KLUANE NATIONAL PARK

RESOURCE DESCRIPTION AND ANALYSIS[1]

VOLUME 1 OF 2

Natural Resource Conservation
Parks Canada, Prairie Region
Winnipeg, Manitoba

1985

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ST. ELIAS MOUNTAINS

"Viewed on a perfect day from Dawson Range, 100 miles or more to the northeast, St. Elias Mountains appear as a broad swelling on the horizon out of which giant peaks project like islands of ice and snow. When haze and smoke shroud the lower levels, these peaks, high in the crystal clear atmosphere above, are sometimes still to be seen, a line of magnificent icebergs floating on the denser air. These are the highest mountains of Canada, and together are the largest group of great peaks in North America. For Canada, at least, and perhaps for the world, they have unique characteristics, and possess a distinct grandeur of their own. Above a sea of lesser peaks and wide ice-fields the great peaks stand solitary or in compact, isolated groups. Besides their colossal size, this individual aloofness adds much to the impressiveness of their vast, wild, and icy beauty, and contrasts them sharply with the jumbled rivalry of summits and other mountains of the Canadian Cordillera. Many of these individual peaks and groups are block-like in form, rising on nearly every side with precipitous cliffs, not to pinnacle-like tops, but to broad, still steep, though relatively gentler, summit areas. This gives them an appearance of stupendous massiveness from all directions. Another outstanding feature is the mantle of snow and ice that even in summer cloaks a great part of them. It spreads unbroken over their gentler, summit areas, smoothing the contours of their upper slopes and concealing bedrock. As the slopes steepen downward, it overhangs the edges of precipices in great cliffs of ice from which it cascades in mighty avalanches thousands of feet to the broad fields of snow and ice below, where it feeds the glaciers that lead away from between the peaks. Almost the only exposures of rock in all the vast expanse of white and blue around the great peaks are in their precipices. Below these dazzling monarchs a sea of lesser peaks, mighty themselves in other company, from a jagged and rocky platform. Such is a general picture of the dominant features of these great mountains beside which the better known ranges of Canada are dwarfed to relative insignificance."

Bostock: 1948:92

The preparation of a Resource Description and Analysis for Kluane National Park was identified as a resource conservation objective in the Kluane Park Management Plan. It is an integral component of the Natural Resource Management Process and contains a description, analysis, and evaluation of the Park's natural and cultural resources. its purpose is to Collate and interpret resource inventory data and resource study results in a format readily used by park planners and managers and, by analysis and evaluation of capabilities and limitations, draw attention to resource management concerns related to the use and preservation of Kluane's resources. Completion of this document was part of a concerted effort to bring the Natural Resource Management Process in Kluane into phase in preparation for Management Plan review in 1985 and future Area Planning. The Park Conservation Plan was prepared concurrently and contains detailed descriptions of resource conservation problems, issues and concerns, their proposed solutions, and a schedule for implementation. It is see" as a companion document to the Resource Description and Analysis.

Kluane National Park is facing a time of extremely important planning and decision-making in the face of increasing visitor use, demand for developed Park facilities, and the consequent pressures on Kluane's wilderness resource and the Park's mandate for preservation. It is hoped that the Resource Description and Analysis will provide background information and clarify the resource-related issues for planning and management in the future.

La rédaction d'un document de description et d'analyse des ressources du parc national Kluane figurait dans le plan de gestion du parc au titre d'objectif de conservation des ressources. Ce document fait partie intégrante du processus de gestion des ressources naturelles et comporte une description, une analyse et une &valuation des ressources naturelles et culturelles du parc. Il vise à recueillir et à interpreter les données sur les ressources répertoriées et les résultats de l'étude des ressources sous une forme facilement utilisable par les planificateurs et les gestionnaires du parc. 11 permet en outre, par le biais de l'analyse et de l'évaluation des possibilités et des limites, de souligner les éléments de la gestion de ressources se rapportan: à l'utilisation et à la préservation des richesses du parc national Kluane. La rédaction du document en question s'inscrivait dans le cadre des efforts concertés pour lancer le processus de gestion des ressources naturelles du parc Kluane en vue de la révision du plan de gestion, en 1985, et de la future planification de la région. Le plan de conservation du parc, établi en même temps, décrit avec précision les problèmes, les questions et les préoccupations que soulève la conservation des ressources, les solutions envisagées et un calendricr de leur mise en oeuvre. 11 est considéré comme un complément de la description et de l'analyse des ressources.

Le parc national Kluane entre dans une période extrêmement importante de planification et de prise de décisions, en raison du nombre accru de visiteurs, de l'augmentation de la demande pour d'installations dans le parc, et des pressions qui s'ensuivent sur les ressources naturelles, et le mandat de préservation du parc Kluane. Nous espérons que le document de description et d'analyse des ressources fournira les renseignements de base et clarifiera les problèmes se rapportant aux ressources aux fins de la planification et de la gestion futures.

Many people in Parks Canada assisted the author in preparation of this document. Project coordination, guidance, and encouragement were provided at different times throughout the project by Jim Barlow, Bryan Lee, and Mel Falk. Their professional help was invaluable and I thank them also for coping with the additional administrative problems which arose with the author working from Calgary. Richard Leonard prepared guidelines for the wildlife section and provided helpful comment and discussion on that. chapter. The limnology and aquatic biology section was reviewed by Rolly wickstrom . Peter Priess and Margaret Burnip prepared the Cultural Resource:; chapter. Susan Plenert is responsible for the excellent drafting and cartography in the document and coordinated final production. Cindy Cyncora did a tremendous job of word processing and for. her dedication special thanks go to her. Thanks are due to Superintendent Jim Masyk for his advice and support end particularly to the Kluane Park Warden Staff who spent many hours on the project in various capacities. Their knowledge, committment to the Park, and enthusiasm were a tremendous contribution. Finally, I would like to thank Parks Canada for the opportunity of working on this project, arranged through an Executive Interchange Agreement between Parks and the Northern Pipeline Agency.

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Park Superintendent	1
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CHAPTER 1

Introduction

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

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1.1 Park Establishment

In recognition of the changes to the natural environment and pressures on wildlife populations likely to result from the building of the Alaska Highway, a Privy Council Order was passed in 1942 establishing a National Park Reserve of over 25000 square kilometres in the southwest Yukon to the west of the Alaska and Haines highways and to the south of the White River. In 1943, this area was designated the Kluane Game Sanctuary until such time as the schedule of the National Parks Act was amended to include and establish Kluane National Park.

In the ensuing 30 years, many attempts were made to formally establish the Park but these were blocked by mining interests. Mining claims were permitted under Game Sanctuary status but the National Parks Act stated that mineral extraction was not compatible with national park status. After considerable discussion, a compromise on boundaries was reached and on February 22, 1972 an Order-In-Council set aside over 22000 square kilometres of the larger Kluane Game Sanctuary as a national park reserve (see Figure 1.1). Official proclamation took place in 1976 and Kluane National Park Reserve is now administered under the National Parks Act. Throughout this document Kluane National Park and Kluane National Park Reserve are used synonymously. The reserve status reflects the possibility of adjustments to the Park boundaries as a result of the settlement of native land claims. While the Act recognizes traditional hunting, fishing and trapping activities in the Park by people of native origin, the regulations determining conditions of use will be developed in discussions related to the land claims. After designation of the Park area, negotiated purchases were undertaken which ultimately removed all mining claims from the Park. However, mining still continues under Territorial regulations in the Kluane Game Sanctuary.

The Park Reserve is a wilderness area representative of the Northern Coast Mountains Natural Region. The St. Elias Mountains, including Canada's highest peaks and the largest nonpolar icefields in the world, are the focus of the Park. Large valley glaciers, such as the Donjek, Lowell, and the Kaskawulsh flow out from the icefields, and are remnants of a once extensive ice sheet which carved and molded the Park landscape. Active geomorphic processes are still altering the landscape and have created a variety of ecological niches which support some of Canada's rarest and most interesting wildlife species - Dall's sheep, grizzly bears, raptors, and mountain goats.

The Park can be divided into two broad areas - the Icefields and the Greenbelt, as shown in Figure 1.2. The Icefields are remote and inaccessible, occupying the central ice-covered and alpine areas of the Park. The Greenbelt constitutes the fringes of this central area where valley glaciers descend to the vegetated lowlands. These areas contain most of Kluane's wildlife habitat

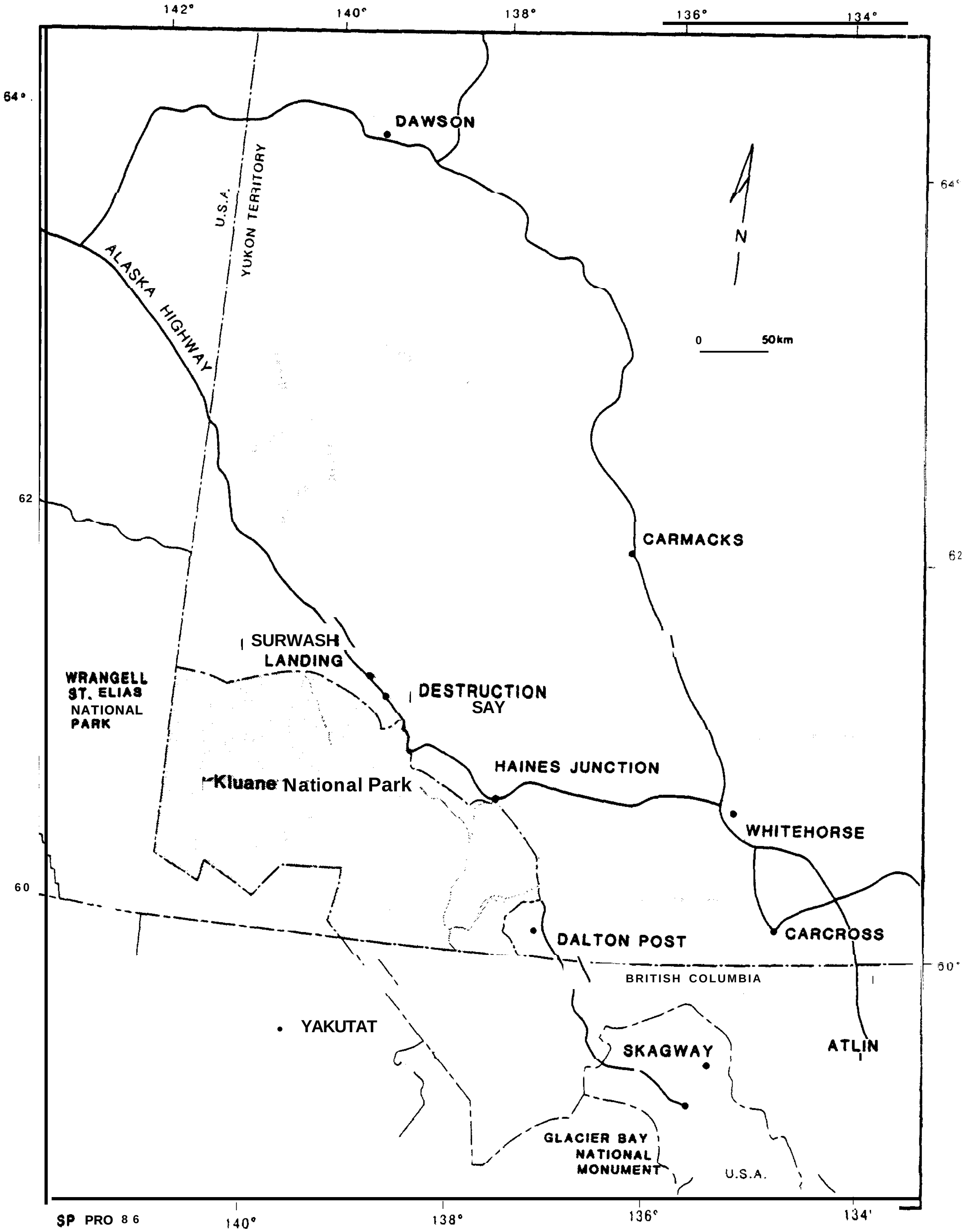

Figure. 1.1 The Kluane region, southwest Yukon.

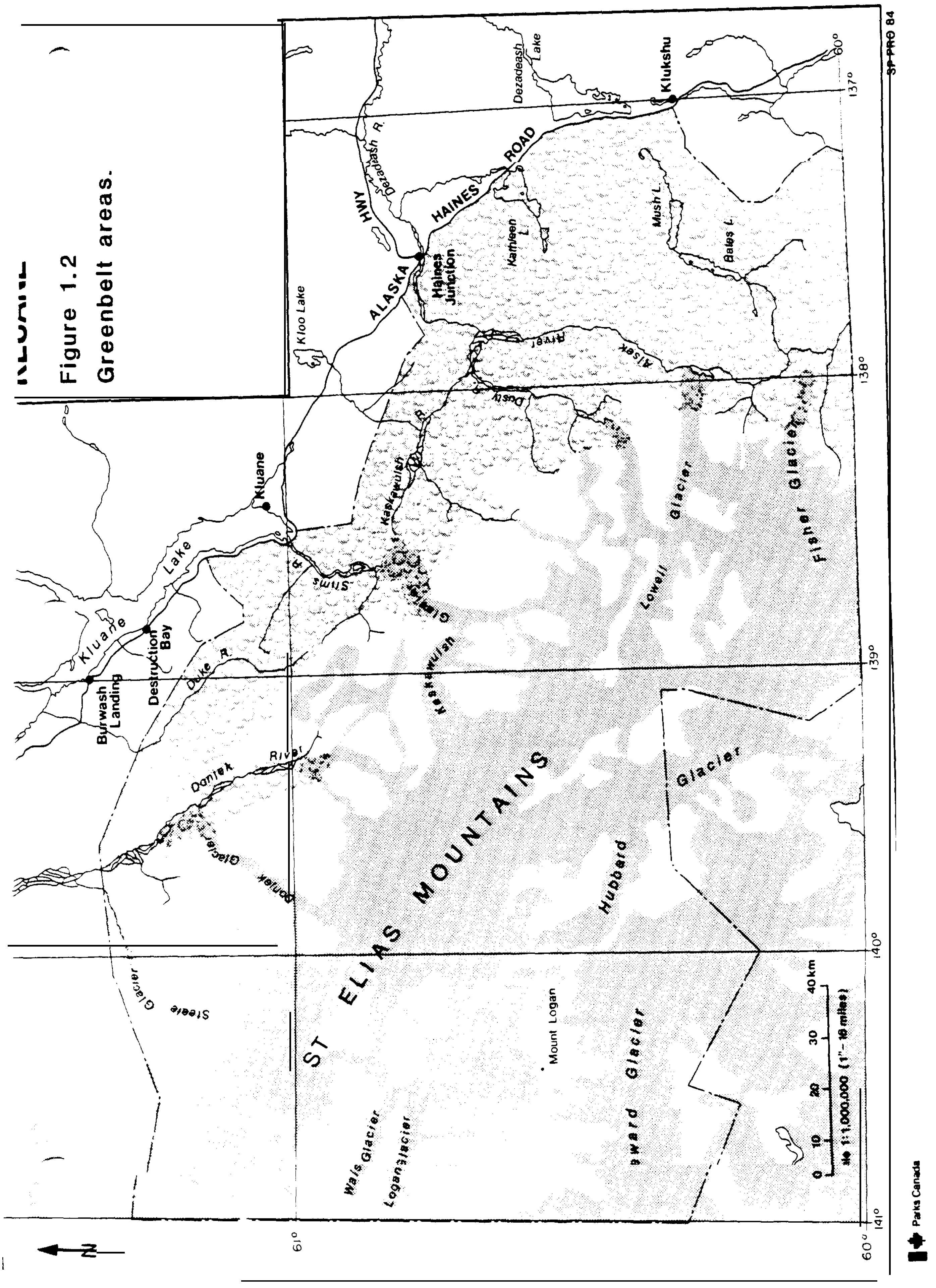

Figure 1.2
Greenbelt areas.

and its areas of greatest visitor access and use. The character of the Greenbelt changes quite markedly from north to south. In the slims-Donjek area, the climate is dry and harsh, permafrost occurs frequently, and the areas provide some of the best Dall's sheep habitