Break-up

The ice freeze-up and break-up measure at YUCH was assigned a *Significance Level* of 2. Data specific to the Yukon River just upstream of the preserve at Eagle do not provide clear evidence that the freeze-up date has changed significantly over the period of record (no statistically significant linear trend); therefore, it is currently of low concern. However, data collected from 1897 to 2011 indicate that ice break-up is occurring earlier in the year, approximately 0.8 days earlier each decade (Figure 65). Data from 1948-2011 indicate break-up is occurring 2.1 days earlier per decade. Similarly, Bieniek et al. (2011) found that break-up is occurring 1.3 days earlier per decade, and that break-up in Alaska is sensitive to large-scale, low frequency climate variability in the Pacific. Therefore, the current condition is of moderate concern (*Condition Level* = 2).

Flood Frequency

Flood frequency was assigned a *Significance Level* of 2. Flood frequency for all tributaries of the Yukon River is a data gap, even for the Kandik and Nation Rivers, which have some years of discharge measurements. Therefore, the condition of flood frequency for these rivers cannot be assessed. Data suggest that peak streamflow on the Yukon River at Eagle typically occurs around 11-12 June, and the timing of annual peak streamflow has remained relatively stable (i.e., it is not occurring earlier or later in the year). During the 59-year period of record at the Yukon River at Eagle stream gage, annual peak discharge has exceeded or equaled 289,000 cfs (estimated bankfull discharge) 40 times, with some years experiencing multiple crests.

Flood Magnitude

Flood magnitude was assigned a *Significance Level* of 2. Flow events on the Yukon River at Eagle greater than or equal to 289,000 cfs appear to be decreasing in magnitude (Figure 65). Ice jams, another important flood type, can have a significant effect on flood magnitude by raising the stage height; however, gage discharge data do not capture these. Historical accounts of the occurrence of large ice jam floods are likely only recorded when they affect human property or disrupt communities as was the case with the 2009 ice jam flood. Otherwise, there are no historical records of these floods. The primary concern surrounding flood magnitude is that climate warming could alter its natural variation. Jones and Fahl (1994) and Curran et al. (2003) provide discharge estimates at several standard recurrence intervals (e.g., 2 yr. and 10 yr.). Given the lack of characterization of what is considered a flood of ecological consequence (i.e., effects of bankfull discharge) and the lack information on ice-jam floods, it is not possible to assign a *Condition Level* for this measure.

Weighted Condition Score
The weighted condition score (WCS) (see Chapter 3 for methodology) for the hydrologic regime component is 0.368, indicating the overall condition is of moderate concern. However only two of the five measures were given a condition score, because other measures generally lack data to determine condition. It is not appropriate to assign trends in the overall condition of the hydrologic regime (flowing surface waters) in YUCH given the lack of information for the majority of Yukon River tributaries in the Preserve. For the Yukon River itself, the only measure indicating a significant trend is date of ice break-ups, which are occurring earlier over the period of record. This appears to represent an alteration in the natural hydrologic regime in the river. Future monitoring and statistical analyses of gage data to detect trends is important, particularly in light of potential changes to hydrologic characteristics from climate change (SNAP et al. 2009).

Hydrology

Measures	SL	CL
• Discharge	3	1
• Snowpack	2	N/A
• Ice freeze-up/break-up	2	2
• Flood frequency	2	N/A
• Flood magnitude	2	N/A

WCS = 0.368

Sources of Expertise
Trey Simmons, CAKN Aquatic Ecologist, NPS.

Literature Cited

Alaska Department of Natural Resources (AK DNR). 2003. Upper Yukon area plan. Alaska Department of Natural Resources, Anchorage, Alaska.

Borg, J. 2011. Freeze-up and break-up of Yukon River ice at Eagle, Alaska. Unpublished data. John Borg, long-time Eagle, Alaska resident. Received 20 July 2011.

Bieniek, P. A., U. S. Bhatt, L. A. Rundquist, S. D. Lindsey, X. Zhang, and R. Thoman. 2011. Large-scale climate controls of interior Alaska river ice breakup. Journal of Climate 24:286-297.

Bjerklie, D. M., and J. D. LaPerriere. 1985. Gold-mining effects on stream hydrology and water quality, Circle Quadrangle, Alaska. Water Resources Bulletin 21(2):235-243.

Brabets, T. P., B. Wang, and R. Meade. 2000. Environmental and hydrologic overview of the Yukon River Basin, Alaska and Canada. Water-resources investigations report 99-4204. U.S. Geological Survey, Anchorage, Alaska.

Brabets, T. P. 2001. Hydrologic data from Nation, Kandik, and Yukon Rivers, Yukon-Charley Rivers National Preserve, Alaska. Open-File Report 01–295. U.S. Geological Survey, Anchorage, Alaska.

Brabets, T. P., and M. A. Walvoord. 2009. Trends in streamflow in the Yukon River Basin from 1944 to 2005 and the influence of the Pacific Decadal Oscillation. Journal of Hydrology 371:109-119.

Curran, J. H., D. F. Meyer, and G. D. Tasker. 2003. Estimating the magnitude and frequency of peak streamflows for ungauged sites on streams in Alaska and conterminous basins in Canada. U.S. Geological Survey Water-Resources Investigations Report 03-4188. U.S. Geological Survey, Anchorage, Alaska.

Environmental Protection Agency (EPA). 2011. What is streamflow and why is it important? Online. (http://water.epa.gov/type/rsl/monitoring/vms51.cfm). Accessed 20 June 2011.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream corridor restoration, principles, processes, and practices. ISBN-0-934213-59-3.

Federal Emergency Management Agency (FEMA). 2009. Final environmental assessment, Native Village of Eagle (new). FEMA-1843-DR-AK. U.S. Department of Homeland Security, Bothell, Washington.

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, Anchorage, Alaska.

Larsen, A., C. Rector, C. Roland, and M. Cook. 2004. Results of an inventory of the vascular plants of Yukon-Charley Rivers National Preserve. National Park Service, Central Alaska Network, Fairbanks, Alaska.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network Vital Signs monitoring plan. National Park Service, Fairbanks, Alaska.

National Oceanic and Atmospheric Administration (NOAA). 2005. National Weather Service: Alaska – Pacific river forecast center. Online. (http://aprfc.arh.noaa.gov/resources/docs/floodterms.php). Accessed 26 June 2011.

National Oceanic and Atmospheric Administration (NOAA). 2011. National Weather Service: Yukon River at Eagle. Online. (http://water.weather.gov/ahps2/hydrograph.php?wfo=pafg&gage=yeaa2). Accessed 26 June 2011.

National Park Service (NPS). 1985. General management plan. National Park Service, Yukon-Charley Rivers National Preserve, Alaska.

National Park Service (NPS). 2009a. Directions. Online. (http://www.nps.gov/yuch/planyourvisit/directions.htm). Accessed 17 July 2011.

National Park Service (NPS). 2009b. 2009 Eagle flood. Online. (http://www.nps.gov/yuch/2009-eagle-flood.htm). Accessed 1 February 2011.

National Park Service (NPS). 2010. Rivers & streams climate change resource brief. October 2010, No. 72. National Park Service, Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). 2011a. Climate change resource brief. Online. (http://www.nature.nps.gov/climatechange/docs/CAKN_CC.pdf). Accessed 9 February 2011.

National Park Service (NPS). 2011b. River & streams climate resource brief. Central Alaska Network, Fairbanks, Alaska.

National Park Service (NPS). 2011c. Mining history and techniques. Online. (http://www.nps.gov/yuch/planyourvisit/upload/Mining_History_Techniques.pdf) Accessed 16 February 2011.

National Park Service (NPS). 2011d. Coal Creek dredge. Online. (http://www.nps.gov/yuch/planyourvisit/coalcreekdredge.htm) Accessed 6 July 2011.

National Wildlife Federation (NWF). 2011. Global warming effects on wildlife and habitat. Online. (http://www.nwf.org/Global-Warming/Effects-on-Wildlife-and-Habitat/Salmon.aspx). Accessed 8 November 2011.

Natural Resource Conservation Service (NRCS). 2011. Alaska SNOTEL sites. Online. (http://www.wcc.nrcs.usda.gov/snotel/Alaska/alaska.html). Accessed 18 February 2011.

Poff, L. N., D. J. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime. BioScience 47(11):769-784.

Poole, G. C., and C. H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27(6):787-802.

Previsic, M., and R. Bedard. 2008. River in-stream energy conversion (RISEC) characterization of Alaska sites. Electric Power Research Institute, Palo Alto, California.

Richter, A., and S. A. Kolmes. 2005. Maximum temperature limits for Chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest. Reviews in Fisheries Science 13:23-49.

Scenarios Network for Alaska Planning (SNAP), The Wilderness Society, and National Park Service. 2009. Projected climate change scenarios for Yukon-Charley Rivers National Preserve. Online. (http://snap.uaf.edu/files/docs/Climate_Change_Sums/YukonC_ClimSum.pdf). Accessed 10 November 2011.

Sousanes, P. J. 2008. Snowpack monitoring: 2006-2007 season. Central Alaska Network. Natural Resource Technical Report NPS/CAKN/NRTR—2008/140. National Park Service, Fort Collins, Colorado.

U.S. Geological Survey (USGS). 2011. USGS water data for Alaska. Online. (http://waterdata.usgs.gov/ak/nwis/). Accessed 31 January 2011.

Wagner, J., and D. Sharrow. 1991. Trip report for travel to Alaska Regional Office (ARO), Yukon-Charley Rivers National Preserve (YUCH), and Denali National Park and Preserve (DENA), August 3-15, 1991. Memorandum to Stan Ponce, Water Resources Division, Fort Collins, Colorado.

Williams, G. P. 1965. Correlating freeze-up and break-up with weather conditions. Canadian Geotechnical Journal 2(4):313-326.

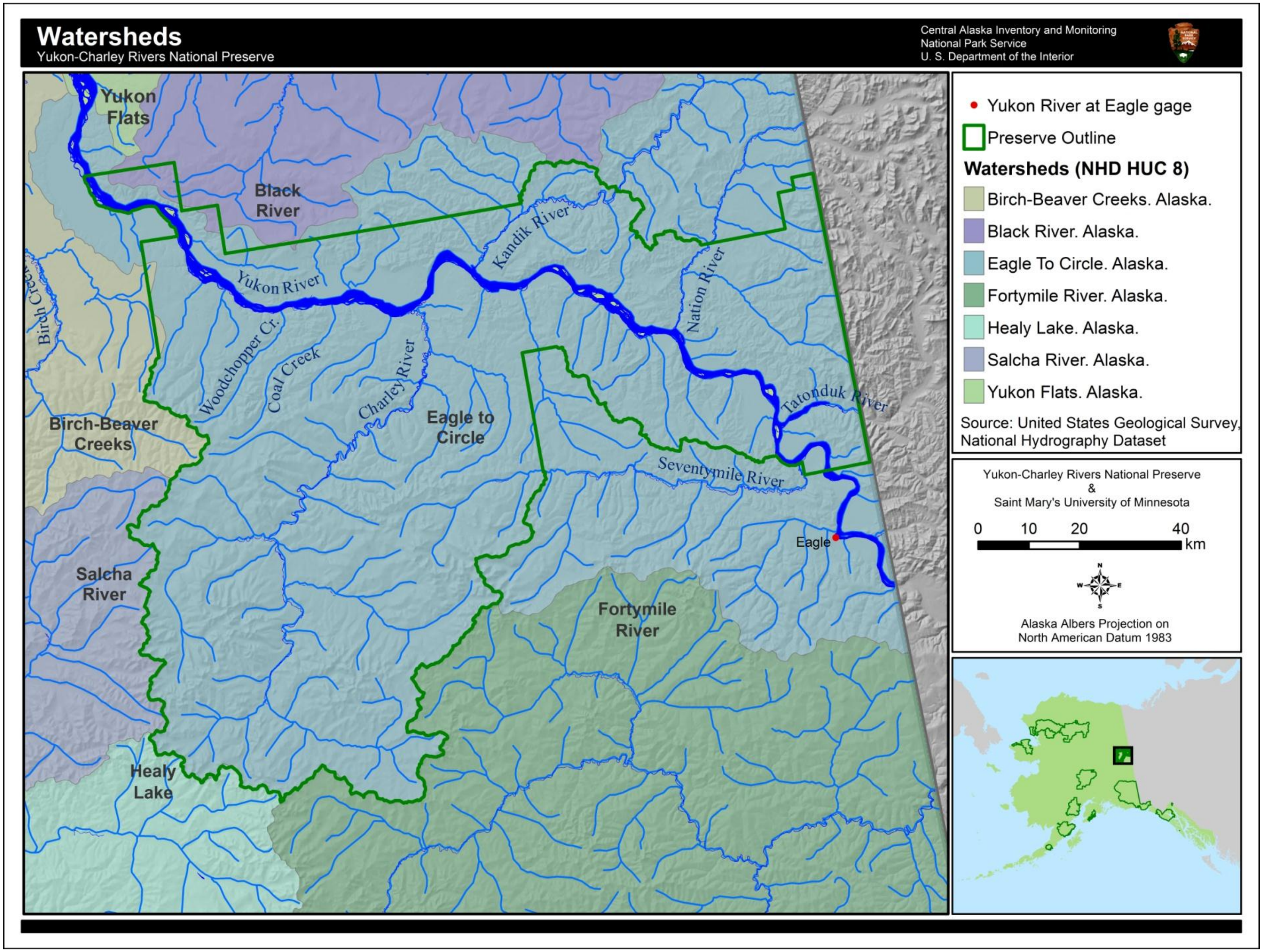


Plate 24. Watersheds and rivers within or near YUCH.

Chapter 5 Discussion

5.1 Component Data Gaps

The identification of key data and information gaps is an important objective of NRCAs. Data gaps or needs are those pieces of information that are currently unavailable, but would help to inform the status of the overall condition of a key resource component. Data gaps/needs exist for all key resource components assessed in this NRCA, and are summarized in Table 37.

Table 37. Data gaps/needs.

Component	Data Gaps/Needs
Land Cover	-characterization of present land cover and changes from historic images (e.g., flooding disturbance) -footprint of past mining disturbance digitally converted/georeferenced for use in a GIS -GIS data of the present extent of disturbance associated with human use -trapline locations (for examining the present-day human footprint)
Lake Ecosystem Function	-research examining contaminants in YUCH lakes -further investigation of lake area change (i.e., lake drying or sudden lake drainage) -determination of how hydrologic conditions at time of photography affect lake area and size estimates
Permafrost	-generally lacking information on permafrost including parameters such as active layer depths, carbon balance, and thermokarst features across the preserve (NRCS data will provide some information on permafrost in the preserve) -permafrost monitoring protocol
Fire Regime	-continued research on the complex interactions of fire and soils, vegetative succession, animal movement patterns, erosion and tree-line movement -improved basic fire statistics and datasets (e.g., accurate end dates) -improved understanding of a changing fire regime on the ecosystem services provided by boreal forests
Forytmile Caribou Herd	-consistent population estimates with comparable methods in order to build relationships between data -examination of the effects of snow-depth on herd productivity and population -further research examining caribou mortality from bear predation
Dall's Sheep / Fannin Sheep	-research on the impacts of disease and insect harassment in YUCH sheep -research on what drives sheep movement in the preserve (e.g., forage availability and quantity and its relationship to changing a climate)
Moose	-examination of moose movements in and around the preserve -understanding what stressors limit moose population in the preserve (e.g., predation, harvest, snow depth, forage quality)
Wolves	-comparable wolf population data between NPS and ADF&G estimates -research on the effects of snow depth on wolves
Bears*	-no population estimates for brown or black bears specific to YUCH exist, only for the much larger and over-lapping GMUs
Small Mammals/Hares*	-data available is limited to two studies, one specific to small mammals and the other as a part of marten study. Further work should focus on water shrews, meadow jumping mouse, little brown bats, deer mice, house mice, least weasels, ermines, and flying squirrels (for clearing up presence and distribution)

Table 37. (continued) Component data gaps/needs for YUCH.

Component	Data Gaps/Needs
Furbearers*	-no information specific to YUCH for abundance, distribution, or harvest estimates. Track count data have been collected and monitoring will continue.
Peregrine Falcons	-satellite imagery or aerial photography could be used to determine land cover and examine possible correlations eyrie success. -additional surveys in other drainages
Ptarmigan*	-long term abundance and distribution data
Breeding Birds*	-regular monitoring would allow for the development of long-term trend data on diversity, population size, and distribution
Anadromous Fish	-no population estimates exist specific to YUCH, escapement estimates upstream only represent fish passing through the preserve -most non-natal streams in the upper U.S. portion of the Yukon River drainage have not been surveyed for rearing habitats of juvenile Chinook salmon -specific case studies of habitat loss for the preserve have not been conducted
Wood Frogs and Boreal Toads*	-survey of YUCH herpetofauna to provide baseline data on abundance and distribution
Native Plant Communities	-exploration of smaller watersheds for rare and unique plant species -surveying high traffic areas not visited during previous seasons surveys to provide an early detection of non-native invasive plant species
Steppe Community	-research into the role of non-vascular plants in how plant communities are organized -research into steppe community ecological succession, roles of natural disturbance in maintaining plant community structure, and importance of steppe communities for grazing animals -comparison of GIS model using a higher resolution elevation data to accurate GPS locations of known step communities and ground-truthing for refinements to GIS model in order to locate new steppe communities for research in the preserve
Water Quality	-well-developed methodology for measuring macroinvertebrate community health in Alaska ecosystems. This would allow for the establishment of long-term trends of community health -present impacts of small-scale mining and continued effects of past mining activity have not be revisited since the 1980s -quantification and monitoring of atmospheric deposition of mercury and other contaminants
Air Quality*	-no monitoring data exists specific to the preserve, considering Hg and SOCs were found in DENA, it may be important to begin monitoring these in YUCH.
Hydrology	-data are very limited for nearly all rivers and streams in the preserve; only short periods of data exist for Kandik and Nation Rivers -gage data at Eagle, AK only measure river discharge outside (upstream) of the preserve -characterization and statistical analysis of low flows and other high flow events (e.g., less predictable late summer high flows) -historic ice-jam floods events, future recording of ice-jam flooding regardless of river discharge at Eagle -further understanding of the hydrological inputs to the Yukon River upstream of the park (e.g., precipitation levels in Canada) will help understand streamflow outputs

*placeholder components, recognized during projects scoping as having little or not data available for an assessment of condition.

5.2 Component Condition Designations

Chapter 5 provides an opportunity to bring together and discuss the common threads in findings regarding the featured components Table 38 displays the condition graphics assigned to each resource component presented in Chapter 4 (definitions of condition graphics are located in Figure 72). This provides the ability to view the condition of all components within identified in the Preserve for this assessment. It is important to remember that the graphics represented are merely symbols for the overall condition and trend assigned to each component and that some condition designations rely on expert knowledge from park staff, NGPN resource experts, or non-NPS researchers. It is necessary to refer to the overall condition section for each component for a more detailed explanation of the assigned condition, as the assignment of condition for most components is based on multiple factors. It is important to note that the framework does not include all possible measures within a 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.

Condition designations for some park resources are supported by existing, long standing datasets and monitoring information, and topical expertise by NPS and other scientists, other components lack historic data or clear understanding of what reference conditions (i.e., what is considered desirable or natural), and may even lack any current information. Peregrine falcons have been monitored in the preserve for a few decades, creating a thorough understanding of their populations (condition). Other focal species are more heavily studied compared with other resources in the preserve, in some cases by multiple agencies. For example, present-day caribou, moose, and wolves populations are relatively well understood, though historic estimates are either unavailable or some scientists question their accuracy. Finally, broad and complex components such as land cover and permafrost lack data to determine their condition. However, information presented in these component section may provide baseline information to which future data can be compared and provide a summary of what is known, what general information is needed, and what may be cause for concern into the future.

Table 38. Summary of component-level condition and trend.

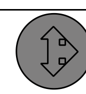
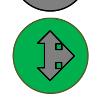
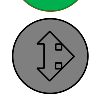
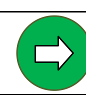
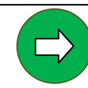
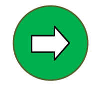
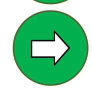
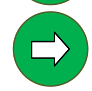
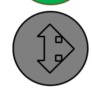
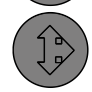
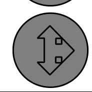
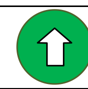
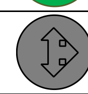
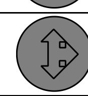
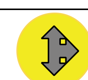
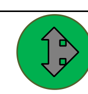
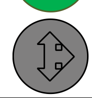
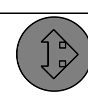
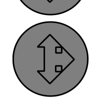
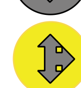
Component	WCS	Condition
Ecosystem Extent and Function		
Land Cover		
Lake Ecosystem Function	0.333	
Permafrost	N/A	
Disturbance Regimes		
Fire	0.148	

Table 38. (continued) Summary of component-level condition and trend.

Component	WCS	Condition
Biological Composition		
Mammals		
Fortymile Caribou Herd	0.167	
Dall's Sheep/Fannin Sheep	0.222	
Moose	0.333	
Wolves	0.042	
Bears*	N/A	
Small Mammals*	N/A	
Furbearers*	N/A	
Birds		
Peregrine Falcons	0.222	
Ptarmigans*	N/A	
Breeding Birds (Passerines)*	N/A	
Fish		
Anadromous Species	0.500	
Ecological Communities		
Native Plant Communities	0.111	
Steppe Communities	N/A	
Environmental Quality		
Water Quality (chemical and biological integrity)	N/A	
Air Qualtily*	N/A	
Water Resources (hydrologic regime of the Yukon River)		

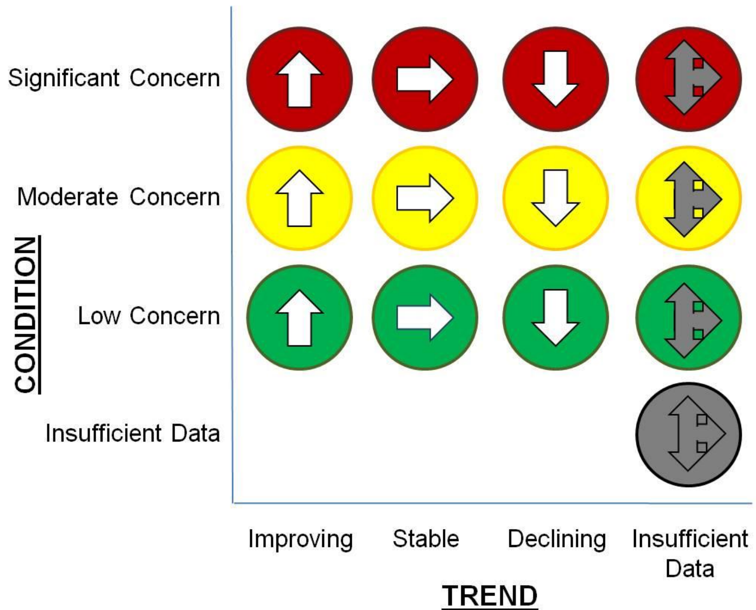


Figure 72. Symbols used for individual component assessments with condition or concern designations along the vertical axis and trend designations along the horizontal.

5.3 Park-wide Condition Observations

A limited amount of anthropogenic influences presently exist in the preserve, compared with many NPS units in Alaska nearer to the road system and population centers in Alaska. Examples of direct anthropogenic influences or stressor sources include the accidental introduction of invasive nonnative plant species and soil/vegetation disturbance in air strips, OHV trails, and areas surrounding public use cabins. Lasting effects of past mining activities are not well documented, but are clearly a visible change in the riparian areas, especially of Woodchopper and Coal Creeks. Therefore, environmental conditions are likely to be in good condition in most of the preserve. However, in the light of climate change predictions in the preserve, with large areas of discontinuous permafrost and with mean annual air temperatures just below 0 degrees Celsius, broad ecological changes are likely to occur. Initial evidence of shallow lake drying and draining, active layer detachments/failures on slopes near Woodchopper Creek, and ice break-up on the Yukon River occurring earlier each decade may be initial evidence of climate warming effects, though further research is need to correlate events with temperature and precipitation records.

Data that describe natural conditions, especially their spatial and temporal variability are lacking for many of the preserve's natural resource components. That is, it is unclear what natural variability may exist in various measures including chemical/physical properties of aquatic ecosystems, natural disturbance frequencies and severities, and species abundance and compositions across different habitats. Climate change predictions provide an underlying impetus to quantify and describe existing conditions in the preserve in order to measure environmental change into the future. Efforts to monitor and inform NPS resource managers are ongoing by some outside researchers and by the NPS (e.g., preserve animal surveys and other Vital Signs Program monitoring efforts). Much of the NPS efforts are focused on quantifying and characterizing existing conditions, detecting environmental changes, and understanding the causes of change in the preserve. Differentiating between environmental changes that are anthropogenic in nature and those that are the result of natural processes and dynamics is important in understanding the status of natural resource components of the preserve. Overall, natural resource components in the preserve appear to be in good condition, though more information is needed to describe many of the preserve's natural conditions.

Appendices

Land Cover

Appendix 1. Land cover class area and percent composition according to Racine (1976) GIS data. Data clipped to the preserve boundaries.

Racine land cover class	Area (ac)	Area (ha)	% Composition
Alpine Tundra	367,945	148,902	19.1
Mixed Needleleaf- Broadleaf Forest	347,116	140,473	18.0
Rockland	216,052	87,433	11.2
Scrub-Broadleaf Deciduous Forest	95,788	38,764	5.0
Needleleaf Evergreen Forest	92,840	37,571	4.8
Needleleaf Evergreen Woodland Dwarf Scrub	72,185	29,212	3.8
Needleleaf Evergreen Forest-Mixed Needleleaf- Broad	67,932	27,491	3.5
Unknown	66,876	27,064	3.5
Scrub (*possibly dwarf tree scrub*)	46,491	18,814	2.4
Broadleaf Deciduous Forest-Scrub	44,919	18,178	2.3
Broadleaf Deciduous Forest-Mixed Needleleaf- Broad	39,747	16,085	2.1
Dwarf Scrub-Scrub	36,095	14,607	1.9
Dwarf Scrub-Needleleaf Evergreen Woodland	32,226	13,042	1.7
Alpine Tundra-Rockland	31,684	12,822	1.6
Water	31,310	12,671	1.6
Needleleaf Evergreen Forest-Broadleaf Deciduous Forest	29,500	11,938	1.5
Dwarf Scrub-Needleleaf Evergreen Woodland-Barrens	27,319	11,056	1.4
Needleleaf Evergreen Woodland and Forest- Dwarf Sc*****	26,271	10,632	1.4
Scrub	24,964	10,103	1.3
Needleleaf Evergreen Forest and Woodland	21,949	8,883	1.1
Needleleaf Evergreen Woodland-Barrens	20,972	8,487	1.1
Broadleaf Deciduous Woodland	17,783	7,196	0.9
Scrub Dwarf Scrub	17,089	6,916	0.9
Mixed Needleleaf- Broadleaf Forest-Needleleaf Ever*****	16,158	6,539	0.8
Needleleaf Evergreen Woodland	15,270	6,179	0.8
Needleleaf Evergreen Woodland and Forest	14,876	6,020	0.8
Scrub-Mixed Needleleaf- Broadleaf Forest	14,744	5,967	0.8
Mixed Needleleaf- Broadleaf Woodland	14,350	5,807	0.7
Mixed Needleleaf- Broadleaf Forest-Scrub	12,990	5,257	0.7
Scrub-Broadleaf Deciduous Woodland	8,848	3,581	0.5
Broadleaf Deciduous Woodland-Alpine Tundra	7,274	2,944	0.4
Dwarf Scrub-Mixed Needleleaf- Broadleaf Woodland	7,116	2,880	0.4

Racine land cover class	**Area (ac)**	**Area (ha)**	**% Composition**
Broadleaf Deciduous Forest	6,281	2,542	0.3
Alpine Tundra-Scrub	5,478	2,217	0.3
Needleleaf Evergreen Woodland-Alpine Tundra	5,417	2,192	0.3
Dwarf Scrub-Barrens	4,881	1,975	0.3
Dwarf Scrub	3,450	1,396	0.2
Scrub-Needleleaf Evergreen Woodland	3,210	1,299	0.2
Mixed Needleleaf- Broadleaf Woodland-Scrub	2,322	940	0.1
Rockland-Alpine Tundra	2,271	919	0.1
Scrub-Needleleaf Evergreen Forest	2,155	872	0.1
Dwarf Scrub-Needleleaf Evergreen Woodland-Barrens-Ma*	1,409	570	0.1
Needleleaf Evergreen Forest-Scrub	1,196	484	0.1

*Full name cut off in original NPS GIS dataset (Racine 1976)

Appendix 2. Land cover composition according to Ducks Unlimited (1997) land cover GIS data in the entire preserve. Data clipped to preserve boundaries. Note, the data were derived from 1991 LandSat Thematic Mapper imagery.

Land cover class/type	**Area (ha)**	**Area (ac)**	**% composition**
Open needleleaf	306,404	757,138	30.0
Woodland needleleaf	150,090	370,880	14.7
Low shrub	115,915	286,432	11.4
Closed deciduous	57,468	142,006	5.6
Low shrub - tussock	55,516	137,182	5.4
Closed mixed needleleaf/deciduous	50,977	125,967	5.0
Dwarf shrub	44,341	109,567	4.3
Terrain shadow	43,753	108,116	4.3
Open mixed needleleaf/deciduous	43,623	107,795	4.3
Rock/gravel	35,610	87,995	3.5
Sparsely vegetated	28,718	70,964	2.8
Fire (burned)	21,191	52,365	2.1
Turbid water	15,666	38,712	1.5
Tall shrub	12,324	30,454	1.2
Tussock tundra	11,909	29,429	1.2
Open deciduous	7,290	18,015	0.7
Dry herbaceous	5,493	13,573	0.5
Closed needleleaf	5,129	12,674	0.5
Clear water	3,078	7,607	0.3
Snow	2,799	6,915	0.3
Woodland needleleaf - lichen	1,531	3,784	0.2
Woodland needleleaf - moss	732	1,808	0.1
Clouds	296	731	<0.1
Tussock tundra - lichen	194	479	<0.1
Open needleleaf - lichen	156	384	<0.1
Cloud shadows	150	371	<0.1
Wet sedge	124	307	<0.1
Low shrub - lichen	56	138	<0.1
Aquatic bed	9	22	<0.1
Totals	**1,020,542**	**2,521,810.7**	**100.0**

Appendix 3. Percent composition of land cover classes (Ducks Unlimited [1997] land cover GIS data) by Ecological Subsection Regions in Swanson (2001) GIS data.

Land Cover Class Description	**% Composition by area for each Ecological Subsection Region**														
	BH	**CF**	**HL**	**KT**	**LB**	**MT**	**OF**	**OM**	**SD**	**TF**	**TH**	**TL**	**UC**	**YV**	**All**
Closed Needleleaf	0.4	0.3	0.5	0.7	0.4	0.0	**1.1**	0.6	--	0.0	0.2	**1.3**	0.1	**1.7**	0.5
Open Needleleaf	**39.7**	**42.4**	**66.9**	**38.3**	**43.9**	**6.3**	**44.4**	**34.2**	**7.1**	**25.3**	**31.3**	**49.8**	**31.4**	**32.4**	**30.0**
Open Needleleaf - Lichen	0.2	0.0	--	--	0.1	0.0	--	--	0.0	--	--	--	--	--	0.0
Woodland Needleleaf	**4.1**	**20.8**	**15.0**	**13.8**	**6.1**	**8.5**	**5.5**	**7.3**	**15.9**	**15.0**	**16.1**	**22.0**	**33.3**	**17.8**	**14.7**
Woodland Needleleaf - Lichen	0.1	0.2	**1.8**	0.1	0.0	0.0	0.2	0.3	0.0	--	0.1	0.0	0.1	0.3	0.1
Woodland Needleleaf - Moss	0.0	0.1	0.1	0.4	0.0	0.0	0.0	0.0	--	0.0	0.0	0.3	0.0	0.3	0.1
Closed Deciduous	**17.0**	**2.9**	**2.0**	**16.2**	**4.5**	0.1	**12.3**	0.7	0.4	--	**12.9**	**8.1**	0.1	**7.1**	**5.6**
Open Deciduous	**1.2**	0.3	0.3	0.5	**3.0**	0.0	**2.5**	0.1	0.8	--	**1.8**	0.2	0.0	0.2	0.7
Closed Mixed Needleleaf/Deciduous	**15.9**	**3.4**	**2.4**	**16.3**	**4.5**	0.1	**10.3**	**2.0**	0.1	0.0	**9.5**	**8.1**	0.1	**6.9**	**5.0**
Open Mixed Needleleaf/Deciduous	**5.4**	**4.0**	**3.8**	**8.2**	**3.6**	0.6	**5.6**	**3.1**	**2.3**	0.2	**14.9**	**3.8**	**1.1**	**4.1**	**4.3**
Tall Shrub	--	0.4	--	--	--	**3.2**	0.6	**2.1**	**1.4**	**1.7**	0.0	--	**1.9**	--	**1.2**
Low Shrub	**1.2**	**4.0**	**2.3**	1.6	**1.8**	**27.2**	**3.2**	**10.4**	**14.4**	**38.3**	**6.1**	**1.6**	**12.2**	**3.7**	**11.4**
Low Shrub - Lichen	--	--	--	--	--	0.0	--	--	--	--	--	--	0.0	0.0	0.0
Low Shrub – Tussock Tundra	0.8	**3.3**	**3.1**	**1.3**	0.8	**6.5**	**1.9**	**2.8**	**13.0**	**15.2**	**4.9**	**3.0**	**11.2**	**6.4**	**5.4**
Dwarf Shrub	0.1	0.2	--	--	--	**16.8**	0.1	**5.5**	**2.3**	**1.6**	0.0	0.0	0.7	0	**4.4**
Wet Sedge	0.0	--	--	0.0	--	--	0.0	--	--	--	0.0	--	--	0.1	0
Dry herbaceous	0.0	0.0	--	--	0.0	**2.0**	0.0	**1.6**	**3.3**	0.1	0.0	0.0	0.1	--	0.5
Tussock Tundra	0.1	0.9	0.0	0.1	0.0	**1.2**	0.1	0.1	**2.6**	**1.7**	0.2	0.4	**5.5**	0.4	1.2
Tussock Tundra - Lichen	--	--	--	--	--	0.0	--	--	**13.9**	--	--	--	--	--	0.0
Aquatic Bed	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0
Clear Water	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	--	0.0	0.0	0.2	0.3	1.9	0.3
Turbid Water	0.2	--	--	0.1	0.7	--	0.1	--	--	--	0.0	0.0	0.0	**12.9**	**1.5**

Land Cover Class Description	% Composition by area for each Ecological Subsection Region														
	BH	**CF**	**HL**	**KT**	**LB**	**MT**	**OF**	**OM**	**SD**	**TF**	**TH**	**TL**	**UC**	**YV**	**All**
Snow	--	0.0	--	0.0	0.0	**1.1**	0.0	0.0	--	--	--	--	0.0	--	0.3
Sparsely Vegetated	0.9	0.5	0.1	0.0	0.7	**8.8**	0.7	**8.3**	0.3	0.5	0.1	0.1	0.8	**1.5**	**2.8**
Rock/Gravel	0.2	0.1	0.0	0.0	0.1	**13.4**	0.1	**3.0**	0.0	0.2	0.0	0.0	0.4	0.9	**3.5**
Clouds	--	--	--	--	--	--	0.1	0.6	--	--	--	--	--	--	0.0
Cloud Shadows	--	--	--	--	--	0.0	0.1	0.1	--	0.0	--	--	--	--	0.0
Terrain Shadow	**6.6**	**6.7**	**1.5**	**2.2**	**3.1**	**4.1**	**11.1**	**17.2**	--	0.1	**1.8**	**1.0**	0.7	0.6	**4.3**
Fire (burned)	**5.8**	**9.1**	--	--	**26.4**	0.1	--	0.0	**22.2**	--	--	--	--	0.7	**2.1**
Unit as percentage of preserve	5.6	11.2	1.6	1.1	1.8	24.2	11.9	2	0.1	2.7	11.4	3.0	11.5	11.4	100

*Dash indicates none, "0.0" indicates present but <0.1%. Percentages ≥ 1.0 are bolded.

Swanson (2001) notes that the line placements (boundaries between ecological subsections) are accurate to within about 500 m and that the original data are 1:250,000 scale.

Ecological Subsection Region codes: CF = Charley Foothills, HL = Hard Luck Lowlands, BH = Biederman Hills, KT = Kandik Tableland, LB = Little Black River Hills, MT = Upper Charley Mountain Tundra, OF = Ogilvie Foothills, OM = Ogilvie Lime/Dolostone Mountains, SD = Snowy Domes, TF = Three Fingers Subalpine Basin, TH = Tintina Hills, TL = Thanksgiving Loess Plain, UC = Upper Charley Valleys, YV = Yukon River Valley, ALL = all subsections (entire preserve area).

Appendix 4. National Wetland Inventory classification statistics (area and percent composition) in YUCH.

Wetland code description	NWI code [a]	ac	ha	% of all subsections	% of all wetlands	% of palustrine wetlands
Palustrine (pond) – aquatic bed, rooted vascular and moss floating bog	PAB3/EM1F	12	5	0.00	0.00	0.00
Palustrine (pond) – aquatic bed, rooted vascular	PAB3F	9	4	0.00	0.00	0.00
Palustrine (pond) – aquatic bed, rooted vascular	PAB3H	925	374	0.04	0.11	0.12
Palustrine (pond) – aquatic bed, beaver influenced	PAB3Hb	5	2	0.00	0.00	0.00
Palustrine – emergent	PEMF	1	1	0.00	0.00	0.00
Palustrine – emergent persistent/ aquatic bed	PEM1/AB3H	6	2	0.00	0.00	0.00
Palustrine – emergent persistent/ broadleaf deciduous scrub shrub	PEM1/SS1A	90	36	0.00	0.01	0.01
Palustrine – emergent persistent / broadleaf deciduous scrub shrub	PEM1/SS1B	9,133	3,696	0.36	1.13	1.20
Palustrine – emergent persistent / broadleaf deciduous scrub shrub	PEM1/SS1C	2,004	811	0.08	0.25	0.26
Palustrine – emergent persistent / broadleaf deciduous scrub shrub	PEM1/SS1Cb	74	30	0.00	0.01	0.01
Palustrine – emergent persistent / broadleaf deciduous scrub shrub	PEM1/SS1F	66	27	0.00	0.01	0.01
Palustrine – emergent persistent / needleleaf evergreen scrub shrub	PEM1/SS4B	74	30	0.00	0.01	0.01
Palustrine – emergent persistent / needleleaf evergreen scrub shrub	PEM1/SS4C	729	295	0.03	0.09	0.10
Palustrine – emergent persistent / unconsolidated bottom	PEM1/UBF	71	29	0.00	0.01	0.01
Palustrine – emergent persistent / unconsolidated bottom	PEM1/UBH	4	2	0.00	0.00	0.00
Palustrine – emergent persistent / unconsolidated shore	PEM1/USA	25	10	0.00	0.00	0.00
Palustrine – emergent persistent / unconsolidated shore	PEM1/USC	15	6	0.00	0.00	0.00
Palustrine – emergent persistent	PEM1A	12	5	0.00	0.00	0.00
Palustrine – emergent persistent	PEM1B	151	61	0.01	0.02	0.02
Palustrine – emergent persistent	PEM1C	1,221	494	0.05	0.15	0.16
Palustrine – emergent persistent	PEM1Cb	4	2	0.00	0.00	0.00
Palustrine – emergent persistent	PEM1F	676	274	0.03	0.08	0.09
Palustrine – emergent persistent	PEM1H	72	29	0.00	0.01	0.01
Palustrine – forest broadleaf deciduous / needleleaf evergreen	PFO1/FO4A	14	6	0.00	0.00	0.00
Palustrine – forest broadleaf deciduous / needleleaf evergreen	PFO1/FO4B	1	1	0.00	0.00	0.00
Palustrine – forested broadleaf deciduous/ scrub shrub broadleaf deciduous	PFO1/SS1B	159	64	0.01	0.02	0.02

Wetland code description	NWI code [a]	ac	ha	% of all subsections	% of all wetlands	% of palustrine wetlands
Palustrine – forest broadleaf deciduous	PFO1A	13	5	0.00	0.00	0.00
Palustrine – forest needleleaf evergreen / emergent	PFO4/EM1C	13	5	0.00	0.00	0.00
Palustrine – forest needleleaf evergreen / forest broadleaf deciduous	PFO4/FO1B	22	9	0.00	0.00	0.00
Palustrine – forest needleleaf evergreen / scrub shrub broadleaf deciduous	PFO4/SS1B	5,182	2,097	0.21	0.64	0.68
Palustrine – forest needleleaf evergreen	PFO4B	2,548	1,031	0.10	0.31	0.34
Palustrine – moss -lichen moss / emergent persistent	PML1/EM1B	100	40	0.00	0.01	0.01
Palustrine – moss/lichen moss / emergent persistent	PML1/EM1C	5	2	0.00	0.00	0.00
Palustrine – moss – lichen moss / moss – lichen	PML1/ML2B	52	21	0.00	0.01	0.01
Palustrine – moss – lichen / scrub shrub broadleaf deciduous	PML1/SS1B	212	86	0.01	0.03	0.03
Palustrine – moss – lichen / scrub shrub needleleaf evergreen	PML1/SS4B	2,591	1,048	0.10	0.32	0.34
Palustrine – moss – lichen moss	PML1B	169	68	0.01	0.02	0.02
Palustrine – moss – lichen, lichen / moss	PML2/ML1B	25	10	0.00	0.00	0.00
Palustrine – moss – lichen, lichen / scrub shrub broadleaf deciduous	PML2/SS1B	161	65	0.01	0.02	0.02
Palustrine – moss – lichen, lichen / scrub shrub needleleaf evergreen	PML2/SS4B	83	34	0.00	0.01	0.01
Palustrine – scrub shrub broad leaf deciduous / emergent persistent	PSS1/EMB	12	5	0.00	0.00	0.00
Palustrine – scrub shrub broadleaf deciduous / emergent persistent	PSS1/EM1A	321	130	0.01	0.04	0.04
Palustrine – scrub shrub broadleaf deciduous / emergent persistent	PSS1/EM1B	292,859	118,516	11.60	36.12	38.60
Palustrine – scrub shrub broadleaf deciduous / emergent persistent	PSS1/EM1C	32,821	13,282	1.30	4.05	4.33
Palustrine – scrub shrub broadleaf deciduous / emergent persistent (beaver influenced)	PSS1/EM1Cb	7	3	0.00	0.00	0.00
Broad leaf scrub shrub broadleaf deciduous / forest broad leaf evergreen	PSS1/FO4B	2,275	921	0.09	0.28	0.30
Palustrine – scrub shrub broadleaf deciduous / forest dead	PSS1/FO5B	62	25	0.00	0.01	0.01
Palustrine – scrub shrub broadleaf deciduous / moss – lichen, moss	PSS1/ML1B	35	14	0.00	0.00	0.00
Palustrine – scrub shrub broadleaf deciduous / scrub shrub needleleaf evergreen	PSS1/SS4A	27	11	0.00	0.00	0.00
Palustrine - scrub shrub broadleaf deciduous / scrub-shrub needleleaf evergreen	PSS1/SS4B	279,071	112,936	11.05	34.42	36.79
Palustrine – scrub shrub broadleaf deciduous / scrub shrub needleleaf evergreen	PSS1/SS4C	1	0	0.00	0.00	0.00
Palustrine – scrub shrub broadleaf deciduous / scrub shrub dead	PSS1/SS5B	2,907	1,176	0.12	0.36	0.38

Wetland code description	NWI code [a]	ac	ha	% of all subsections	% of all wetlands	% of palustrine wetlands
Palustrine – scrub shrub broadleaf deciduous / unconsolidated shore	PSS1/USA	1,408	570	0.06	0.17	0.19
Palustrine – scrub shrub broadleaf deciduous / unconsolidated shore	PSS1/USB	16	7	0.00	0.00	0.00
Palustrine – scrub shrub broadleaf deciduous / unconsolidated shore	PSS1/USC	28	11	0.00	0.00	0.00
Palustrine – scrub shrub broadleaf deciduous	PSS1A	2,244	908	0.09	0.28	0.30
Palustrine – scrub shrub broadleaf deciduous	PSS1B	6,038	2,444	0.24	0.74	0.80
Palustrine – scrub shrub broadleaf deciduous	PSS1C	51	21	0.00	0.01	0.01
Palustrine – scrub shrub broadleaf deciduous	PSS1Cb	12	5	0.00	0.00	0.00
Palustrine – scrub shrub broadleaf deciduous	PSS1Fb	2	1	0.00	0.00	0.00
Palustrine – scrub shrub needleleaf evergreen / emergent broadleaf deciduous	PSS4/EM1B	27	11	0.00	0.00	0.00
Palustrine – scrub shrub needleleaf evergreen / emergent broadleaf deciduous	PSS4/EM1C	41	17	0.00	0.01	0.01
Palustrine – scrub shrub needleleaf evergreen / moss – lichen, moss	PSS4/ML1B	403	163	0.02	0.05	0.05
Palustrine – scrub shrub needleleaf evergreen / scrub shrub broadleaf deciduous	PSS4/SS1B	104,585	42,324	4.14	12.90	13.79
Palustrine – scrub shrub needleleaf evergreen	PSS4B	4,148	1,679	0.16	0.51	0.55
Palustrine – scrub shrub dead / scrub shrub broadleaf deciduous	PSS5/SS1B	1,258	509	0.05	0.16	0.17
Palustrine – scrub shrub dead	PSS5Fb	2	1	0.00	0.00	0.00
Palustrine – unconsolidated bottom / emergent persistent	PUB/EM1F	9	4	0.00	0.00	0.00
Palustrine – unconsolidated bottom / emergent persistent	PUB/EM1H	5	2	0.00	0.00	0.00
Palustrine – unconsolidated bottom	PUBF	42	17	0.00	0.01	0.01
Palustrine – unconsolidated bottom (beaver influenced)	PUBFb	7	3	0.00	0.00	0.00
Palustrine – unconsolidated bottom (excavated)	PUBFx	1	0	0.00	0.00	0.00
Palustrine – unconsolidated bottom	PUBH	1,095	443	0.04	0.14	0.14
Palustrine – unconsolidated bottom (beaver influenced)	PUBHb	49	20	0.00	0.01	0.01
Palustrine – unconsolidated bottom (diked / impounded)	PUBHh	8	3	0.00	0.00	0.00
Palustrine – unconsolidated bottom	PUBHx	12	5	0.00	0.00	0.00
Palustrine – unconsolidated shore	PUSA	4	2	0.00	0.00	0.00
Lacustrine – unconsolidated bottom	L1UBH	629	255	0.02	0.08	NA
Lacustrine – unconsolidated bottom (beaver influenced)	L1UBHb	62	25	0.00	0.01	NA

Wetland code description	NWI code [a]	ac	ha	% of all subsections	% of all wetlands	% of palustrine wetlands
Lacustrine – littoral – aquatic bed – rooted vascular / aquatic bed algal	L2AB3/AB1H	139	56	0.01	0.02	NA
Lacustrine – aquatic bed rooted vascular	L2AB3H	836	338	0.03	0.10	NA
Riverine - lower perennial scrub shrub broadleaf deciduous / unconsolidated shore	R2SS1/USA	7	3	0.00	0.00	NA
Riverine – lower perennial unconsolidated bottom (open water)	R2UBH	33,916	13,725	1.34	4.18	NA
Riverine – lower perennial – unconsolidated shore	R2USA	4,721	1,911	0.19	0.58	NA
Riverine – upper perennial – unconsolidated shore	R2USC	4,574	1,851	0.18	0.56	NA
Riverine – upper perennial - unconsolidated bottom / unconsolidated shore	R3UB/US	504	204	0.02	0.06	NA
Riverine – upper perennial – unconsolidated bottom	R3UBH	4,845	1,961	0.19	0.60	NA
Riverine –upper perennial - unconsolidated shore / unconsolidated bottom	R3US/UB	165	67	0.01	0.02	NA
Riverine – upper perennial - unconsolidated shore habitats	R3USA	841	341	0.03	0.10	NA
Riverine – upper perennial – unconsolidated shore	R3USC	939	380	0.04	0.12	NA
UPLAND (non wetland)	U	1,714,197	693,711	67.89	NA	NA
Unknown[b]	(blank)*	60	24	0.00	NA	NA
Grand Total:		**2,525,057**	**1,021,854**			
Total area of wetlands:		**810,801**	**328,119**			
Total area of palustrine wetlands:		**758,623**	**307,004**			

[a] Not defined in the wetland description column are the water regimes of each wetland class. These include the following: A = temporarily flooded, B = saturated, C = seasonally flooded, E = seasonally flooded/saturated, F = semi-permanently flooded, H = permanently flooded. The vast majority of wetlands (by area) in the preserve fall within the B water regime.

[b] The unknown area listed above is due to horizontal positional inaccuracy caused by the 1:250,000 map scale of the ecological subsection data (i.e., the boundaries do not precisely line up with the preserve boundaries). The National Wetland Inventory (NWI) data were first clipped to the YUCH boundaries, then summarized by ecological subsection.

Appendix 5. Fire area (ha) by year in each ecological subsection of YUCH (1950-2010).

Year	BH	CF	HL	KT	LB	MT	OF	OM	SD	TF*	TH	TL	UC	YV	Totals
1950	12,530	187	--	9,059	--	--	10,524	--	--	--	10,621	--	--	2,313	32,704
1951	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1952	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1953	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1954	--	--	--	--	1,216	--	--	--	--	--	--	--	--	--	1,216
1955	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1956	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1957	--	--	1,908	--	--	--	5	--	--	--	--	4,657	--	1	6,571
1958	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1959	--	--	--	--	--	--	--	--	--	--	1,222	--	--	--	1,222
1960	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1961	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1962	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1963	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1964	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1965	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1966	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1967	387	--	2,688	--	--	--	781	104	--	--	682	4,422	--	205	8,882
1968	--	--	1,287	--	--	--	943	--	--	--	--	--	--	--	2,230
1969	--	7,093	--	1,146	--	--	--	234	--	--	86,083	--	--	20,358	114,914
1970	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1971	734	--	--	--	--	--	4,571	--	--	--	--	--	--	275	4,846
1972	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1973	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1974	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1975	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0

Year	BH	CF	HL	KT	LB	MT	OF	OM	SD	TF*	TH	TL	UC	YV	Totals
1976	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1977	--	--	--	--	3,853	--	--	--	--	--	--	--	--	--	3,853
1978	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1979	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1980	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1981	--	--	--	--		--	--	--	--	--	--	--	--	--	0
1982	--	--	--	--		--	--	--	--	--	--	--	--	--	0
1983	--	--	--	--		--	--	--	--	--	--	--	--	--	0
1984	--	--	--	--		--	--	--	--	--	--	--	--	--	0
1985	--	--	--	--		--	--	--	--	--	--	--	--	--	0
1986	5,031	--	--	--	6,378	--	--	--	468	--	--	--	--	1,691	8,537
1987	--	--	--	--		--	--	--	--	--	--	--	--	--	0
1988	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1989	--	--	--	--	--	--	--	--	--	--	--	--	--	40	40
1990	--	--	--	--	--	--	46	--	--	--	--	--	--	--	46
1991	--	14,030	--	--	--	202	--	--	--	--	--	--	--	59	14,291
1992	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1993	--	2,885	--	--	22	649	276	--	40	--	1,130	2,261	--	4	7,267
1994	--	--	--	--	--	--	85	--	--	--	--	--	108	--	193
1995	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1996	--	--	--	--	11	--	527	406	--	--	--	3,413	--	59	4,416
1997	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1998	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
1999	1,164	5,324	1,981	--	--	447	27,044	839	--	--	--	--	2,628	5,966	44,229
2000	--	--	25	--	--	--	--	--	--	--	--	--	--	113	138
2001	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
2002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0

Year	BH	CF	HL	KT	LB	MT	OF	OM	SD	TF*	TH	TL	UC	YV	Totals
2003	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
2004	21,442	18	7,596	--	10,156	217	17,511	--	1,112	--	303	--	--	10,344	47,257
2005	--	--	--	--	--	--	9,776	--	--	--	--	--	--	94	9,870
2006	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
2007	3,465	305	--	17	--	5	705	--	--	--	2,671	1,956	--	1,082	6,741
2008	--	--	--	--	--	--	--	--	--	--	--	--	--	252	252
2009	--	--	--	--	6,172	--	105	--	--	--	--	81	--	6	6,364
2010	--	144	505	--	--	--	1,182	--	--	--	--	--	--	428	2,259
Totals:	44,753	29,986	15,990	10,222	27,808	1,520	74,081	1,583	1,620		102,712	16,790	2,736	43,290	328,338

Subsection areas (ha): BH 57,187; CF 113,626; HL 16,113; KT 11,585; LB 23,950; MT 247,374; OF 121,402, OM 20,844; SD 1,158; TF 27,413; TH 116,089; TL 30,126; UC 116,998; YV 147,991.

*The Three Fingers Subalpine (TF) ecological subsection contained no fires for the period of record.

Appendix 6. Fire protection points, types, site descriptions, fire protection classes, management agency, data collection method, and collection date of structures in YUCH. Data current from NPS Regional GIS dataset as of September 2011.

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
COCR-STR-028	Airstrip and buildings	Coal Creek Airstrip and Buildings	1	Full	NPS	GPS-Ground	Unknown	1/8/2010
BECR-STR-002	Cabin	Ben Creek Airstrip Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	1/11/2010
CHRI-STR-001	Cabin	Al Ames Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	3/15/2006
CHRI-STR-002	Cabin	Bonanza Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/14/2005
CHRI-STR-004	Cabin	Silvia Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-005	Cabin	Hanna Creek Cabin - Non Historic (1973)	1	Non-Sensitive	NPS	Unknown	No	12/14/2005
CHRI-STR-007	Cabin	Essie Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-008	Cabin	50 Mile Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-011	Cabin	Hosford Creek Cabin - did not locate	1	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
CHRI-STR-012	Cabin	Bryant's Hosford Upriver Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
CHRI-STR-014	Cabin	Copper Creek Line Cabin #1	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-015	Cabin	Upper Copper Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-017	Cabin	Elmer Nelson Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-018	Cabin	Dewey Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
CHRI-STR-021	Cabin	Gelvin's Cabin - Non Historic (1963)	1	Full	NPS	Unknown	No	7/30/2010
CHRI-STR-022	Cabin	Crescent Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
COCR-STR-003	Cabin	Frank Hall/Boulder Creek Mine Cabin - UPM	1	Full	NPS	Unknown	Unknown	7/1/2008
COCR-STR-004	Cabin	Phil Berail's Colorado Creek Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
COCR-STR-008	Cabin	Claim #8 Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
COCR-STR-009	Cabin	Cat Trail Cabin (COCR-014 Upper CC Cabin)	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
COCR-STR-010	Cabin	Colorado Creek Mouth Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
COCR-STR-012	Cabin	Coal Creek Tributary Cabin	1	Non-Sensitive	NPS	GPS-Ground	Unknown	12/15/2005
COCR-STR-015	Cabin	Slaven Dome Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
COCR-STR-020	Cabin	Middle Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
COCR-STR-021	Cabin	Claim #10 Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
COCR-STR-024	Cabin	Ben Creek Road Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
COCR-STR-026	Cabin	Dredge Master's Cabin	1	Non-Sensitive	NPS	GPS-Ground	Unknown	12/20/2007
COCR-STR-027	Cabin	Sam Harvey Cabin	1	Non-Sensitive	NPS	GPS-Ground	Unknown	1/28/2008
EUCR-STR-001	Cabin	Hermit Bill's Cabin - Not historic	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
FOJU-STR-002	Cabin	Fourth of July Creek Cabin	1	Full	NPS	GPS-Ground	Yes	7/30/2010
KARI-STR-002	Cabin	Gordon Bertison Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
KARI-STR-004	Cabin	Charlie Edward's Cabin/Woodruff's Cabin - Non Historic	1	Full	NPS	Unknown	No	3/14/2011
KARI-STR-010	Cabin	Three Mile Creek Cabin - Non	1	Non-	NPS	GPS-	No	12/15/2005

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
		Historic		Sensitive		Ground		
KARI-STR-015	Cabin	Snow Drift Cabin	1	Non-Sensitive	NPS	GPS-Ground	Unknown	1/28/2008
NARI-STR-003	Cabin	Nation's Coal Mine	1	Non-Sensitive	NPS	GPS-Ground	Unknown	12/15/2005
NARI-STR-004	Cabin	Old Hard Luck Creek Cabin - did not locate	1	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
NARI-STR-006	Cabin	Brad Snow's Cabin - Non Historic (1974)	1	Non-Sensitive	NPS	Unknown	No	1/1/1900
SACR-STR-001	Cabin	Sam Creek Cabin and Cache	1	Full	NPS	GPS-Ground	Yes	10/15/2010
SACR-STR-003	Cabin	Cap Reynolds Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
SACR-STR-004	Cabin	Alfred Johnson Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
WOCR-STR-015	Cabin	Upper Woodchopper Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
YURI-STR-009	Cabin	Wood Island Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
YURI-STR-020	Cabin	Evans Rock Creek Cabin - Non Historic(1977)- Burned Down	1	Non-Sensitive	NPS	GPS-Ground	No	6/25/2010
YURI-STR-025	Cabin	George Beck's Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
YURI-STR-027	Cabin	Solomon Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
YURI-STR-028	Cabin	S-Shaped Lake Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
YURI-STR-036	Cabin	Mail Trail Waystation Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/16/2005
YURI-STR-046	Cabin	Lake 695 Cabin	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
YURI-STR-056	Cabin	22 Mile Cabin	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
YURI-STR-065	Cabin	Washington Creek Steam Tractor Cabin	1	Non-Sensitive	NPS	GPS-Ground	Unknown	1/28/2008
NARI-STR-005	Cabin (non-NPS)	Evans Hard Luck Creek Cabin - did not locate	1	Unknown	Regional Corporation	Unknown	No	4/5/2008
COCR-STR-022	Cabin (public use)	Coal Creek Camp	1	Full	NPS	GPS-Ground	Yes	1/8/2010
KARI-STR-009	Cabin (public use)	Ricketts/Trainor Cabin - Non Historic P/U	1	Full	NPS	GPS-Ground	No	3/14/2011
YURI-STR-013	Cabin (public use)	Nation Bluff Cabin - P/U	1	Full	NPS	GPS-Ground	Yes	3/15/2006
YURI-STR-023	Cabin (public use)	Glenn Creek Cabin - P/U	1	Full	NPS	GPS-Ground	Unknown	8/24/2009
YURI-STR-045	Cabin (public use)	Ray Bell (40-mile) Cabin - Non Historic 1971	1	Full	NPS	GPS-Ground	No	2/17/2010
YURI-STR-050	Cabin (public use)	Wilson's Washington Creek Cabin - Non Historic (1976)	1	Full	NPS	Unknown	No	3/14/2011
YURI-STR-063	Cabin (public use)	Slaven's Public Use Cabin - Non Historic P/U	1	Full	NPS	GPS-Ground	No	3/15/2006
CHRI-STR-010	Cabin (ruin)	Canoe Cabin Ruin	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
YURI-STR-041	Cabin (ruins)	McGregors Cabin Ruin	1	Non-Sensitive	NPS	GPS-Ground	Yes	10/8/2010
YURI-STR-011	Cabins	Sager Cabins - Trout Creek	1	Full	NPS	GPS-Ground	Unknown	3/14/2011
COCR-STR-006	Camp	Unlucky Strike Camp	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
COCR-STR-023	Camp	Cheese Camp	1	Full	NPS	GPS-Ground	Yes	7/30/2010
YURI-STR-053	Camp (fish)	Wood Island Fish camp - Non Historic	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
BECR-STR-004	Complex	Ben Creek Complex	1	Full	NPS	GPS-Ground	Yes	7/30/2010
COALCP83	Dredge	Coal Creek Dredge	1	Full	NPS	GPS-Ground	Yes	7/30/2010

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
KARI-STR-008	Gate Estate (non-NPS)	Gate Estate - Doyon	1	Unknown	Regional Corporation	GPS-Ground	No	12/15/2005
CHRI-STR-013	Mine	Copper Creek Mine	1	Non-Sensitive	NPS	GPS-Ground	Yes	12/14/2005
COCR-STR-005	Mine	Colorado Creek Mine	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
YURI-STR-044	Roadhouse	Woodchopper Roadhouse	1	Non-Sensitive	NPS	GPS-Ground	Yes	10/8/2010
YURI-STR-040	Roadhouse (public use)	Frank Slaven Roadhouse	1	Full	NPS	GPS-Ground	Yes	3/15/2006
YURI-STR-057	Rock Shelter	Kathul Mtn. Rock Shelter	1	Non-Sensitive	NPS	GPS-Ground	Unknown	12/16/2005
KARI-STR-003	Saloon	Bigfoot Bob Tepley's New Moon Saloon - Non Historic	1	Non-Sensitive	NPS	GPS-Ground	No	12/15/2005
CHRI-STR-019	Tentframe	East Fork Tent Frame	1	Non-Sensitive	NPS	GPS-Ground	No	12/14/2005
BECR-STR-RAWS	Weather Station	Ben Creek RAWS	1	Full	NPS	GPS-Ground	Unknown	3/8/2011
CHRI-STR-RAWS	Weather Station	Upper Charley River RAWS	1	Full	NPS	Unknown	Unknown	3/8/2011
COCR-STR-RAWS	Weather Station	Coal Creek RAWS	1	Full	NPS	Unknown	Unknown	2/8/2011
YURI-STR-068	NA	No Name Given	1	Non-Sensitive	NPS	GPS-Ground	Unknown	1/28/2008
CHRI-STR-003	Cabin (removed)	Everett Creek Cabin - removed 1999	2	Non-Sensitive	NPS	Unknown	Unknown	12/14/2005
WOCR-STR-007	Camp (mining, LSI)	Alice Gulch Drift Mining Camp-land status issues	2	Non-Sensitive	NPS	Unknown	Unknown	1/29/2008
RPTR-HILLARD	Radio Repeater (non-NPS)	Hillard Radio Repeater	2	Full	BLM	Unknown	Unknown	1/8/2010
RPTR-KATHUL	Radio Repeater (non-NPS)	Kathul Radio Repeater	2	Full	BLM	Unknown	Unknown	1/8/2010

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
RPTR-TWIN	Radio Repeater (non-NPS)	Twin Radio Repeater	2	Full	BLM	Unknown	Unknown	1/8/2010
RPTR-YUKON	Radio Repeater (non-NPS)	Yukon Radio Repeater	2	Full	BLM	Unknown	Unknown	1/8/2010
BECR-STR-001	Cabin	Ben Creek Cabin	3	Non-Sensitive	NPS	Unknown	Unknown	12/14/2005
BECR-STR-003	Cabin	Mine Shaft Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	12/14/2005
CHRI-STR-006	Cabin	Highland Creek Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	12/14/2005
COCR-STR-014	Cabin	Upper Coal Creek Cabin - refer to COCR-009	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
FOJU-STR-001	Cabin	Crowley Creek cabin	3	Non-Sensitive	NPS	GPS-Ground	Yes	11/24/2008
KARI-STR-011	Cabin	Easy Moose Creek Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
KARI-STR-016	Cabin	Grinnell's Below Johnson Gorge Cabin	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
MICR-STR-001	Cabin	Sager Line Cabin - Non Historic (1980)	3	Non-Sensitive	NPS	Unknown	No	3/25/2011
NARI-STR-001	Cabin	Phonograph Nelson's Hardluck Crk Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
NARI-STR-002	Cabin	Six Mile Cabin - Non Historic (1974)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
SACR-STR-002	Cabin	Big Smokey Creek Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
SERI-STR-003	Cabin	Diamond Fork Line Shack - Non Historic (1975)	3	Non-Sensitive	NPS	Unknown	No	1/1/1900
WOCR-STR-016	Cabin	Moore Creek Cabin- land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
WOCR-STR-020	Cabin	Woodchopper Creek Cabin A	3	Non-Sensitive	NPS	Unknown	Unknown	12/20/2007

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
WOCR-STR-021	Cabin	Woodchopper Creek Cabin B	3	Non-Sensitive	NPS	Unknown	Unknown	12/20/2007
WOCR-STR-023	Cabin	Woodchopper Creek Cabin C	3	Non-Sensitive	NPS	Unknown	Unknown	12/20/2007
YURI-STR-010	Cabin	Montauk Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
YURI-STR-014	Cabin	Taylor Cabin - burned in 1999	3	Non-Sensitive	NPS	GPS-Ground	Unknown	1/1/1900
YURI-STR-018	Cabin	Rock Creek Cabin - burned down 1999	3	Non-Sensitive	NPS	Unknown	Unknown	1/27/2011
YURI-STR-019	Cabin	Older Rock Creek Cabin - burned down 1999	3	Non-Sensitive	NPS	Unknown	Unknown	1/27/2011
YURI-STR-021	Cabin	Charlie Edwards Line Cabin - Non Historic (1978)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
YURI-STR-022	Cabin	Abel's Lake Cabin - NPS removed 1999	3	Non-Sensitive	NPS	Unknown	Unknown	6/8/2010
YURI-STR-037	Cabin	A-Frame Cabin - Non Historic (1962)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
YURI-STR-043	Cabin	Slough Cabin - Non Historic (1977)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
YURI-STR-051	Cabin	Andrew Flats/George Moore Cabin - Non Historic (1976)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
YURI-STR-055	Cabin	Montauk Sidestream Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
YURI-STR-058	Cabin	Charlie Edward's Dry Creek Cabin - Non Historic (1977)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
YURI-STR-059	Cabin	Abel's Slough Cabin - Non Historic (1975-6)	3	Non-Sensitive	NPS	Unknown	No	6/8/2010
YURI-STR-062	Cabin	Roberts' Cabin - Non Historic (1980)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
YURI-STR-066	Cabin	Webber Creek Cabin	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
YURI-STR-072	Cabin	Biederman's IceBox Cabin	3	Non-Sensitive	NPS	Unknown	Unknown	3/5/2008

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
YURI-STR-073	Cabin	Twenty Mile Cabin	3	Non-Sensitive	NPS	Unknown	Unknown	3/5/2008
TRCR-STR-002	Cabin (burned, non-NPS)	Gillman Creek Cabin - burned in 1969	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
WACR-STR-002	Cabin (burned, non-NPS)	Surprise Creek Cabin - burned in 1969	3	Non-Sensitive	NPS	Unknown	Unknown	3/5/2008
SERI-STR-001	Cabin (complex, non-NPS)	Flume Creek Cabin Complex - Doyon	3	Unknown	Regional Corporation	Unknown	Unknown	12/15/2005
WOCR-STR-006	Cabin (LSI)	Iron Creek Drift Mining Cabin-land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
WOCR-STR-009	Cabin (LSI)	Lower Woodchopper Cabin-land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
YURI-STR-001	Cabin (non-NPS)	Len Hart Cabin at Pickeral Slough - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
YURI-STR-002	Cabin (non-NPS)	Biederman's Cabin on Pickeral Slough - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
YURI-STR-003	Cabin (non-NPS)	Ed Olson Cabin at Pickeral Slough - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
YURI-STR-008	Cabin (non-NPS)	Max Drew's Cabin - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
YURI-STR-035	Cabin (non-NPS)	George Beck's Cabin at Biederman's - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
YURI-STR-061	Cabin (non-NPS)	Bob Stacey's Cabin - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
SERI-STR-005	Cabin (non-NPS)	Seventy Mile Line Cabin - Doyon	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
SERI-STR-006	Cabin (non-NPS)	Elferon's Cabin	3	Non-Sensitive	NPS	Unknown	Unknown	12/21/2007
WACR-STR-001	Cabin (non-NPS)	Wilson Line Cabin - Non Historic (1976)	3	Full	NPS	Unknown	No	3/14/2011
WACR-STR-003	Cabin (non-NPS)	4 1/2 Mile Cabin - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
WECR-STR-001	Cabin (non-NPS)	Webber Creek Cabin #2	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
WOCR-STR-010	Cabin (non-NPS)	Caribou Creek Cabin- land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
HLCR-STR-001	Cabin (non-NPS)	Hard Luck Creek Cabin #1	3	Unknown	Regional Corporation	Unknown	Unknown	4/5/2008
KARI-STR-013	Cabin (non-NPS)	Upper Easy Moose Creek Cabin - Doyon	3	Unknown	Regional Corporation	Unknown	Unknown	12/15/2005
WOCR-STR-018	Cabin (non-NPS)	Stan Gelvin's Private Cabin	3	Unknown	State	Unknown	Unknown	3/6/2009
YURI-STR-006	Cabin (non-NPS)	Mail Trail Cabin - Hungwitchin	3	Unknown	Village Corporation	Unknown	No	12/15/2005
YURI-STR-052	Cabin (non-NPS)	Lord's Lake Cabin - Hungwitchin	3	Unknown	Village Corporation	Unknown	Unknown	12/15/2005
YURI-STR-049	Cabin (private)	Straub's Cabin - private	3	Unknown	State	Unknown	Unknown	1/11/2010
YURI-STR-031	Cabin (removed)	Sarge Waller Cabin - NPS removed 1999	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
FOJU-STR-003	Cabin (ruins)	Ruby Creek Cabin Ruins - Doyon	3	Non-Sensitive	NPS	Unknown	Unknown	3/6/2009
CHRI-STR-020	Cabins	5 Mile Cabin Ruins - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	12/14/2005
WOCR-STR-025	Cabins	MINERAL CREEK MOUTH CABINS	3	Non-Sensitive	NPS	Unknown	Unknown	12/21/2007
WOCR-STR-002	Cabins (LSI)	Upper Mineral Creek Cabins- land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
WOCR-STR-011	Cabins (LSI)	Caribou Creek Line Cabins- land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
TARI-STR-003	Cabins (ruin, non-NPS)	Ruins of Two Cabins	3	Full	BLM	Unknown	Unknown	12/20/2007
SERI-STR-004	Cabins (ruins)	Efrem Razumny's Cabin - Doyon	3	Non-Sensitive	NPS	Unknown	Unknown	12/15/2005
YURI-STR-012	Camp (fish - allotment)	Evan's Fish Camp Tentframe - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
YURI-STR-029	Camp (fish)	Seymour Abel Fish Camp - Non Historic	3	Non-Sensitive	NPS	Unknown	No	6/8/2010
YURI-STR-060	Camp (fish)	Randy Brown's Fish Camp - Non Historic	3	Non-Sensitive	NPS	Unknown	No	6/8/2010
YURI-STR-004	Camp (fish, non-NPS)	Cap Dalphus' Fish Camp - allotment	3	Full	BLM	Unknown	Unknown	1/28/2008
YURI-STR-042	Camp (fish, non-NPS)	Tom Young's Fish Camp - did not locate	3	Unknown	Regional Corporation	Unknown	Unknown	4/5/2008
WOCR-STR-019	Camp (mining)	Iron Creek Mining Camp	3	Non-Sensitive	NPS	Unknown	Unknown	12/12/2007
WOCR-STR-001	Camp (mining, LSI)	Woodchopper Mining Camp (Complex) - land status issues	3	Full	NPS	Unknown	Unknown	1/28/2008
WOCR-STR-004	Camp (mining, LSI)	Mineral Creek Mining Camp (Complex)- land status issue	3	Non-Sensitive	NPS	Unknown	Unknown	1/29/2008
YURI-STR-034	Camp (non-NPS)	Biederman's Camp Complex - allotment	3	Full	BLM	Unknown	Unknown	2/25/2011
YURI-STR-007	Camp (non-NPS)	Miller's Camp	3	Unknown	State	Unknown	Unknown	2/18/2010
TRCR-STR-003	Camp (tentframe, non-NPS)	Trout Creek Tent Frame Camp	3	Non-Sensitive	NPS	Unknown	Unknown	5/30/2007
YURI-STR-075	City	Ivy City	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
YURI-STR-005	City (non-NPS)	Star City/SeventyMile City - Hungwitchin	3	Unknown	Village Corporation	Unknown	Unknown	1/28/2008
TARI-STR-002	Complex (allotment)	Dick Cook's Complex - allotment	3	Full	NPS	Unknown	Unknown	1/8/2010
WOCR-STR-022	Ditch Complex	Woodchopper Creek Ditch Complex	3	Non-Sensitive	NPS	Unknown	Unknown	12/20/2007
YURI-STR-016	Homestead (burned, non-NPS)	Fred Krager Homestead - burned in 1969	3	Unknown	State	Unknown	Unknown	1/1/1900
NARI-STR-008	Mine	Nation River Coal Mine	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
WOCR-STR-017	Mining Shaft	Woodchopper Creek Mining Shaft- land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	1/29/2008
CHRI-STR-024	NA	Independence	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
COCR-STR-025	NA	No Name Given	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
NARI-STR-007	NA	No Name Given	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
YURI-STR-070	Private	Sandy Johnson	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
CHRI-STR-023	Roadhouse	Charley River Roadhouse	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
YURI-STR-026	Roadhouse	Washington Creek Roadhouse	3	Non-Sensitive	NPS	GPS-Ground	Yes	12/15/2005
YURI-STR-069	Roadhouse	Tom King Roadhouse	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
YURI-STR-071	Roadhouse	Webber Creek Roadhouse	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
YURI-STR-074	Roadhouse	Montauk Roadhouse	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008
MICR-STR-002	Structure (non-NPS)	Native Allotment with Structure	3	Full	BLM	Unknown	Unknown	3/25/2011
YURI-STR-017	Tentframe	Rock Creek Tentframe - Non Historic (1980-84)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
WOCR-STR-005	Tentframe (LSI)	Iron Creek Tentframe- land status issues	3	Non-Sensitive	NPS	Unknown	Unknown	1/29/2008
THCR-STR-001	Tentframe (non-NPS)	Winter Trail Tentframe - Non Historic (1984)	3	Non-Sensitive	NPS	Unknown	No	12/15/2005
TRCR-STR-001	Tentframe (non-NPS)	Trout Creek Tentframe -did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900
CHRI-STR-009	Townsite	Bonanza Creek Townsite - did not locate	3	Non-Sensitive	NPS	Unknown	Unknown	1/1/1900

Unique ID	Site Type	Site Description	GPS Confidence Code [a]	Fire Protection Status [b]	Management Control Agency [c]	Site Collection Method	Historical	Date Updated
YURI-STR-015	Townsite (flood destroyed, non-NPS)	Old Nation Townsite - destroyed in flood May 1989	3	Full	BLM	Unknown	Unknown	3/5/2008
WOCR-STR-024	underground storage	Underground Storage Structure	3	Non-Sensitive	NPS	GPS-Ground	Unknown	12/20/2007
YURI-STR-067	Village	Charley's Village (Not Sure???)	3	Non-Sensitive	NPS	Unknown	Unknown	3/4/2009
YURI-STR-RAWS	Weather Station	Eagle RAWS	3	Full	NPS	Unknown	Unknown	2/8/2011
WOCR-STR-026	Dredge	Woodchopper Creek Dredge	3	Non-Sensitive	NPS	Unknown	Unknown	1/28/2008

[a] GPS Accuracy: 1 = Excellent point captured with GPS unit (~10 m accuracy), 2 = Fair positional accuracy (30 to 300 ft), 3 = Poor positional accuracy (>300 ft - from map, local knowledge, etc.).

[b] Non-Sensitive = structures that the NPS would not protect from fire, Full = sites/structures that are important to protect from fire, Unknown = sites that the protection status is determined by another agency.

[c] Contact Agency is the agency that determines the fire protection status level and is the contact in case the structure is threatened by fire: BLM = Bureau of Land Management, Regional Corporation = Native Corporation Owned, Unknown = non-NPS Lands (often private or individual Native Corporation allotments).

Appendix 7. Spatial data related to human activity in YUCH.

GIS dataset name [a]	Data type(s)	No. of records	Activity time-frame [b]	Notes
Airstrips	points	2	C	Also contained in the Protection Point dataset
AKEPIC Exotic Plants in or near national Parks	points	65 (within preserve), 60 (nearby)	A	The sites themselves are often selected for survey because of their potential for non-native, invasive plant species spread and can be redundant with other locations in this list.
Alaska Volcano Observatory - Seismic Stations	points	0	A	None
Archeology Sites (2010 edition)	point	327	B	Archaeology Site Management Inventory System (ASMIS) database derived, updated September 2010
Archeology Surveys YUCH - Group Layer	GPS tracklog points, lines, and polygons	N/A	B	This represents a group layer with wide array of archeological survey spatial data covering several different years and multiple different survey efforts represented with survey GPS track points, line, and polygons from older maps.
Cabins	point	95	C	Redundancy exists with fire protection points
Cell phone towers	point	0	A	No Cell towers within the preserve
Climatological Monitoring Sites - YUCH	points	9 (within preserve), 6 nearby	A	Includes sites for various agencies (I&M RAWS, NRCS Aerial Snow Marker, NWS Coop)
COREL weather stations	point	0	N/A	No COREL weather station in the preserve
FAA webcams	point	1 (Eagle, AK)	A	No FAA webcams within the preserve, only in Eagle, AK
Fire Protection Points (primarily cabins)	point	181	C	Contains several different site types (e.g., cabins, mine sites, fish camps, radio repeater towers)
GPS Base Stations	point	1 in Eagle, AK	A	None in preserve
Historic Structures	point	177	B	Data compiled by the ASMIS (Archaeology Site Management Inventory System). Some redundancies exist between the fire protection points data, however Historic Structures contains additional information not contained in the fire protection points data and as presented here it is up-to-date as of November 2010.

Microwave towers	no data	no data	N/A	GIS data not readily available.
Mining Claims/Prospects	polygons	35 Sections (PLSS)	C	Data presented are current as of 2 November 2000.
National Geographic Survey Monuments	point	67	B	Nearly no visitation or impact to vegetation or soil
NOAA weather stations	point	0	N/A	No weather stations exist in YUCH.
OHV (Coal Creek Trail Condition 2006)	points	246 features	C	Field survey, highly detailed and spatially accurate dataset.
OHV (Coal Creek Trail Condition 2006)	lines	467 trail segments	A	Field survey, highly detailed and spatially accurate dataset.
Radio Repeaters Sites	point	4	A	Data also found in the Fire protection points dataset.
RAWS weather stations	points	3 (in park all RAWS), 3 outside preserve	A	Initial construction and associated disturbance may be greater than some of the other items in this list, but little potential after installation
Roads	line	none	N/A	No active roads in the traditional sense of a "road"
RS2477 Trails	line	NA	B	All RS2477 trails are in the "ready to assert" category, with the exception of some private land containing “asserted” trails. Some may be redundant with locations of the Coal Creek OHV trails
Stream Gauges*	points	14 (within preserve), 16 (within 25 km of preserve)	C	The only presently active site is outside the preserve
YUCH Exotic Plant Surveys	polygons	163	A	Years 2005 and 2008

[a] Layer name according to the NPS Alaska Regional GIS Team's Theme Manager as of January 2011, unless otherwise noted.

[b] This column is a rough estimation of what sites relate more to current conditions compared with those that relate more to historic sites. B = primarily before preserve establishment (c.a. 1980), A = primarily after establishment, C = both before and after preserve establishment, UD = undetermined.

* Stream gauges are found on the USGS National Water Information System: Web Interface online at: http://waterdata.usgs.gov/ak/nwis/inventory. Accessed 6 December 2011.

Appendix 8. Physical and water chemistry data for sampled lakes. Reproduced from O'Brien and Huggins (1976).

Lake	Max. depth (m)	Secchi depth (m)	Temp (°C)	Conductivity (µmhos)	Dis. Oxygen (mg/L)	% saturation	alkalinity (mg $CCaCO_3$/L)	pH	Chloride (mg Cl/L)	P (PO_4 µg/L)	N (NH_3 µg/L)	N (NO_2 µg/L)	N (NO_3 µg/L)	Total N (µg/L	Si (SiO_2 mg/L	SO_4 (mg/L	Ca (mg/L	Mg (mg/L)	Fe (mg/L)
1	1.2	bottom	20.5	177	10.2	116	75	7.5	4.4	129	24.1	1.47	4.58	30.2	3.15	8.5	13.5	4.6	0.1
2	--	2.5	19.8	90	8	90	39	7	0.8	10.8	12.5	4.41	7.07	24	2.8	B.D.	6.2	2.1	0.1
3	3	1.1	21.5	91	10.8	125	43	7.5	0.8	16.6	33	1.47	3.53	38	0.18	B.D.	4.1	0.8	0.54
4	2	bottom	19.5	172	11	123	87	8	0.2	8.9	21.4	5.88	B.D.	27.3	0.23	1.25	16.5	7.3	0.1
5	1.6	1.5	20.5	73	10.6	121	32	7	0.4	8.9	10.9	2.94	3.89	17.7	0.88	0.5	10.5	3	0.25
6	1.1	bottom	23	153	16.5	197	93	9	0.6	7.1	19.9	1.47	5.19	26.6	0.21	B.D.	19.1	9.6	0.25
7	--		23	260	11.2	134	85	9	16.8	6.6	11.4	2.35	2.77	16.5	0.45	15	26.2	9.6	0.65
at 1 m			21	73	9	104	32	7	0.6										
8	4.1	2.5																	
at 4 m			13	139	0	0	69	6.5	2.4	25.9	B.D.	12.9	14.3	26.7	0.22	7.6	17.5	4.9	3.8
at 1 m			21	75	9.6	111	37	7	1.1	4	17.8	2.94	2.06	22.8	0.19	2.8	26.6	3.4	2.05
9 (at 3 m)	3.1	--	19	78	6	67	39	6.5	0.2	2	21.9	2.35	1.07	25.3	0.25	B.D.	9.9	2.6	0.83

B.D. = Below detection

Appendix 9. Lake sample locations (geographic coordinates) (O'Brien and Huggins 1976). Coordinates were converted from degrees, minutes (original document) to decimal degrees. No datum information listed in original document.

Lake Number	1	2	3	4	5	6	7	8	9
Latitude	65.35	65.3833	65.4833	65.3667	65.35	65.3167	65.3	65.3	65.3
Longitude	-142.45	-142.6	143.617	143.117	-142.85	-142.75	142.817	142.817	142.817

Appendix 10. Macroinvertebrate species composition of sampled lakes. Reproduced from O'Brien and Huggins (1976).

Taxonomic Classification	**Lake 1**	**Lake 2**	**Lake 3**	**Lake 4**	**Lake 5**	**Lake 6**	**Lake 7**	**Lake 8**
Class Oligochaeta	x							
Class Gastropoda								
Helisoma sp.	x	x	x			x	x	x
Lymnea sp.	x	x			x	x	x	
Class Pelecypoda*								
Sphaerium spp.	x	x		x	x	x	x	x
Pisidium sp.	x						x	
Class Crustacea								
Gammarus lacustris	x	x	x	x	x		x	x
Class Insecta								
Order Ephemeroptera								
Siphlonorus sp.				x			x	
Order Odonta								
Aeshna eremita	x	x				x		
A. juncea	x					x		
A. interupta lineate	x	x	x	x		x		x
Somatochlora albicincta								x
Cordulia shurteleffi	x							x
Libellula quadrimaculata	x							
Leucorrhinia borealis	x							
L. hudsonia	x	x		x	x			x
L. proxima	x					x	x	
Leucorrhinia sp.								x
Sympetrum danae	x			x				
Nehalennia irene						x		
Enallagma boreale	x	x		x		x	x	
Order Hemiptera								

Taxonomic Classification	**Lake 1**	**Lake 2**	**Lake 3**	**Lake 4**	**Lake 5**	**Lake 6**	**Lake 7**	**Lake 8**
Gerris sp. A	x	x		x		x		x
Gerris sp. B					x		x	
Microvelia sp.						x		x
Arctocorisa sp.	x							
Order Trichoptera								
Banksiola sp.	x							
Limnephilus sp.	x							
Polycentropus sp.	x				x			
Order Coleoptera								
Peltodytes sp.	x							
Haliplus sp.	x							
Graphoderus sp.	x		x	x		x	x	
Hydrovatus sp.		x						
Dytiscus sp.	x			x			x	x
Rhantus sp.	x						x	
Hydroporus sp.							x	
Agabus sp.	x	x						
Neoscutopterus sp.	x							
Bidessus sp. A	x	x						
Bidessus sp. B	x							
Bidessus sp. C	x							
Ilybius sp.		x						
Gyrinus pectoralis	x							
G. minutus	x				x	x		x
Paracymus sp.		x						
Order Diptera								
Paradixa sp.							x	
Chaoborus sp.								x

Taxonomic Classification	Lake 1	Lake 2	Lake 3	Lake 4	Lake 5	Lake 6	Lake 7	Lake 8
Prionocera sp.						x		
Family Chironomidae	x					x		
Total number of species	34	13	5	11	7	16	14	13

* Class Pelecypoda is now known as Class Bivalvia.

Appendix 11. Macroinvertebrate taxa list from 2003 and 2004 NPS sampling efforts (all lakes, NPS lake numbers 1-19, except lakes 15 and 18).

Phylum / subphylum	Class	Subclass	Order	Suborder	Family	Genus	Species	Lake No.
Annelida								
	Clitellata	Hirudinea						2, 4, 5, 6, 8, 9, 11
	Clitellata	Oligochaeta						1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17
Arthropoda								
Chelicerata	Arachnida	Acari						1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17
Crustacea	Branchio-poda	Phyllopoda	Conchostraca					2, 5, 8, 19
	Branchio-poda	Phyllopoda	Diplostraca	Cladocera				1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17
Crustacea	Branchio-poda	Sarsostraca	Anostraca					2, 4
Crustacea	Malaco-straca	Eumalacostraca	Amphipoda	Gammaridea	Hyalellidae	*Hyalella*	*azteca*	1, 4, 5, 6, 7, 11, 12, 13, 14, 16, 19
Crustacea	Maxillo-poda	Copepoda						1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 19
Crustacea	Ostra-coda							1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19
Hexapoda	Insecta	Pterygota	Coleoptera					3, 4, 5
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Carabidae			2, 3
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae			2,4 ,5, 6, 7, 8, 9, 10, 14, 17
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Agabus*		2
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Rhantus*		2, 4, 5, 8, 10, 17
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Cybister*		1, 2, 3, 4, 5, 6, 7, 8, 9
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Dytiscus*		4, 5
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Hydaticus*		2
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Hydroporus*		2, 7

Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Gyrinidae		
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Haliplidae	*Haliplus*	2, 5, 8, 12, 13
Hexapoda	Insecta	Pterygota	Coleoptera	Polyphaga	Chrysomelidae		1, 2, 4, 5, 8, 9, 16
Hexapoda	Insecta	Pterygota	Coleoptera	Polyphaga	Curculionidae		8
Hexapoda	Insecta	Pterygota	Coleoptera	Polyphaga	Hydrophilidae		1, 2, 3, 5, 7, 8, 9, 12, 13, 14
Hexapoda	Insecta	Pterygota	Coleoptera	Polyphaga	Scirtidae		9
Hexapoda	Insecta	Pterygota	Coleoptera	Polyphaga	Staphylinidae		2, 4, 7, 9, 13, 16
Hexapoda	Insecta	Pterygota	Diptera			*A*	12, 16, 17
Hexapoda	Insecta	Pterygota	Diptera			*B*	13, 16, 17
Hexapoda	Insecta	Pterygota	Diptera		Hydroptilidae	*Oxyethira*	1, 4, 6, 7, 12, 13, 16
Hexapoda	Insecta	Pterygota	Diptera	Brachycera			4, 5, 7, 8, 16
Hexapoda	Insecta	Pterygota	Diptera	Brachycera	Dolichopodidae		6, 8, 14, 17
Hexapoda	Insecta	Pterygota	Diptera	Brachycera	Empididae		1, 5, 8
Hexapoda	Insecta	Pterygota	Diptera	Brachycera	Empididae	*Oreogeton*	8
Hexapoda	Insecta	Pterygota	Diptera	Brachycera	Muscidae		1, 12, 13, 17
Hexapoda	Insecta	Pterygota	Diptera	Brachycera	Sciomyzidae		1, 2, 3, 9, 10, 12, 16, 17
Hexapoda	Insecta	Pterygota	Diptera	Brachycera	Tabanidae		1, 6, 7, 8, 17
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Ceratopo-gonidae		1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 16, 17
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Chaoboridae	*Chaoborus*	2, 3, 6, 7, 8, 9, 11, 17
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Chironomidae		1, 2, 3, 4, 6, 7, 8, 10, 11, 13, 14, 16, 17, 19
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Orthocla-diinae		1
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Tanypodinae		1
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Culicidae		1, 5, 6, 7, 8, 9
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Dixidae	*Dixella*	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 16, 17
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Psychodidae	*Pericoma*	7, 14, 17
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Psychodidae	*Psychoda*	14
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Tipulidae	*Hexatoma*	7
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Tipulidae	*Helius*	14
Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Tipulidae	*Limonia*	10

Hexapoda	Insecta	Pterygota	Diptera	Nematocera	Tipulidae	*Tipula*	3, 8, 12
Hexapoda	Insecta	Pterygota	Epheme-roptera	Furcatergalia	Caenidae	*Caenis*	1, 4, 6, 7, 9, 10, 11, 12, 14, 16, 17, 19
Hexapoda	Insecta	Pterygota	Epheme-roptera	Furcatergalia	Leptophlebiidae	*Paraleptophlebia*	1, 4, 5
Hexapoda	Insecta	Pterygota	Epheme-roptera	Pisciforma	Baetidae	*Callibaetis*	1, 2, 4, 5, 6, 7, 8, 11, 13
Hexapoda	Insecta	Pterygota	Epheme-roptera	Pisciforma	Siphlonuridae	*Parameletus*	1, 2, 3, 4, 5, 6, 7, 8, 9
Hexapoda	Insecta	Pterygota	Hemiptera	Auchenor-rhyncha	Cicadellidae		1, 3, 6, 7, 8, 9, 12, 13, 19
Hexapoda	Insecta	Pterygota	Hemiptera	Heteroptera	Corixidae		2, 3, 5, 8, 9, 10, 12, 13, 19
Hexapoda	Insecta	Pterygota	Hemiptera	Heteroptera	Gerridae		1, 2, 4, 5, 6, 7, 8, 19
Hexapoda	Insecta	Pterygota	Hemiptera	Heteroptera	Macroveliidae		4, 6
Hexapoda	Insecta	Pterygota	Hemiptera	Heteroptera	Veliidae		3, 4, 5, 6, 7, 8, 9, 12, 13
Hexapoda	Insecta	Pterygota	Lepidoptera				1, 3, 7, 8, 9
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Aeshnidae		2, 5, 6, 7, 8, 9, 11, 13, 16, 17
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Aeshnidae	*Aeshna*	1, 3, 4, 5, 6, 7, 8, 11, 13
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Aeshnidae	*Anax*	1, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 17
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Libellulidae		1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Libellulidae	*Leucorrhinia*	1, 3, 4, 6, 7, 8, 9, 11, 13, 16
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Libellulidae	*Libellula*	4, 6, 7, 8, 10, 11, 13, 14, 16, 17
Hexapoda	Insecta	Pterygota	Odonata	Anisoptera	Libellulidae	*Sympetrum*	1, 11
Hexapoda	Insecta	Pterygota	Odonata	Zygoptera	Coenagrio-nidae	*Coenagrion/ Enallagma*	1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19
Hexapoda	Insecta	Pterygota	Odonata	Zygoptera	Lestidae	*Lestes*	1, 2, 3, 4, 5, 6, 7, 8
Hexapoda	Insecta	Pterygota	Plecoptera	Euholognatha	Capniidae		9
Hexapoda	Insecta	Pterygota	Plecoptera	Systellognatha	Chloroperlidae		9
Hexapoda	Insecta	Pterygota	Trichoptera		Brachycentridae	*Brachycentrus*	9

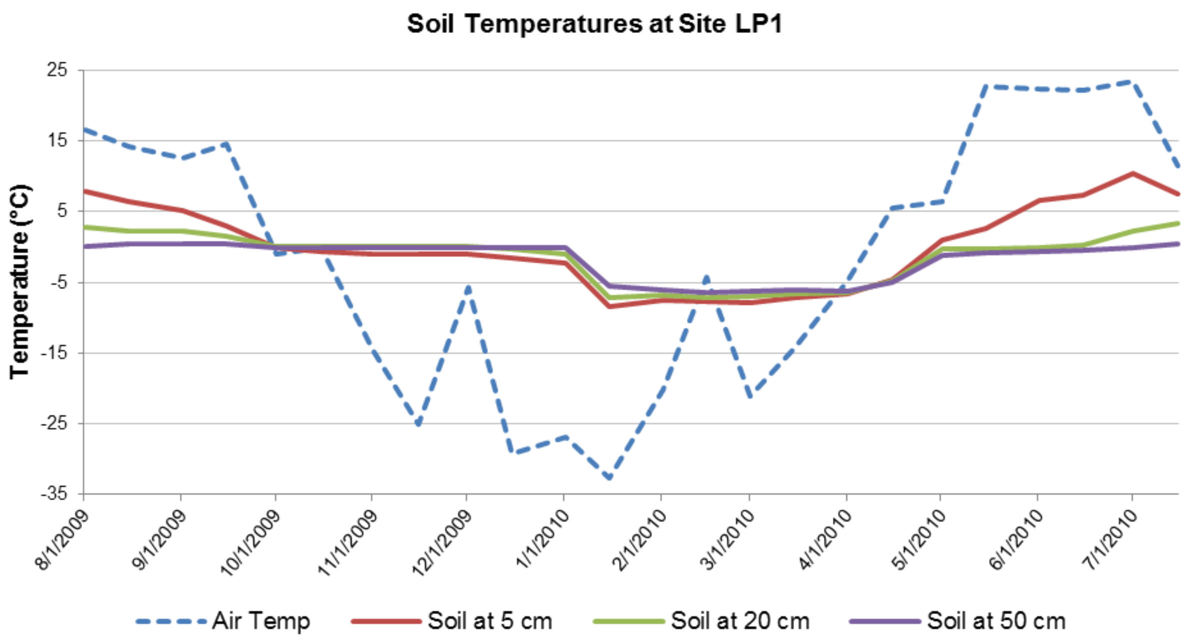
Hexapoda	Insecta	Pterygota	Trichoptera		Hydroptilidae	*Agraylea*		12
Hexapoda	Insecta	Pterygota	Trichoptera		Hydroptilidae	*Hydroptila*		10
Hexapoda	Insecta	Pterygota	Trichoptera		Leptoceridae			10, 19
Hexapoda	Insecta	Pterygota	Trichoptera		Leptoceridae	*Mystacides*		19
Hexapoda	Insecta	Pterygota	Trichoptera		Leptoceridae	*Oecetis*		1, 4, 10, 19
Hexapoda	Insecta	Pterygota	Trichoptera		Limnephilidae	*Psychoglypha*		1
Hexapoda	Insecta	Pterygota	Trichoptera		Limnephilidae	*Grammo-taulius*		2
Hexapoda	Insecta	Pterygota	Trichoptera		Limnephilidae	*Limnephilus*		9
Hexapoda	Insecta	Pterygota	Trichoptera		Limnephilidae	*Nemotaulius*		1, 5
Hexapoda	Insecta	Pterygota	Trichoptera		Phryganeidae			3, 4, 6, 8, 9, 10, 14, 16, 19
Hexapoda	Insecta	Pterygota	Trichoptera		Phryganeidae	*Banksiola*		4, 5, 6, 14
Hexapoda	Insecta	Pterygota	Trichoptera		Phryganeidae	*Phryganea*		5, 10, 19
Hexapoda	Insecta	Pterygota	Trichoptera		Polycentropodidae	*Neureclipsis*		1, 4, 5, 6, 8, 10, 11, 12, 14
Hexapoda	Insecta	Pterygota	Coleoptera	Adephaga	Dytiscidae	*Laccophilus*	*biguttatus*	2
Cnidaria	Hydrazoa		Anthoathe-catae	Capitata	Hydridae	*Hydra*		1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16
Mollusca								1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 19
	Bivalvia	Heterodonta	Veneroida		Pisidiidae			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 19
	Gastro-poda		Basommato-phora		Lymnaeidae	*Fossaria*		1, 2, 4, 5, 6, 7, 10, 12, 13, 14, 16
	Gastro-poda		Basommato-phora		Lymnaeidae	*Stagnicola*		1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, 16, 17, 19
	Gastro-poda		Basommato-phora		Physidae			1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 16, 17, 19

Mollusca					
	Gastropoda	Basommatophora	Planorbidae		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19
	Gastropoda	Heterostropha	Valvatidae	*Valvata*	1, 2, 5, 6, 7, 8, 10, 11, 12, 13, 14, 16, 17, 19
Nematoda					1, 2, 3, 4, 5, 6, 7, 8, 9, 14, 16, 17
Platyhelminthes	Turbellaria				5, 8

Permafrost

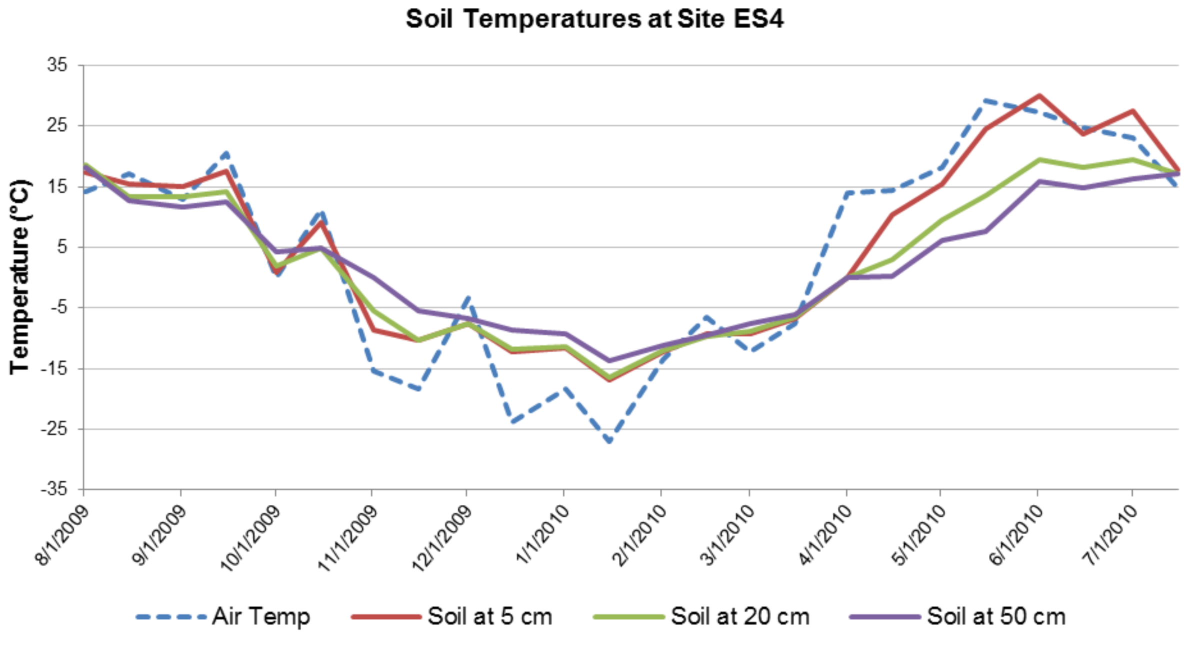
Appendix 12. NRCS soil temperature monitoring sites.

The FM1 data-logger is located on this island in the Yukon, near the end in the foreground of this photo (NRCS 2011a)



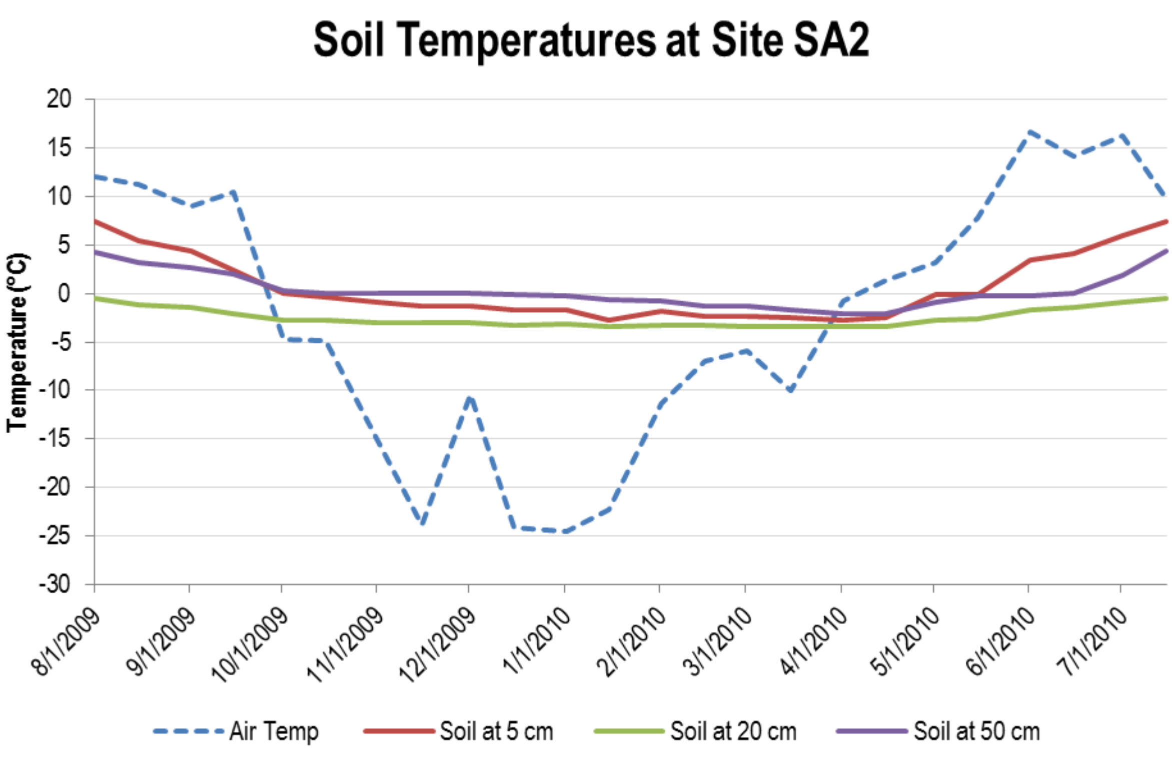
Soil temperatures at various depths in comparison to air temperature at noon at the mid-floodplain site in YUCH (NRCS 2011b).

The ES4 data-logger is located near the base of this bluff on the Yukon River (NRCS 2011a)



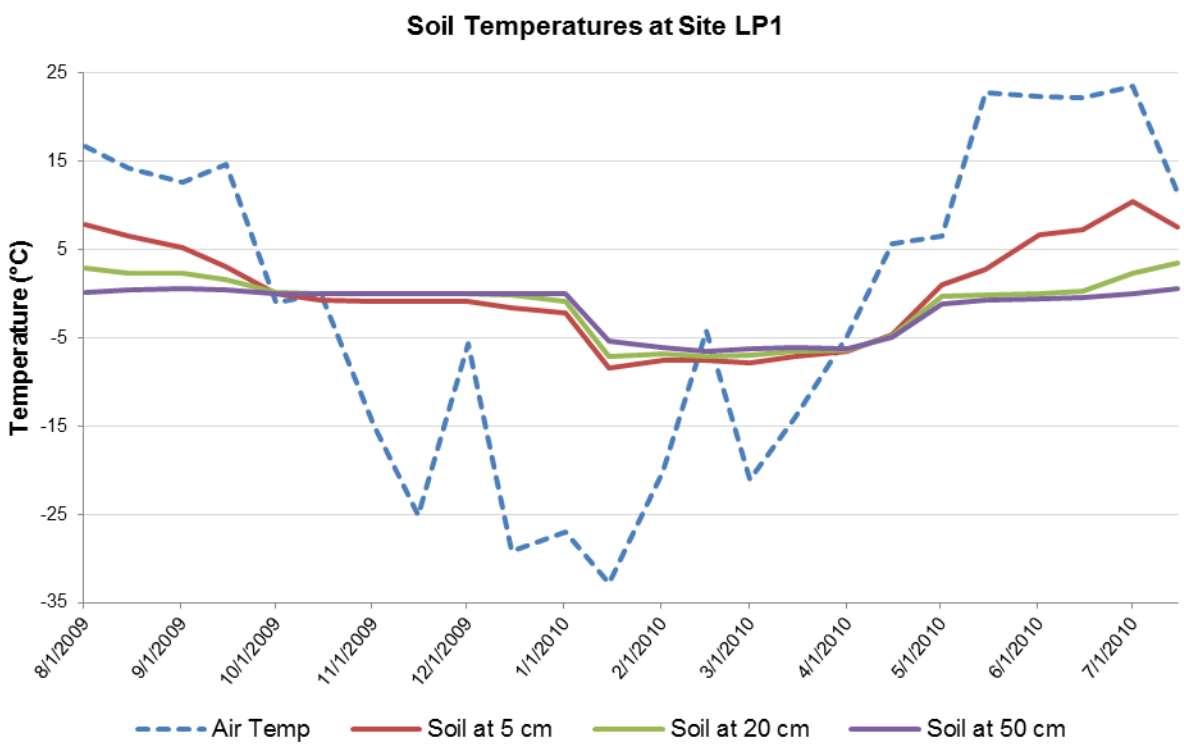
Soil temperatures at various depths in comparison to air temperature at noon at the aspen-graminoid site in YUCH (NRCS 2011b).

The SA2 data-logger is located near the center of this photo in the Three Fingers basin area (NRCS 2011a).



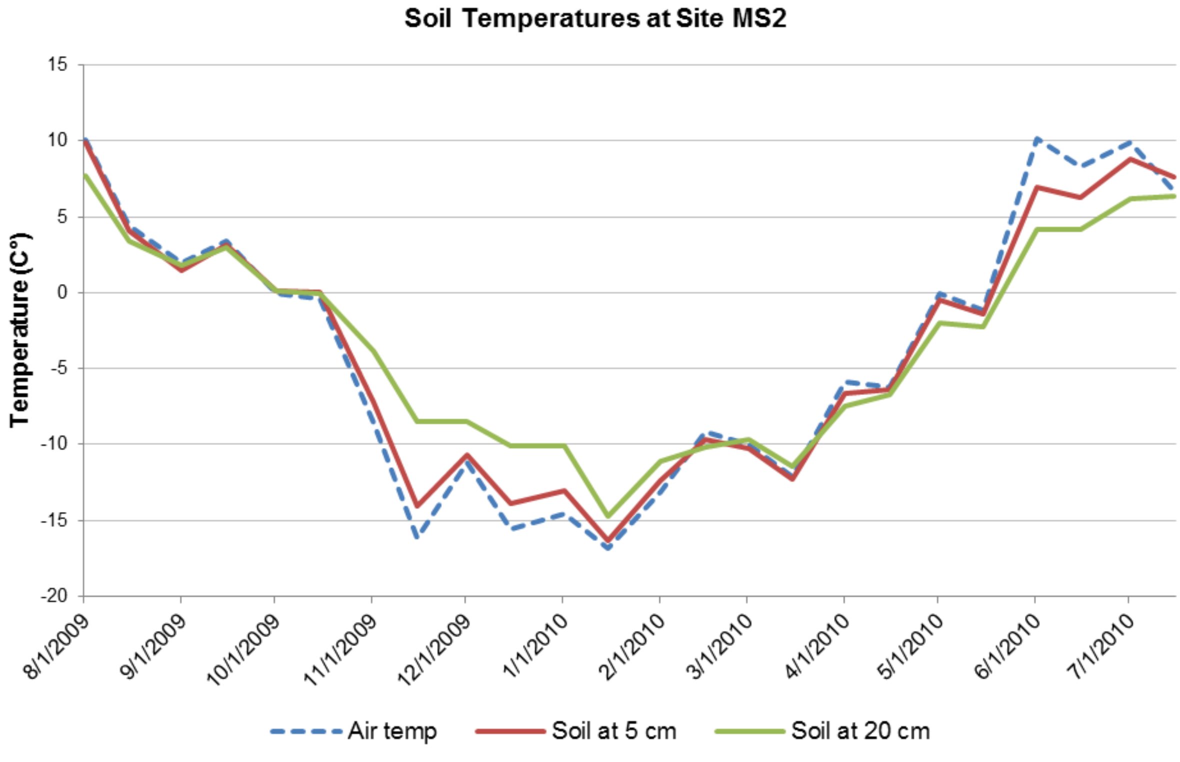
Soil temperatures at various depths in comparison to air temperature at noon at the Three Fingers subalpine site in YUCH (NRCS 2011b).

The LP1 data-logger is located near the bottom center of this photo in a black spruce forest (NRCS 2011a).



Soil temperatures at various depths in comparison to air temperature at noon at the mesic black spruce site in YUCH (NRCS 2011b).

The MS2 data-logger is located on the flat ridge near the center of this photo (NRCS 2011a).



Soil temperatures at various depths in comparison to air temperature at noon at the alpine graminoid site in YUCH (NRCS 2011b)

Fire

Appendix 13. Annualized burn area and individual fire burn area; inside of YUCH, fires within and overlapping YUCH boundaries, of whole fires associated with the North Ogilvie Mountains and Yukon-Tanana ecoregions (AICC fire perimeter data).

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	**Fire Name**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**
1947	70 Mile Falls					982.9	397.8
1950		111775.1	45234.0	111787.7	45239.1	1570190.1	635435.9
	Angel Creek - Chena Dome					2497.3	1010.6
	Boundary 40 mile #2					1222.0	494.5
	Charley River N	13801.4	5585.2	13814.0	5590.3	13814.0	5590.3
	Charley River S. #2	17954.7	7266.0	17954.7	7266.0	17954.7	7266.0
	Circle City Fire					42908.9	17364.7
	Coal Creek #2	23939.7	9688.1	23939.7	9688.1	23939.7	9688.1
	Columbia Creek					3124.0	1264.2
	Eagle #1					13134.8	5315.5
	Little Black River					1366723.6	553095.6
	Munson Creek					8987.3	3637.1
	Nation River #1	48853.5	19770.4	48853.5	19770.4	48853.5	19770.4
	Nation River #2					2273.1	919.9
	S.W. Butte					17531.3	7094.7
	Woodchopper Creek	7225.9	2924.2	7225.9	2924.2	7225.9	2924.2
1951						3922.6	1587.4
	Preacher Creek					2876.5	1164.1
	Read Fire					1046.1	423.3
1953						45993.7	18613.1
	Beaver Creek Fire					14058.7	5689.4
	Crazy Mountain					16706.2	6760.8
	Mile 53 Taylor Fire					15228.9	6162.9
1954		3042.2	1231.2	14160.3	5730.5	10772.2	4359.4
	Circle S.10	3042.2	1231.2	14160.3	5730.5		
	IN-ALASKA					10772.2	4359.4
1955						2798.8	1132.6
	Cache Mountain					2798.8	1132.6
1956						7358.7	2978.0
	Beaver Creek					7358.7	2978.0
1957		16229.1	6567.7	16229.1	6567.7	100247.0	40568.7
	Boundary Creek					1661.9	672.5
	Central W-10					49701.5	20113.6
	Nation River	4727.1	1913.0	4727.1	1913.0	4727.1	1913.0

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	Fire Name	Area (ac)	Area (ha)	Area (ac)	Area (ha)	Area (ac)	Area (ha)
	Sand Creek					899.3	363.9
	Upper Tatalina					43257.2	17505.6
	Woodchopper W-10	11502.0	4654.7	11502.0	4654.7		
1958						181638.1	73506.6
	Chena Domes-3					58294.2	23590.9
	Fairbanks Creek NE-7					23208.1	9392.0
	Fairplay W-5					2913.2	1178.9
	Far Mountain					41710.8	16879.8
	Globe Creek NW-5					5219.0	2112.1
	Goldstream #1					2965.5	1200.1
	Kandik					25261.6	10223.0
	Murphy Dome W-5					22065.7	8929.7
1959		3017.9	1221.8	3019.2	1221.8	20314.5	8221.0
	Colorado Creek					8095.6	3276.2
	Eilson #1					9199.7	3723.0
	NationNE-16	3017.9	1221.8	3019.2	1221.8	3019.2	1221.8
1966						962047.0	389328.2
	Canadian					334861.8	135514.3
	Cement Creek					334863.1	135514.5
	Gold Stream					6940.6	2808.8
	Missile					43843.0	17742.7
	Salcha Military					47777.4	19334.9
	West Fork					193762.0	78413.0
1967		22905.8	9269.7	25279.2	10230.2	48996.7	19828.3
	Anaconda Creek					1492.0	603.8
	Funnel Creek	2291.5	927.4	4664.9	1887.8	4664.9	1887.8
	Nation River	7045.1	2851.0	7045.1	2851.0	7045.1	2851.0
	Ridgeway					9014.0	3647.8
	Sand Cr					7783.2	3149.8
	Taylor Mt					5428.4	2196.8
	Wood Chopper	13569.2	5491.3	13569.2	5491.3	13569.2	5491.3
1968		5511.9	2230.6	5511.9	2230.6	43780.1	17717.2
	Central Creek					37026.3	14984.1
	Nation	5511.9	2230.6	5511.9	2230.6	5511.9	2230.6
	Redmond Creek					1241.9	502.6
1969		335472.2	135761.3	510624.5	206643.2	738959.5	299047.5
	Apples					307.6	124.5
	Bluff Ridge					14747.1	5968.0

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	**Fire Name**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**
	Butte Creek	309776.7	125362.7	469183.0	189872.4	469183.0	189872.4
	Calico Bluff	9912.6	4011.5	25658.6	10383.7	25658.6	10383.7
	Dome Road					247.7	100.2
	King Creek					4617.6	1868.7
	Ladue River					89885.4	36375.4
	Montauk Bluff	15782.9	6387.2	15782.9	6387.2	15782.9	6387.2
	Ninety Eight					49142.9	19887.5
	White Creek					69386.9	28080.0
1971		13910.7	5629.5	29259.7	11841.0	43043.6	17419.2
	Cabin	6473.7	2619.8	6473.7	2619.8	6473.7	2619.8
	Kan	7436.9	3009.6	22785.9	9221.2	22785.9	9221.2
	Wickersham Dome					13783.9	5578.2
1972						1224.3	495.5
	Eureka Creek					1224.3	495.5
1974						1993.1	806.6
	Albert Creek					1993.1	806.6
1975						7252.8	2935.1
	Alps					7252.8	2935.1
1976						5728.6	2318.3
	Eil NE 20					5728.6	2318.3
1977		9534.3	3858.4	9672.4	3914.3	1519.1	614.8
	CEM E 20	9534.3	3858.4	9672.4	3914.3		
	Sam Trout					1519.1	614.8
1980						3668.6	1484.6
	FAI E 35					3668.6	1484.6
1981						17670.8	7151.1
	Aggie Creek					13281.2	5374.7
	Hard Luck					1776.4	718.9
	Monopoly Creek					2613.2	1057.5
1983						28526.6	11544.4
	Munson Creek					21677.7	8772.7
	Rosie Creek					6848.9	2771.6
1984						5568.4	2253.5
	Glacier Creek					2521.8	1020.6
	Tract 12					3046.6	1232.9
1985						1234.1	499.4
	531004					1234.1	499.4
1986		33523.8	13566.7	44749.1	18109.4	80737.5	32673.4

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	Fire Name	Area (ac)	Area (ha)	Area (ac)	Area (ha)	Area (ac)	Area (ha)
	60 Mile					1262.1	510.8
	Blueberry					10279.1	4159.8
	Caribou					3491.5	1413.0
	CHP ENE 34	33523.8	13566.7	44749.1	18109.4	44749.1	18109.4
	Dennison					1078.8	436.6
	Porcupine					13641.4	5520.5
	Rapid Creek					4587.8	1856.6
	West Fork					1647.7	666.8
1987						58895.7	23834.3
	732076					38570.9	15609.2
	CEM W 44					8774.5	3550.9
	Eielson					9184.9	3717.0
	FBK E 155					2365.3	957.2
1988						312728.5	126557.2
	832014					463.1	187.4
	832064					284465.4	115119.5
	832093					27196.3	11006.0
	832184					277.7	112.4
	CEM NE 80					326.0	131.9
1989		99.4	40.2	99.4	40.2	99.4	40.2
	932011	99.4	40.2	99.4	40.2	99.4	40.2
1990		114.1	46.2	114.1	46.2	306294.7	123953.5
	032019					810.9	328.2
	032042					131906.3	53380.8
	60 Mile Butte					1085.4	439.2
	Cassier					3206.6	1297.7
	CEM E 90					2010.8	813.8
	CEM S 13					7375.2	2984.7
	CEM W 26					8610.6	3484.6
	EAA NW 20	114.1	46.2	114.1	46.2	114.1	46.2
	Frozen Foot					4183.2	1692.9
	Granite T					3472.5	1405.3
	Healy Lake					96.1	38.9
	Idaho Ck					1251.6	506.5
	Ladue River					4895.0	1980.9
	North Fork					1623.9	657.2
	Pedro Dome					1326.3	536.8
	Porcupine					11670.3	4722.8

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	Fire Name	Area (ac)	Area (ha)	Area (ac)	Area (ha)	Area (ac)	Area (ha)
	Salcha Tr					2175.0	880.2
	Shawnee					9839.2	3981.8
	Spitler					5883.4	2380.9
	Splits					269.3	109.0
	Teuchet #3					1214.3	491.4
	Tok River					103274.9	41793.9
1991		35298.5	14290.9	35313.4	14290.9	142369.8	57615.2
	132306					1352.9	547.5
	132339	35298.5	14290.9	35313.4	14290.9	35313.4	14290.9
	132407					4457.5	1803.9
	132416					264.1	106.9
	CEM E 55					37833.3	15310.7
	CEM NE 20					56431.1	22837.0
	Divide Mtn					205.8	83.3
	EAA N 47					2630.1	1064.4
	FAI E 26					565.6	228.9
	Scottie Mtn					2653.4	1073.8
	Third Pup					502.5	203.4
	Wicker					160.0	64.7
1992						46186.0	18690.9
	CEM NW 42					4519.6	1829.0
	CEM NW 45					4592.5	1858.5
	CEM SW 50					3447.8	1395.3
	CEM W 58					77.9	31.5
	Mansfield Lake					470.3	190.3
	Mansfield Mount					20.8	8.4
	Paradise					33057.3	13377.8
1993		17949.1	7266.8	17956.6	7266.8	38512.6	15585.5
	331568					2175.6	880.5
	331585					7651.7	3096.5
	332262					936.2	378.9
	Butte Cr					524.1	212.1
	CEME42	123.4	50.0	123.5	50.0	123.5	50.0
	CEMESE 35	29.5	11.9	29.5	11.9	29.5	11.9
	CEMSE34	17104.1	6924.7	17111.3	6924.7	17111.3	6924.7
	EAA NW 50					2259.4	914.4
	Frozen Foot					1097.5	444.1
	FYU E 100					155.7	63.0

Year	Fire Name	Fire perimeter inside YUCH [a] Area (ac)	Fire perimeter inside YUCH [a] Area (ha)	Whole Fire [b] Area (ac)	Whole Fire [b] Area (ha)	North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d] Area (ac)	North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d] Area (ha)
	Linney Bay Fire	692.1	280.2	692.4	280.2	692.4	280.2
	Porcupine					4650.3	1881.9
	T-Lake					234.9	95.1
	West Fork					870.4	352.2
1994		477.8	193.5	478.0	193.5	54139.9	21909.7
	431535					4576.8	1852.2
	60 Mi Butte					187.3	75.8
	Big Creek					290.3	117.5
	EAA N 31	210.3	85.1	210.3	85.1	210.3	85.1
	EAA SW 20					2806.4	1135.7
	EAA SW 37					1151.1	465.9
	EAA SW 42					935.0	378.4
	EAA W 56	267.6	108.3	267.7	108.3	267.7	108.3
	East Fork					349.7	141.5
	East Fork					237.4	96.1
	FBK NE 37					1014.3	410.5
	FYU E 76					31030.5	12557.7
	FYU SE 82					405.6	164.1
	Gardner Cr					8978.5	3633.5
	Ladue River					505.7	204.6
	Mt. Sheba					641.3	259.5
	Stone Boy Cr					409.7	165.8
	West Fork					142.3	57.6
1995						10658.5	4313.3
	532274					179.4	72.6
	Dennison Fork					1702.7	689.1
	FAI N 36					185.8	75.2
	Live 19					8590.6	3476.5
1996		11185.6	4526.7	77192.8	31239.0	41468.2	16781.7
	Circ Mountain	32.7	13.2	37532.9	15189.1		
	Crazy Mountains					116.3	47.0
	Fire Mountain					332.4	134.5
	Graveyard Creek 631360					11362.5	4598.3
	Hard Luck Creek	2316.7	937.5	2316.7	937.5	2316.7	937.5
	Kandik River					490.7	198.6
	Monkey Boy					1141.1	461.8
	Monkey Girl	8836.2	3575.9	37343.2	15112.3		
	O`Brien Creek					258.9	104.8

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	**Fire Name**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**
	Tetlin					6593.3	2668.2
	Vrain Mountain					151.9	61.5
	Windy Creek					9938.8	4022.1
	Yellow Creek					8765.6	3547.3
1997						28250.1	11432.5
	Bitters Creek					956.1	386.9
	Brigadier					974.9	394.5
	Butte Creek					3590.1	1452.9
	Camp Lake					1913.3	774.3
	East Fork					16352.3	6617.6
	Gardner Creek					605.1	244.9
	Gold Creek					903.1	365.5
	Lost Creek					482.3	195.2
	McCoy Creek					77.1	31.2
	Mid-Fork Chena					273.1	110.5
	Midway					343.9	139.2
	Preacher Cr.					311.1	125.9
	Shawnee Peak					1467.8	594.0
1998						11574.9	4684.2
	Eisemenger 1					33.7	13.6
	Forty Mile					438.7	177.6
	Little Black River					559.2	226.3
	Midway Lake					495.3	200.4
	Walker Fork					3316.4	1342.1
	West Fork					6731.6	2724.2
1999		121164.0	49033.5	160336.3	64886.1	649831.3	262978.5
	Bear Creek					5803.3	2348.5
	Beaver Creek					13208.0	5345.1
	Beverly	20753.2	8398.6	20753.2	8398.6	20753.2	8398.6
	Big Ol' Monster					23200.3	9388.9
	Birch					20186.8	8169.3
	Dennison/Taylor					6666.2	2697.7
	Engineer Hill					273.6	110.7
	Flume Creek					954.5	386.3
	Indian Grave					1734.0	701.7
	Jessica	49333.4	19964.6	49333.4	19964.6	49333.4	19964.6
	Kevinjik					232604.6	94132.1
	Kink					92000.1	37231.3

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	**Fire Name**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**
	Lower Ladue					53842.0	21789.1
	McArthur Creek					9209.1	3726.8
	McCoy Creek					5101.7	2064.6
	Montauk	360.5	145.9	360.5	145.9	360.5	145.9
	Mt. Terrel					11670.7	4723.0
	N. fork 40 Mile River					645.8	261.4
	Pingo	2972.6	1203.0	42110.5	17041.6	42110.5	17041.6
	Porphyry Creek					299.9	121.4
	Salmon Trout					2403.4	972.6
	Tetthajik					9420.5	3812.4
	Willow Creek					270.9	109.6
	Witch	47744.2	19321.5	47778.6	19335.4	47778.6	19335.4
2000		340.7	137.9	340.8	137.9	5667.1	2293.4
	Beaver Ck					1159.2	469.1
	Beaver Creek					3379.1	1367.5
	Hard Luck Creek	340.7	137.9	340.8	137.9	340.8	137.9
	Rock Ck					788.0	318.9
2001						620.9	251.3
	South Fork					620.9	251.3
2002						29005.1	11738.0
	Crazy					1596.6	646.1
	Ditch					338.0	136.8
	Globe					323.0	130.7
	Un Chena					4475.6	1811.2
	West Fork Chena					22271.9	9013.2
2003						55582.8	22493.7
	Albert Creek					1547.2	626.1
	Mardow Creek					336.9	136.3
	Molly Creek					2389.7	967.1
	Porcupine					1195.1	483.6
	Ptarmigan					204.8	82.9
	Sand Creek					49816.0	20159.9
	Teuchet					93.1	37.7
2004		169188.3	68468.4	372101.1	150584.6	3323253.0	1344878.1
	Aggie 2					3324.8	1345.5
	American Summit					11727.8	4746.1
	Anomaly					19667.2	7959.1
	Beaver Creek					148.7	60.2

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	**Fire Name**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**	**Area (ac)**	**Area (ha)**
	Big Bend					1572.0	636.2
	Billy Creek					463992.0	187771.7
	Black Shell Creek					273.3	110.6
	Blueberry					360.6	145.9
	Bolgen Creek					201893.5	81703.7
	Boundary					536523.8	217124.3
	Bullion Creek					15563.1	6298.2
	Camp Creek					179598.3	72681.2
	Champion Creek					15591.3	6309.6
	Chicken #1					320154.6	129562.5
	Crazy					52055.5	21066.2
	Dawson 31					7413.2	3000.0
	Deer Creek					103091.9	41720.0
	Edwards Creek	78369.3	31715.1	278114.9	112549.6	278114.9	112549.6
	Essie Creek	579.5	234.5	579.5	234.5	579.5	234.5
	Gardiner Creek					125739.1	50884.9
	Gold Creek					1993.9	806.9
	Indian Grave Creek					26609.8	10768.7
	Kandik River					65990.0	26705.3
	King Creek					40599.1	16429.9
	Lucky Creek					48231.3	19518.6
	Nation River	73213.2	29628.4	76380.4	30910.2	76380.4	30910.2
	Porcupine					284593.7	115171.2
	Rock Creek					41883.1	16949.6
	Runt Fork					24120.4	9761.2
	Tatalina					16025.3	6485.2
	T-Lake					1751.4	708.8
	Tors					30408.5	12305.9
	Upper Healy River					6036.5	2442.9
	Wall Street					89279.1	36130.1
	Wolf Creek					214867.9	86954.3
	Woodchopper Creek	14901.5	6030.4	14901.5	6030.4	14901.5	6030.4
	Yarger					71.9	29.1
	Yukon	2124.8	859.9	2124.8	859.9	2124.8	859.9
2005		25543.1	10337.0	79575.3	32203.1	691084.3	279673.0
	Beaver Creek					164731.8	66664.8
	Big Sitdown Creek					6969.2	2820.4
	Big Sitdown Creek 2					11621.4	4703.0

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	Fire Name	Area (ac)	Area (ha)	Area (ac)	Area (ha)	Area (ac)	Area (ha)
	Boundary Creek					131108.8	53058.1
	Butte Creek					285.0	115.3
	Change					11641.2	4711.1
	Charley Creek 1	19275.5	7800.6	73307.7	29666.7	73307.7	29666.7
	Fossil Creek					6382.3	2582.8
	Island Lake					1449.9	586.8
	Kandik River					154431.0	62496.2
	Lost Horse Creek					1866.6	755.4
	Mission Creek					33655.1	13619.8
	Munson Creek					821.3	332.4
	Preacher Creek					69429.6	28097.3
	Smith Creek					16976.1	6870.0
	Stone Boy					17.0	6.9
	Stuart Creek					122.8	49.7
	Trout Creek	6267.6	2536.4	6267.6	2536.4	6267.6	2536.4
2006						4587.9	1856.7
	9 Mile Trail					177.0	71.6
	Dennison					3132.2	1267.6
	Fairplay					1199.2	485.3
	Stuart Creek #4					33.1	13.4
	West Fork					46.4	18.8
2007		25207.2	10205.3	25217.8	10205.3	69147.6	27983.1
	Biederman Bluff	171.6	69.5	171.7	69.5	171.7	69.5
	Big Bend					2939.7	1189.7
	Charley River	2872.6	1163.0	2873.8	1163.0	2873.8	1163.0
	Ladue					19246.0	7788.6
	Nation River	2111.5	854.9	2112.4	854.9	2112.4	854.9
	Paldo					4605.4	1863.8
	Runt Creek					9807.2	3968.8
	Salmon Trout					295.7	119.7
	Stuart Creek 1					466.0	188.6
	Tinder Creek					512.0	207.2
	West Crazy					6057.8	2451.5
	Woodchopper 2	20051.4	8118.0	20059.9	8118.0	20059.9	8118.0
2008		621.9	251.8	622.2	251.8	3294.1	1333.1
	Dennison Fork					326.6	132.2
	Glenn Creek	621.9	251.8	622.2	251.8	622.2	251.8
	Rosa Creek					35.4	14.3

		Fire perimeter inside YUCH [a]		Whole Fire [b]		North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d]	
Year	Fire Name	Area (ac)	Area (ha)	Area (ac)	Area (ha)	Area (ac)	Area (ha)
	Stuart Creek 2					523.1	211.7
	Sullivan					1361.4	551.0
	Tindir Creek					425.5	172.2
2009		15735.4	6367.9	95904.4	38811.3	141609.3	57307.5
	Bluff Creek					41755.9	16898.1
	Hardluck Creek					12850.0	5200.2
	Healy River					47.3	19.2
	Jagged Ridge	200.7	81.2	53889.4	21808.4		
	Ladue River					23528.0	9521.5
	Mardow Creek					8753.8	3542.5
	Nation	272.0	110.1	272.0	110.1	272.0	110.1
	Old Man Fire					777.9	314.8
	Paddle	15262.7	6176.6	41743.0	16892.9	41743.0	16892.9
	Puzzle Gulch					2054.6	831.5
	Swamp Creek					6590.6	2667.1
	The Mine Fire					436.1	176.5
	Unknown					2800.3	1133.2
2010		5616.3	2272.8	5731.8	2319.6	90589.9	36660.6
	Big Swede					3934.5	1592.2
	Bull Creek					41911.1	16960.9
	Fryingpan Creek					2707.1	1095.5
	Gilles Creek					19442.7	7868.2
	Granite Tors					7886.4	3191.5
	Healy River					74.5	30.2
	Indian Grave Creek					2496.6	1010.4
	Judge Creek					1449.7	586.7
	Mid Moose Creek RX					203.9	82.5
	Red Fox					1.8	0.7
	Silvia Creek	354.7	143.5	354.7	143.5	354.7	143.5
	South Fork Chena					976.2	395.1
	South Fork Healy					2204.7	892.2
	Stuart Creek 1					1126.6	455.9
	Waterfall	1136.6	460.0	1252.1	506.7	1252.1	506.7
	Witch Mountain	1459.2	590.5	1459.2	590.5	1459.2	590.5
	YTA Fall RX pile burning					387.5	156.8
	YTA Grouse Habitat RX					54.7	22.1
	Yukon Slough	2665.8	1078.8	2665.8	1078.8	2665.8	1078.8
2011						88622.1	35864.2

Year	Fire Name	Fire perimeter inside YUCH [a] Area (ac)	Area (ha)	Whole Fire [b] Area (ac)	Area (ha)	North Ogilvie Mtns & Yukon-Tanana Ecoregions [c,d] Area (ac)	Area (ha)
	Bear Creek					401.4	162.4
	Chena dome					139.3	56.4
	East Volkmar					58078.7	23503.7
	Harrington Cr.					3.9	1.6
	Hastings					23110.3	9352.5
	Montana Creek					42.1	17.1
	Moose Mountain					858.1	347.3
	Sourdough Creek					1187.9	480.7
	Stuart CreekRX					1532.4	620.2
	Tatalina River					3267.9	1322.5

a.) This area represents all fires spatially clipped to the boundaries of YUCH (i.e., fire only within the boundaries of YUCH).

b.) This area represents all fires that are within or overlap the boundaries of YUCH.

c.) These two were chosen to represent regional fire trends, as they comprise nearly 90% of the area of YUCH.

d.) Fire data representing the ecoregions or fires that overlap the boundaries of YUCH do not include fires that extend into Canada.

Appendix 14. Start dates, end dates, and duration for individual fires and fire seasons in YUCH from 1950 to 2010 (NPS 2011b).

Fire year	Fire name	Start date	End date[a]	Duration of individual fire	Length of fire season (days)[b]
1950	CHARLEY RV	7/24/1950	10/22/1950	90	128
	CHARLIE1&2	7/24/1950	09/22/1950	60	
	COAL CK #2	7/24/1950	09/22/1950	60	
	COAL/WOODC	6/16/1950	07/24/1950	38	
	KANDIK/CHA	7/21/1950	09/22/1950	63	
1957	ALDER CRK	6/19/1957	07/04/1957	15	104
	MILLER N-5	6/18/1957	06/21/1957	3	
	MILLER S5	6/19/1957	06/20/1957	1	
	NATION RIV	6/18/1957	06/22/1957	4	
	UP NATIONR	6/18/1957	06/22/1957	4	
	WOODCHOPPE	8/8/1957	09/30/1957	53	
1958	HARDLUCK C	6/3/1958	10/10/1958	129	129
	WOODCHOPPE	6/9/1958	06/18/1958	9	
1959	CHARLEY RI	7/20/1959	7/20/1959	0	26
	COAL CK N5	6/25/1959	06/26/1959	1	
	COAL CREEK	6/25/1959	06/26/1959	1	
	NATON NE16	6/24/1959	07/08/1959	14	
1960	NATION 6	6/26/1960	06/28/1960	2	2
1967	BUTTE CR	6/13/1967	06/13/1967	0	32
	ETTRAIN	6/16/1967	06/16/1967	0	
	FUNNEL CR	6/17/1967	06/17/1967	0	
	HARD LUCK	6/15/1967	06/15/1967	0	
	LOGAN CR	6/14/1967	06/14/1967	0	
	MCARTHUR	7/15/1967	07/15/1967	0	
	MILLERS CA	6/14/1967	06/14/1967	0	
	MONTAUK CR	6/15/1967	06/15/1967	0	
	NAME SAKE	6/16/1967	06/16/1967	0	
	NATION RIV	6/16/1967	06/16/1967	0	
	PINTO	6/14/1967	06/14/1967	0	
	TROUT CR	6/16/1967	06/16/1967	0	
	TWIN MT	6/18/1967	06/18/1967	0	
	WOOD CHOPP	6/18/1967	06/18/1967	0	
1968	BEATOH PUM	6/5/1968	06/05/1968	0	10
	BLUFF	6/15/1968	06/15/1968	0	
	MOUNTAIN	6/15/1968	06/15/1968	0	
	NATION	6/13/1968	06/13/1968	0	
	TWIN	6/15/1968	06/15/1968	0	
1969	BUTTE CK	6/10/1969	07/31/1969	51	51

Fire year	Fire name	Start date	End date[a]	Duration of individual fire	Length of fire season (days)[b]
	CALICO BLF	6/22/1969	07/31/1969	39	
	MONTAUK BL	6/23/1969	07/31/1969	38	
	WOODCHOPPE	6/17/1969	06/21/1969	4	
1970	JOSEPH	7/3/1970	07/03/1970	0	48
	SHEEP CK	5/16/1970	05/27/1970	11	
	TROUT CK	5/18/1970	05/22/1970	4	
1971	CABIN	6/21/1971	07/19/1971	28	33
	HARDLUCK	6/22/1971	06/26/1971	4	
	TATOMDUK	6/19/1971	06/19/1971	0	
	WATERFALL	6/21/1971	06/21/1971	0	
	WEBBER CK	6/16/1971	06/17/1971	1	
	WINDFLL MT	6/23/1971	06/25/1971	2	
1972	NATION REE	7/14/1972	07/15/1972	1	3
	TROUT CRK	7/12/1972	07/15/1972	3	
1973	NATION RIV	5/26/1973	05/28/1973	2	98
	NIMROD PEA	7/9/1973	09/01/1973	54	
1974	BASQUE	6/24/1974	06/27/1974	3	4
	SKATE	6/24/1974	06/25/1974	1	
	SLUG	6/23/1974	06/25/1974	2	
1975	CIRCL E45	7/13/1975	07/13/1975	0	42
	NATION	7/23/1975	07/28/1975	5	
	NUGGET	7/10/1975	07/13/1975	3	
	PINGO	7/12/1975	07/14/1975	2	
	TROUT CR	6/16/1975	06/18/1975	2	
	WATERFALL	7/12/1975	07/13/1975	1	
1976	CATHEDRAL	7/13/1976	07/14/1976	1	29
	CIR 20 SE	7/7/1976	07/07/1976	0	
	CIRCLE 20E	7/18/1976	07/18/1976	0	
	MONTAUK	8/3/1976	08/05/1976	2	
1977	CEM E 20	7/29/1977	09/21/1977	54	75
	NATION 2	7/8/1977	07/20/1977	12	
	SLY CREEK	7/16/1977	07/16/1977	0	
	TROUT CK	7/17/1977	07/19/1977	2	
1979	N YUKON120	6/3/1979	06/08/1979	5	5
1980	CEM E 60	6/28/1980	06/29/1980	1	65
	EAA NNW 40	6/29/1980	06/30/1980	1	
	EAA NNW 41	6/29/1980	06/30/1980	1	
	EAA NW 25	6/28/1980	06/30/1980	2	
	EAA NW 31	6/28/1980	06/28/1980	0	
	TROUT CR	5/5/1980	07/09/1980	65	

Fire year	Fire name	Start date	End date[a]	Duration of individual fire	Length of fire season (days)[b]
1982	CEM E 40	7/8/1982	07/12/1982	4	18
	CEM E 47	7/8/1982	07/10/1982	2	
	CEM SE 39	6/24/1982	06/30/1982	6	
	FYU SE 97	7/7/1982	07/10/1982	3	
1983	CHP SE 35	6/26/1983	06/27/1983	1	47
	EAA N 16	7/2/1983	07/04/1983	2	
	EAA NW 20	6/2/1983	06/04/1983	2	
	EAA NW 22	7/4/1983	07/19/1983	15	
	EAA NW 30	6/26/1983	06/27/1983	1	
	EAA NW 37	7/2/1983	07/11/1983	9	
	EAA NW 40	6/23/1983	06/23/1983	0	
	EAA W 59	7/7/1983	07/14/1983	7	
	FYU SE 90	7/7/1983	07/11/1983	4	
1984	CEMSE001	5/22/1984	05/29/1984	7	7
	CEMSE002	5/22/1984	05/23/1984	1	
1985	CEM SE 50	6/5/1985	06/10/1985	5	5
	CEM SE 65	6/5/1985	06/05/1985	0	
	EAA N 18	8/7/1985	08/10/1985	3	
1986	BEN CREEK	6/20/1986	06/22/1986	2	128
	CEM A 168	7/2/1986	07/05/1986	3	
	CEM SE 82	5/25/1986	05/30/1986	5	
	EAA NW 11	7/2/1986	07/05/1986	3	
	EUREKA CK	6/29/1986	09/30/1986	93	
	TUNDRA	6/29/1986	07/02/1986	3	
1987	FBK E 117	6/23/1987	06/27/1987	4	4
1988	CEM SE 55	6/12/1988	06/15/1988	3	37
	EAA NW 20	7/4/1988	07/19/1988	15	
1989	932011	7/9/1989	08/01/1989	23	64
	CEM E 52	7/12/1989	07/25/1989	13	
	CEM NE 27	7/9/1989	07/10/1989	1	
	EAA NW 17	9/9/1989	09/11/1989	2	
1990	EAA NW 20	7/5/1990	08/28/1990	54	54
1991	132339	6/21/1991	09/27/1991	98	98
1992	CEM E 35	7/20/1992	09/17/1992	59	89
	CEM E 60	6/20/1992	07/07/1992	17	
1993	CEM E 32	7/30/1993	09/10/1993	42	87
	CEM E 42	6/16/1993	09/09/1993	85	
	CEM ESE	6/23/1993	09/10/1993	79	
	CEM SE 34	6/15/1993	09/10/1993	87	
	CEM SE 40	7/1/1993	07/12/1993	11	

Fire year	Fire name	Start date	End date[a]	Duration of individual fire	Length of fire season (days)[b]
	CEM SE 43	6/16/1993	06/29/1993	13	
	EAA NW 21	7/17/1993	08/26/1993	40	
	EAA NW 36	7/1/1993	09/10/1993	71	
	EAA NW 40	7/1/1993	07/12/1993	11	
	EAA NW 45	6/30/1993	07/12/1993	12	
1994	EAA N 31	8/5/1994	09/13/1994	39	97
	EAA NW 54	7/13/1994	07/19/1994	6	
	EAA W 56	6/8/1994	06/30/1994	22	
1995	CEM E 47	5/15/1995	05/16/1995	1	42
	EAA NW 16	6/14/1995	06/26/1995	12	
1996	GODGE CREE	7/27/1996	08/06/1996	10	74
	HARDLUCK	6/17/1996	08/30/1996	74	
1998	MONTAUK	6/30/1998	07/27/1998	27	27
1999	BEVERLY	6/12/1999	09/27/1999	107	108
	CHARLEY R	6/11/1999	06/18/1999	7	
	JESSICA	6/13/1999	09/09/1999	88	
	JOSEPH	7/17/1999	07/21/1999	4	
	MONTAUK	7/21/1999	07/21/1999	0	
	WITCH	6/12/1999	09/27/1999	107	
2000	FOX	6/7/2000	07/07/2000	30	89
	HARD LUCK	6/12/2000	07/06/2000	24	
	WITCH B242	4/19/2000	07/17/2000	89	
2001	WINDFALL M	6/26/2001	07/09/2001	13	13
2004	DEWEY CRK	7/14/2004	07/19/2004	5	126
	ESSIE CK	6/30/2004	09/30/2004	92	
	NATION RIV	6/15/2004	10/19/2004	126	
	WOODCHOPPE	6/26/2004	10/19/2004	115	
	YUKON	6/26/2004	10/19/2004	115	
2005	HOSFORD CR	6/17/2005	06/28/2005	11	105
	TROUT CREE	6/13/2005	09/26/2005	105	
2007	BIEDERMAN BLUFF	7/5/2007	08/11/2007	37	100
	CHARLEY RIVER	7/4/2007	09/14/2007	72	
	COAL CREEK	6/6/2007	06/22/2007	16	
	EUREKA CREEK	6/21/2007	07/07/2007	16	
	HOYT CREEK	6/6/2007	06/22/2007	16	
	NATION RIVER	6/25/2007	08/11/2007	47	
	WITCH MOUNTAIN	7/10/2007	07/16/2007	6	
	WOODCHOPPER 1	6/6/2007	07/11/2007	35	
	WOODCHOPPER 2	6/6/2007	09/14/2007	100	
2008	2008 PILE BURNS	9/22/2008	09/25/2008	3	111

Fire year	Fire name	Start date	End date[a]	Duration of individual fire	Length of fire season (days)[b]
	GLENN CREEK	6/6/2008	07/07/2008	31	
	MONTAUK BLUFF	6/26/2008	06/27/2008	1	
	PADDLE CREEK	7/10/2008	07/16/2008	6	
	PASS CREEK	6/16/2008	06/26/2008	10	
2009	NATION	7/4/2009	07/15/2009	11	100
	PADDLE	7/23/2009	09/28/2009	67	
	TACOMA BREAKS	7/29/2009	09/03/2009	36	
	WEBBER CREEK	6/20/2009	06/25/2009	5	
2010	SILVIA CREEK	6/7/2010	06/14/2010	7	21
	WATERFALL	6/3/2010	06/14/2010	11	
	WITCH MOUNTAIN	6/2/2010	06/23/2010	21	
	YUKON SLOUGH	6/2/2010	06/22/2010	20	

Not all end dates are accurate; sometimes when the end date is unknown the end of the fiscal year is used.

Length of fire season was calculated by taking the earliest start date of the year and subtracting it from the latest end date of each year.

Appendix 15. YUCH individual fire burn severity classification (MTBS 2011).

Year	Name	Unburned to Low Severity	Low Severity	Moderate Severity	High Severity	Increased Greenness	Nodata/Non-Processing Mask
1986	Eureka						
Ac		2,730	9,212	4,178	15,213	228	1,044
Ha		1,105	3,728	1,691	6,156	92	422
% composition		8.4	28.3	12.8	46.7	0.7	3.2
1991	132339						
Ac		8,414	14,188	10,649	1,235	1,225	891
Ha		3,405	5,742	4,309	500	496	361
% composition		23.0	38.8	29.1	3.4	3.3	2.4
1993	CEMSE34						
Ac		4,075	4,002	7,009	4,950	10	240
Ha		1,649	1,620	2,837	2,003	4	97
% composition		20.1	19.7	34.6	24.4	0.1	1.2
1999	Witch						
Ac		9,316	14,174	9,158	15,044	NA	134
Ha		3,770	5,736	3,706	6,088	NA	54
% composition		19.5	29.6	19.1	31.5	NA	0.3
1999	Beverly						
Ac		5,045	4,944	6,529	4,039	264	113
Ha		2,042	2,001	2,642	1,634	107	46
% composition		24.1	23.6	31.2	19.3	1.3	0.5
1999	Jessica						
Ac		2,297	15,591	23,072	9,074	197	1,153
Ha		929.43	6309.63	9337.05	3672.27	79.65	466.56
% composition		4.5	30.3	44.9	17.7	0.4	2.2
1999	Pingo						
Ac		687.6	628.5	738.6	908.7	53.2	NA
Ha		278.3	254.3	298.9	367.7	21.5	NA
% composition		22.8	20.8	24.5	30.1	1.8	NA
2004	Nation River						
Ac		5,775	13,545	32,999	11,998	11	12,755
Ha		2,337	5,482	13,354	4,856	5	5,162
% composition		7.5	17.6	42.8	15.6	0.0	16.5
2004	Edwards Creek						
Ac		10,517	23,357	26,332	3,508	109	17,189
Ha		4,256	9,452	10,656	1,420	44	6,956
% composition		13.0	28.8	32.5	4.3	0.1	21.2

Year	Name	Unburned to Low Severity	Low Severity	Moderate Severity	High Severity	Increased Greenness	Nodata/Non-Processing Mask
2004	Wood-chopper						
Ac		1,736	3,985	6,043	804	25	2,980
Ha		703	1,613	2,446	326	10	1,206
% composition		11.1	25.6	38.8	5.2	0.2	19.1
2005	Charley C1						
Ac		2,558	3,197	7,457	6,693	47	13
Ha		1,035	1,294	3,019	2,710	19	5
% composition		12.8	16.0	37.4	33.5	0.2	0.1
2005	Trout Creek						
Ac		1225	1656	2936	1217	1	NA
Ha		496	670	1189	493	1	NA
% composition		17.4	23.5	41.7	17.3	0.0	NA
2007	Charley River						
Ac		514	649	1186	599	23	266
Ha		208	263	480	242	10	108
% composition		15.9	20.0	36.6	18.5	0.7	8.2

Note: The thresholds on which the different categories of severity are assigned vary from fire to fire based on the interpretation from the MTBS analyst. The MTBS metadata contains the threshold categories used for each fire and have similar threshold values.

Fortymile Caribou Herd

Appendix 16. Estimated size of the Fortymile Caribou Herd since 1920 (Valkenburg et al. 1994).

Year	Month of Survey	# of Caribou Counted	Estimate of Herd Size	Estimated density caribou/km^2	Source
1920	October	13,200	568,000	2.6	Murie 1935
1950			6,500 [a]		Scott et al. 1950
1950			20,000+ [b]		Skoog 1956
1953	June	63,600	46,000 [c,d]	0.5	Skoog1956
1956	June	30,000	45,000 [d]		Olson1957
1958	June		40,000		Olson 1959
1960	June		50,000 [d]		Jones 1962
1962	June		50,000 [d]		Jones 1963
1963	September	26,000	50,000		Skoog 1964
1969	June	8-10,000	20,000 [d]		LeResche 1975
1970	October	<6,000	<15000 [e]		Jennings 1971
1971	October		10-12,000		Jennings 1973
1972	October	10,000	15,000		Jennings 1973
1973	June	3,200 [f,g]	5,312 [d]		Davis et al. 1978
1974	June	2,587 [g]	4,041 [d]		Davis et al. 1978
1975	June	5,429 [g]	3,982 [d]	.1-.2	Davis et al. 1978
1975	June		5,740-8,610 [h]		Valkenburg and Davis 1989
1981	June	7,914	10,093 [i]		Valkenburg and Davis 1989
1983	June	12,350	12,350		Valkenburg and Davis 1989
1984	June	13,402	13,402		Valkenburg and Davis 1989
1986	June	15,303	15,303		Valkenburg and Davis 1989
1988	June	19,975	19,975		Valkenburg and Davis 1989
1990	June	22,766	22,766	0.5	ADF&G files

a - Based on superficial surveys, b - Based on modeling backward from the 1953 estimate. c - Skoog's original estimate was 58,820 based on an assumed 1:1 September-October sex ratio. This estimate was adjusted based on a more realistic ratio of 50 bulls: 100 cows. d - October population estimate extra.
e - No basis given for extrapolation. f - Aerial photos were lost, and the actual number of caribou counted was not recorded. The 3,200 figure represents the estimated number of adult females present in June. g - Adults only. h - June estimate based on reanalysis of 1973-1975 estimates. i- From 1981 to 1990, census estimates include only the total of caribou photographed or counted during the census. However, in 1981 there was confusion over one large group that was found one day after the census. It may or may not have been included in the 7,914 originally counted.

Appendix 17. Fall Fortymile Caribou Herd statistics from 1953-2008*.

Date	Bulls: 100 cows	Yrlgs:100 cows	Calves: 100 cows	Yrlg % in herd	No. yrlg	Calf % in herd	No. calves	Cow % in herd	No. cows	Small bull %	Small bulls	Med bull %	Medbulls	Large bull %	Large bulls	Bull % in herd	Total bulls	n
11/1/53	0	0	0	0	0	29	66	0	0	0	0	0	0	0	0	0	0	228
10/1/54	78	0	64	0	0	26	50	41	78	0	0	0	0	0	0	32	61	189
10/1/55	0	0	0	0	0	16	268	0	0	0	0	0	0	0	0	0	0	1,659
10/1/56	0	0	0	0	0	5	34	0	0	0	0	0	0	0	0	0	0	737
10/1/57	0	0	0	0	0	5	26	0	0	0	0	0	0	0	0	0	0	576
8/1/58	0	0	0	0	0	31	40	0	0	0	0	0	0	0	0	0	0	127
10/1/59	0	0	0	0	0	36	45	0	0	0	0	0	0	0	0	0	0	124
10/1/61	75	30	45	12	133	18	200	40	444	0	0	0	0	0	0	30	333	1,110
10/11/62	0	0	0	0	0	11	85	0	0	0	0	0	0	0	0	0	0	743
10/1/72	30	16	21	10	66	12	84	60	400	0	0	0	0	0	0	18	122	672
9/20/74	32	6	20	4	35	12	108	63	553	0	0	0	0	0	0	20	176	872
9/21/74	35	9	21	5	46	13	110	61	525	0	0	0	0	0	0	21	185	866
9/1/74	33	8	20	5	81	13	218	62	1078	0	0	0	0	0	0	21	361	1,738
9/23/76	42	11	34	6	54	18	164	53	476	0	0	0	0	0	0	23	202	896
9/27/77	53	14	45	7	75	21	245	47	543	0	0	0	0	0	0	25	287	1,150
10/19/78	39	14	26	8	59	15	109	56	417	0	0	0	0	0	0	22	163	748
10/15/80	109	53	61	0	0	23	222	37	364	24	96	51	200	25	100	40	396	982
9/26/81	52	0	31	0	0	17	171	54	547	0	0	0	0	0	0	28	286	1,004
9/29/82	54	41	27	0	0	15	241	55	901	38	185	30	143	32	155	30	483	1,625
9/20/83	44	40	30	0	0	17	166	58	560	46	113	0	0	54	134	25	247	973
10/7/83	61	33	36	0	0	18	180	51	498	27	81	34	104	39	117	31	302	980
10/16/85	50	39	36	0	0	19	208	54	574	39	111	23	65	38	109	27	285	1,067
10/13/86	36	25	28	0	0	17	235	61	842	35	106	24	73	41	125	22	304	1,381

9/28/87	40	11	37	0	0	21	475	57	1,274	13	67	43	215	44	222	22	504	2,253
10/3/88	38	22	30	0	0	18	229	59	770	29	86	41	121	30	89	23	296	1,295
10/13/89	27	18	24	12	216	16	283	66	1,182	34	108	41	130	25	78	18	316	1,781
9/28/90	44	37	29	21	374	17	295	58	1,002	42	187	39	172	19	86	26	445	1,742
10/10/91	39	32	16	21	298	10	149	64	931	41	149	34	123	26	93	25	365	1,445
9/26/92	48	36	30	20	516	17	422	56	1,416	37	258	36	246	27	188	27	692	2,530
10/3/93	46	44	29	25	922	17	601	57	2,095	48	461	36	343	17	159	26	963	3,659
9/30/94	44	38	27	22	646	16	562	57	1,710	45	323	33	236	22	158	24	717	2,990
9/28/95	43	37	32	21	700	18	609	57	1,879	43	350	31	249	27	216	25	815	3,303
9/29/96	41	38	36	21	980	20	931	57	2,601	46	490	31	331	23	245	23	1066	4,582
9/30/97	46	44	41	24	1,468	22	1,346	53	3,313	48	734	28	432	24	371	25	1537	6,196
9/29/98	40	39	38	22	950	21	915	56	2,433	49	475	27	267	24	232	23	974	4,322
9/29/99	48	53	37	29	1,240	20	857	54	2,347	55	620	29	331	16	181	26	1132	4,336
10/1/00	45	43	27	25	1,632	16	1,029	58	3,780	48	816	28	475	24	412	26	1703	6,512
9/29/01	49	43	38	23	1,574	20	1,399	53	3,658	44	787	32	590	24	445	27	1821	6,878
9/28/02	43	35	39	20	1,194	21	1,295	55	3,347	42	597	28	407	30	434	24	1438	6,080
9/27/03	50	51	17	30	1,918	10	328	60	3,777	51	959	29	541	21	391	30	1891	6,296
9/28/04	45	29	28	16	786	16	724	59	2,254	31	393	37	434	32	352	25	1179	4,157
10/5/05	51	25	18	15	350	10	246	59	1,391	25	175	23	166	52	372	30	713	2,350
10/5/06	43	23	34	13	646	19	961	57	2,839	27	323	29	341	44	530	24	1195	4,995
10/4/07	36	24	37	14	737	22	1,111	58	3,031	34	368	34	346	33	372	21	1086	5,228
10/8/08	37	23	33	13	474	19	695	59	2,164	30	242	43	346	27	219	22	786	4,119

* Years 53-59, 61 & 62, 72, 74, 76, 77&78, 80-83, and 85-02 (Gardner 2002), 03-08 (Gross 2008).

Appendix 18. Proportion of calves in the Fortymile Caribou Herd, 1953-1960 (Valkenburg et al. 1994).

	Late May-Early June		Mid to Late June		Sep.-Oct.			April	
Cohort birth year	**Calf:100 cow**	**n**	**Calf:100 cow**	**n**	**Calf:100 cow**	**% Calves**	**n**	**Calf:100 cow**	**n**
1953	73	0	0	0	0	29	228	21	1,359
1954	73	23,910	0	0	64	26	189	16	684
1955	65	508	0	0	0	16	1,659	14	1,286
1956	54	14,206	0	0	0	5	737	3	1,120
1957	38	1,436	0	0	0	5	576	3	458
1958	62	16,446	0	0	0	31	127	19	857
1959	58	2,061	0	0	0	36	450	37	652
1960	78	7,650	0	0	56	36	901	44	349
1961	74	8,178	0	0	45	18	1,110	0	0
1962	27	1,352	0	0	0	19	1,462	0	0
1963	0	0	0	0	20	16	0	0	0
1972	0	0	0	0	21	13	484	0	0
1973	57	0	0	0	16	11	2,292	0	0
1974	53	1,990	24	1,424	0	13	0	0	0
1975	64	0	18	0	0	0	0	0	0
1976	0	0	0	0	35	16	640	0	0
1977	0	0	39	2,252	45	21	788	0	0
1978	0	0	35	479	26	15	516	0	0
1980	0	0	41	1,930	61	25	586	0	0
1981	0	0	31	2,528	31	17	718	0	0
1982	0	0	0	0	27	15	1,142	29	304
1983	35	2,840	38	1,020	33	18	1,404	27	960
1984	73	2,550	45	3,052	0	0	0	32	783
1985	0	0	48	3,388	36	19	782	40	533
1986	0	0	0	0	28	17	1,077	0	0
1987	0	0	47	2,743	37	21	1,749	0	0
1988	0	0	36	1,285	30	18	999	0	0
1989	0	0	0	0	24	16	1,465	0	0
1990	0	0	0	0	29	17	1,297	0	0

Appendix 19. Alaska harvest quota allocation for Fortymile Caribou.

Area	**Regulatory Year**			
	2001-2002	**2002-2003**	**2003-2004**	**2004-2005**
Steese/Chena Hot Springs Area (35%)	230	250	230	230
Taylor Highway Area (50%)	320	355	320	320
Salcha-Goodpaster Roadless Area (15%)	90	105	90	90
Fall Hunt Total Quota	**640**	**710**	**640**	**640**
Steese/Chena Hot Springs Area	N/A [a]	95	125 (181)[b]	125(181)[b]
Taylor Highway Area	N/A [a]	145	85 (121)[b]	85 (135)[b]
Winter Hunt Quota	**210**	**240**	**210 (302)[b]**	**210 (335)[b]**
Total Quota	**850**	**950**	**850**	**850**
Actual Harvest	693	864	800	840
Number of Permits Issued	4537	4,156	5,718	412[c]

a - The winter quota was not allocated by area until regulatory year 2002-2003.

b - This number is the remaining unfilled quota, which equals the winter quota allocation plus the unfilled portion of the fall quota.

c - The 3 fall registration permits were combined into one permit so hunters were not issued multiple permits to hunt Fortymile caribou in different places during the fall period.

Wolves

Appendix 20. Unit 20E wolf harvest, regulatory years 1990-1991 through 2004-2005 (Gross 2006).

	Reported Harvest						Method of take				Successful	
Regulatory year	M	%	F	%	Total[a]	% Autumn population[b]	Trap or snare (%)	Shot (%)	SDA[c,d] (%)	UNK	Trappers, hunters and wolf control permittees	Wolves/person
1990-1991	15	63	9	37	24	10	12	52	6	1	13	1.8
1991-1992	13	68	6	32	19	11	14	77	3	1	10	1.9
1992-1993	28	49	28	49	57	28	52	95	0	2	21	2.7
1993-1994	34	57	26	43	68	32	55	90	0	7	21	3.2
1994-1995	24	63	14	37	39	20	29	74	2	0	16	2.4
1995-1996	37	51	39	49	84	37	80	95	1	0	18	4.6
1996-1997	24	44	23	43	54	24	48	89	0	0	15	3.6
1997-1998	16	44	20	56	36[e]	16	32	91	0	0	10	3.5
1998-1999	9	53	6	35	17	8	12	71	0	0	9	1.9
1999-2000	18	58	11	35	31	_[f]	27	96	0	3	21	1.5
2000-2001	27	54	20	40	50	_[f]	44	88	0	0	12	4.2
2001-2002	20	63	11	34	32	_[f]	29	91	0	0	10	3.2
2002-2003	15	56	12	44	28	11[g]	23	85	0	1	14	2
2003-2004	22	55	18	45	40	16[g]	34	85	0	0	17	2.4
2004-2005	58	57	44	43	105	37[g]	28	27	58	0	33	3.2

[a] Total harvest includes animals of undetermined sex
[b] Proportion of the estimated fall population harvested by the end of the season in April. If a range was given for the fall estimate, the proportion taken is given as the harvest divided by the mean estimate.
[c] Same-day-airborne (SDA) taking prohibited during regulatory years 1997-2003.
[d] SDA wolf control was allowed in regulatory year 2004-2005 within the upper Yukon-Tanana wolf control area, in the southern portion of the unit, by permittees only.
[e] One wolf was accidentally killed during a capture operation; it was only included in the total take.
[f] Population was not estimated, therefore percent autumn population was not calculated.
[g] Midpoint population estimate used in calculation.

Appendix 21. Units 20B & 25C wolf harvest, regulatory years 2000-2001 through 2004-2005 (Young 2006).

		Reported Harvest[a]						Method of take[b]							Successful	
Unit	**Regulatory year**	**M**	**F**	**F(%)**	**UNK**	**Total**	**3-year mean**	**Trap**	**%**	**Snare**	**%**	**Shot**	**%**	**UNK**	**Trappers/hunters**	**Wolves/person**
20B	2000-2001	48	48	50	3	99	80	35	35	48	48	16	16	0	47	2.1
	2001-2002	37	45	55	8	90	85	39	44	44	49	6	7	1	34	2.6
	2002-2003	42	28	40	3	73	87	13	18	48	66	12	16	0	34	2.1
	2003-2004	39	40	51	1	80	81	16	20	55	69	9	11	0	32	2.5
	2004-2005	21	32	60	0	55	69	17	32	26	49	10	19	0	30	1.8
25C	2000-2001	5	4	44	0	9	7	4	44	3	33	2	22	0	4	2.3
	2001-2002	1	3	75	7	11	9	0	0	8	73	3	27	0	5	2.2
	2002-2003	10	10	50	0	20	13	9	45	6	30	5	25	0	10	2
	2003-2004	4	5	56	0	9	13	0	0	6	67	3	33	0	7	1.3
	2004-2005	7	11	61	0	18	16	8	44	9	50	1	6	0	9	2

[a] Unknown sex not used to calculate harvest percent.

[b] "Unknown" method of take not used to calculate harvest percent.

Appendix 22. Unit 25B & 25D wolf harvest, regulatory years 1996-1997 through 2004-2005 (Stephenson 2006).

		Reported Harvest				Method of take		
Unit	**Regulatory year**	**M**	**F**	**UNK**	**Total**	**Trap/Snare**	**Shot**	**UNK**
25B	1996-1997	5	5	0	10	9	1	1
	1997-1998	8	9	0	17	17	0	0
	1998-1999	5	2	1	8	7	1	1
	1999-2000	11	7	1	19	18	0	0
	2000-2001	3	5	0	8	7	1	1
	2001-2002	3	5	0	8	7	1	1
	2002-2003	2	3	0	5	5	0	0
	2003-2004	5	2	0	7	7	0	0
	2004-2005[a]	0	0	0	0	0	0	0
25D	1996-1997	12	6	1	19	16	3	0
	1997-1998	8	1	1	10	6	4	0
	1998-1999	1	1	2	4	3	1	0
	1999-2000	4	2	1	7	6	0	1
	2000-2001	6	2	3	11	9	1	1
	2001-2002	4	13	2	19	18	1	0
	2002-2003	9	4	0	13	9	4	0
	2003-2004	13	12	3	28	23	5	0
	2004-2005	17	11	4	32	26	4	2

a - No harvest reported.

Appendix 23. Unit 20D wolf harvest, regulatory years 1985-1986 through 2004-2005 (DuBois 2006).

	Reported Harvest			Estimated harvest		Method of take				
Regulatory year	**M**	**F**	**UNK**	**Unreported**	**Illegal**	**Trap/Snare**	**Shot**	**SDA[a]**	**UNK**	**Total**
1985-1986	17	10	1	0	0	19	0	9	0	28
1986-1987	11	7	0	0	0	18	0	0	0	18
1987-1988	5	7	0	0	0	11	1	0	0	12
1988-1989	5	12	4	0	0	20	1	0	0	21
1989-1990	2	4	0	0	0	4	2	0	0	6
1990-1991	8	13	2	0	0	6	4	13	0	23
1991-1992	4	3	2	0	0	3	5	1	0	9
1992-1993	8	9	5	0	0	16	6	0	0	22
1993-1994	17	27	4	0	0	37	10	0	1	48
1994-1995	16	9	0	0	0	24	1	0	0	25
1995-1996	16	24	1	0	0	39	1	0	1	41
1996-1997	17	10	1	0	0	22	6	0	0	28[b]
1997-1998	22	15	4	0	0	37	3	0	1	41[c]
1998-1999	14	9	2	0	0	24	1	0	0	25[d]
1999-2000	19	19	4	0	0	34	8	0	0	42
2000-2001	21	16	4	0	0	33	8	0	0	41
2001-2002	17	22	1	0	0	49	1	0	0	50
2002-2003	16	8	1	0	0	18	6	0	1	25
2003-2004	20	14	0	0	0	30	4	0	0	34
2004-2005	10	18	1	0	0	20	6	0	3	29

[a] SDA refers to animals taken by hunters the same day hunters were airborne.

[b] An additional 4 wolves were relocated from northern Unit 20D to another area.

[c] An additional 6 wolves were relocated from northern Unit 20D to another area.

[d] An additional wolf was relocated from northern Unit 20D to another area.

Appendix 24. Unit 20D wolf population estimates for RY00-RY04 (Dubois 2006).

Area	Regulatory Year (1 Jul- 30 Jun)				
	2000-2001	**2001-2002**	**2002-2003**	**2003-2004**	**2004-2005**
Southern Unit 20D [a,b]	44-47	46-52	47-57	56-59	43-45
Northern Unit 20D[c]	42-44	45	52-56	n/a	48-52
Unit 20D subtotal	86-91	91-97	99-113	n/a	91-97
Estimate 10% single wolves	9	9-10	9-11	n/a	9-10
Unit 20 Total	95-100	100-107	108-124	n/a	100-107
Estimated wolves/1000 mi^2	16.9-17.7	17.7-18.9	19.2-22.0	n/a	17.7-18.9
Estimated wolves/1000km^2	6.5-6.9	6.9-7.3	7.4-8.5	n/a	6.9-7.3

[a] Includes a "pack equivalent" calculation for the 100-Mile Creek pack which overlaps eastern Unit 20A.

[b] Unit 20D south of the Tanana River.

[c] Unit 20D north of the Tanana River

Appendix 25. Rare plant taxa recorded in YUCH and the physiographic regions where they were found during the 2002 vascular plant inventory (Larsen et al. 2004). Species with no location information were collected prior to 2002. Table adapted from Table 5.2 in Larsen et al. (2004).

Species	Global Rank*	State Rank**	River Floodplain	Ogilvie Mountains	Yukon-Tanana Upland	Steppe Bluffs
Antennaria densifolia	G3	S1S2		x		
Campanula aurita	G3G4	S3	x			
Carex atratiformis	G5	S2				
Carex crawfordii	G5	S2S3	x			
Carex eburnea	G5	S2S3				
Carex holostoma	G4	S2			x	
Carex interior	G5	S1	x			
Carex lapponica	G4G5Q	S2			x	
Ceratophyllum demersum	G5	S2	x			
Cicuta bulbifera	G5	S1S2	x			
Corispermum ochotense	G3G4T2?Q	S3				
Cryptantha shackletteana	G1Q	S1				x
Cryptogramma stelleri	G5	S2S3			x	
Douglasia arctica	G3	S2S3		x		x
Douglasia gormanii	G3	S3		x	x	
Draba densifolia	G5	S1			x	
Draba murrayi	G2	S2		x	x	x
Draba ogilviensis	G2	S1		x		
Draba praealta	G5	S1S3				
Eriogonum flavum	G5t2	S2				x
Eriophorum viridi-carinatum	G5	S2				
Erysimum asperum var. *angustatum*	G5t2	S1S2				x
Festuca lenensis	G4	S3		x		x
Glyceria pulchella	G5	S2S3	x			
Lesquerella calderi	G3	S1S2		x		
Lycopus uniflorus	G5	S3	x			
Malaxis paludosa	G4	S2S3	x			
Minuartia biflora	G5	S2			x	
Minuartia yukonensis	G3G4	S3			x	x
Montia bostockii	G3	S3			x	
Myriophyllum verticillatum	G5	S3	x		x	
Najas flexilis	G5	S1S2	x			
Oxytropis huddelsonii	G3	S2S3			x	
Pedicularis macrodonta	G4Q	S3	x			
Phacelia mollis	G2	S2S3	x		x	
Phacelia sericea	G5	S2		x		x
Phlox hoodii	G5	S1S2				x
Poa porsildii	G3	S2		x	x	
Podistera yukonensis	G2	S1		x		x

Species	Global Rank*	State Rank**	River Floodplain	Ogilvie Mountains	Yukon-Tanana Upland	Steppe Bluffs
Potamogeton obtusifolius	G5	S1	x			
Ranunculus glacialis ssp. *chamissonis*	G4T3T4	S2			x	
Ranunculus turneri	G2G3Q	S1		x		
Salix candida	G5	S2S3	x			
Scheuchzeria palustris	G5T5	S3	x			
Smilacina stellata	G5	S2				x
Stellaria dicranoides	G3	S3		x	x	
Stellaria umbellata	G5	S2S3			x	
Tanacetum bipinnatum ssp. *huronense*	G5T4T5	S3	x			
Viola selkirkii	G5	S3		x		

*Species Global Ranks (Copyright 1998, University of Alaska Anchorage)
G1: Critically imperiled globally.
G2: Imperiled globally.
G3: Rare or uncommon globally.
G4: Apparently secure globally, but cause for long-term concern.
G5: Demonstrably secure globally.
G?: Unranked.
G#G#: Global rank of species uncertain, best described as a range between the two ranks.
G#Q: Taxonomically questionable.
G#T#: Global rank of species and global rank of the described variety or subspecies of the species.

**Species State Rankings (Copyright 1998, University of Alaska Anchorage)
S1: Critically imperiled in state.
S2: Imperiled in state.
S3: Rare or uncommon in state.
S4: Apparently secure in state, but with cause for long-term concern.
S5: Demonstrably secure in state.
S#S#: State rank of species uncertain, best described as a range between the two ranks.

Appendix 26. Alaska-Yukon endemic species recorded in YUCH and the physiographic regions where they were found during the 2002 inventory. Species with no location information were collected prior to 2002. Adapted from Table 5.3 in Larsen et al. (2004).

Species	River Floodplain	Ogilvie Mountains	Yukon-Tanana Uplands	Steppe Bluffs
Antennaria friesiana ssp. *alaskana*			x	
Antennaria monocephala ssp. *monocephala*			x	
Artemisia alaskana	x		x	
Astragalus williamsii	x			
Boykinia richardsonii		x	x	
Campanula aurita	x			
Carex microchaeta ssp. *microchaeta*				
Claytonia scammaniana			x	
Corydalis sempervirens				
Douglasia arctica		x		
Douglasia gormanii		x	x	
Draba murrayi		x	x	
Draba ogilviensis		x		
Draba palanderiana		x	x	
Dryas alaskensis		x	x	
Elymus alaskanus ssp. *alaskansus*				
Erigeron hyperboreus		x		
Erigeron yukonensis				
Eriogonum flavum var. *aquilinum*				x
Erysimum asperum var. *angutatum*				x
Montia bostockii			x	
Oxytropis huddelsonii			x	
Oxytropis scammaniana		x	x	
Papaver mcconnellii		x	x	
Papaver nudicaule	x	x	x	
Penstemon gormani				
Phacelia mollis	x		x	
Phacelia sericea		x		
Poa porsildii		x	x	
Podistera yukonensis				
Polygonum alaskanum		x	x	
Puccinellia interior			x	
Saxifraga reflexa		x	x	
Saxifraga spicata		x	x	
Senecio ogotorukensis		x		
Senecio yukonensis		x	x	
Silene williamsii			x	
Smelowskia borealis		x		
Synthyris borealis		x	x	

Appendix 27. Occurences of amphiberingean endemic taxa found within Yukon Charley Rivers National Preserve. Taxa with localities shown as "na" were collected prior to the 2002 field season and were not available in the Automated National Cataloging System (ANCS+) database. Reproduced from Larsen et al. (2004).

Species	River Floodplain	Ogilvie Mountains	Yukon-Tanana Uplands
Aconitum delphinifolium	x	x	x
Anemone multiceps			
Antennaria monocephala ssp. *monocephala*			
Arnica griscomii ssp*. frigida*		x	
Arnica lessingii		x	x
Astragalus umbellatus		x	x
Cardamine purpurea		x	x
Carex lugens			x
Carex microchaeta		x	
Carex microchaeta ssp. *nesophila*			
Castilleja caudata	x		x
Castilleja hyperborea		x	x
Chrysosplenium wrightii			x
Claytonia sarmentosa		x	x
Claytonia tuberosa		x	x
Cnidium cnidiifolium	x		x
Delphinium brachycentrum			x
Dodecatheon frigidum		x	x
Draba stenopetala			x
Elymus macrourus			x
Eritrichium aretoides		x	x
Festuca brevissima			x
Festuca lenensis		x	
Geum glaciale		x	
Lagotis glauca		x	x
Luzula rufescens			
Luzula tundricola			x
Minuartia elegans			
Minuartia yukonensis			x
Oxytropis borealis var. *borealis*		x	
Oxytropis campestris ssp. *jordalii*		x	
Oxytropis mertensiana			x
Papaver macounii		x	x
Phlox sibirica		x	
Podistera macounii		x	x

Species	River Floodplain	Ogilvie Mountains	Yukon-Tanana Uplands
Polygonum bistorta var. *plumosum*		x	
Potentilla biflora			
Primula eximia		x	x
Salix phlebophylla		x	x
Salix pulchra	x	x	x
Saxifraga calycina			x
Saxifraga davurica		x	x
Saxifraga eschscholtzii		x	
Saxifraga serpyllifolia			x
Selaginella sibirica		x	x
Senecio kjellmanii			x
Spiraea stevenii		x	x
Stellaria dicranoides		x	x
Taraxacum alaskanum		x	x
Taraxacum kamtschaticum			x
Wilhelmsia physodes	x		x

Water Quality

Appendix 28. Macroinvertebrate species composition of sampled lakes. Reproduced from O'Brien and Huggins (1976).

Taxonomic Classification	**Charley River**	**Dewey Creek**	**Drayhan Creek**	**Uncompahgre Creek**	**Flat Creek**	**Bonanza Creek**	**Yukon River**	**Sam Creek**
Class Oligochaeta			x			x		x
Class Crustacea								
Gammarus lacustris			x			x		
Class Insecta								
Order Plecoptera								
Alloperla sp.	X					x	x	x
Isoperla sp. A							x	
Isoperla sp.B							x	
Diura sp.							x	
Nemoura sp.		x	x	x	x			
Capnia		x						x
Order Ephemeroptera								
Siphlonorus sp. B	X					x	x	
Parameletus						x		
Baetis sp. A						x		x
Baetis sp. B								x
Cinygmula sp.								x
Siphloplecton sp.							x	
Ephemerella sp. A							x	
Ephemerella sp. B							x	
Order Odonata								
Aeshna eremita	X						x	
A. juncea	X						x	
A. interupta lineatea	X							
Order Trichoptera								
Arctopsyche sp.							x	
Psychoronia sp.	X							x
Drusinus sp.	X					x	x	x
Limnephilus sp.	X							
Brachycentrus sp.						x		x
Order Coleoptera								
Agabetes sp.						x		
Order Diptera								
Family Simuliidae		x				x		x
Family Chironomidae	X	x		x	x	x	x	x

Taxonomic Classification	Charley River	Dewey Creek	Drayhan Creek	Uncompahgre Creek	Flat Creek	Bonanza Creek	Yukon River	Sam Creek
Paradixa sp.						x		
Limnophora sp.				x		x		
Tipula (Arctotipula)	X		x					x

Hydrology

Appendix 29. Ice freeze-up and break-up on the Yukon River at Eagle by water year (1 Oct to 30 Sept, defined by the calendar year in which it ends) (unpublished data received from J. Borg 2011).

Water year	Freeze-up	Break-up	Duration (days)	Water year	Freeze-up	Break-up	Duration (days)	Water year	Freeze-up	Break-up	Duration (days)
1897	--	10-May	--	1922	20-Nov	15-May	189	1947	17-Nov	8-May	193
1898	--	16-May	--	1923	23-Nov	10-May	197	1948	21-Nov	13-May	191
1899	--	--	--	1924	18-Nov	3-May	198	1949	9-Dec	13-May	211
1900	8-Nov	8-May	176	1925	24-Nov	9-May	200	1950	16-Nov	10-May	190
1901	2-Nov	12-May	174	1926	29-Nov	28-Apr	215	1951	11-Dec	7-May	218
1902	13-Nov	15-May	182	1927	3-Dec	12-May	205	1952	--	18-May	--
1903	15-Nov	14-May	185	1928	25-Nov	--	--	1953	23-Nov	6-May	202
1904	19-Nov	6-May	196	1929	14-Nov	6-May	193	1954	9-Dec	16-May	207
1905	13-Nov	9-May	189	1930	29-Nov	11-May	202	1955	26-Nov	16-May	194
1906	14-Nov	9-May	189	1931	21-Oct	10-May	164	1956	4-Dec	6-May	211
1907	--	3-May	--	1932	--	--	--	1957	12-Nov	10-May	187
1908	14-Nov	7-May	190	1933	18-Nov	8-May	195	1958	--	15-May	--
1909	4-Nov	10-May	179	1934	--	--	--	1959	5-Dec	15-May	204
1910	29-Oct	10-May	172	1935	21-Nov	--	--	1960	14-Nov	2-May	195
1911	22-Nov	6-May	200	1936	--	--	--	1961	18-Nov	--	--
1912	8-Nov	3-May	188	1937	--	--	--	1962	--	--	--
1913	15-Nov	15-May	185	1938	--	13-May	--	1963	--	--	--
1914	16-Nov	10-May	190	1939	26-Nov	8-May	202	1964	--	--	--
1915	16-Nov	--	--	1940	16-Nov	25-Apr	204	1965	--	--	--
1916	27-Nov	--	--	1941	13-Nov	2-May	196	1966	--	--	--
1917	24-Nov	15-May	194	1942	10-Nov	7-May	187	1967	--	--	--
1918	28-Nov	11-May	201	1943	11-Nov	4-May	191	1968	--	8-May	--
1919	11-Nov	10-May	185	1944	8-Nov	4-May	187	1969	--	8-May	--
1920	28-Oct	18-May	162	1945	9-Dec	17-May	207	1970	--	8-May	--
1921	15-Nov	11-May	189	1946	--	8-May	--	1971	--	--	--

Water year	Freeze-up	Break-up	Duration (days)	Water year	Freeze-up	Break-up	Duration (days)
1972	--	11-May	--	2000	19-Nov	6-May	196
1973	--	8-May	--	2001	23-Nov	12-May	201
1974	--	12-May	--	2002	26-Nov	12-May	198
1975	21-Nov	9-May	196	2003	1-Jan	29-Apr	109
1976	5-Nov	2-May	186	2004	20-Nov	3-May	200
1977	8-Dec	5-May	218	2005	25-Nov	28-Apr	212
1978	15-Nov	7-May	192	2006	11-Nov	7-Apr	218
1979	18-Nov	2-May	200	2007	13-Nov	30-Apr	197
1980	11-Dec	3-May	221	2008	5-Dec	3-May	215
1981	30-Nov	7-May	208	2009	11-Nov	3-May	193
1982	8-Dec	14-May	208	2010	13-Nov	29-Apr	198
1983	14-Nov	2-May	196	2011	1-Dec	7-May	208
1984	28-Nov	10-May	201				
1985	12-Nov	15-May	182				
1986	31-Oct	11-May	173				
1987	21-Nov	9-May	196				
1988	30-Nov	1-May	212				
1989	12-Nov	29-Apr	198				
1990	12-Nov	27-Apr	199				
1991	12-Nov	28-Apr	198				
1992	19-Nov	11-May	191				
1993	20-Nov	29-Apr	206				
1994	27-Nov	27-Apr	214				
1995	20-Nov	28-Apr	206				
1996	9-Nov	8-May	184				
1997	15-Nov	4-May	196				
1998	28-Nov	29-Apr	213				
1999	21-Nov	11-May	194				

NPS 191/114573, June 2012

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA ™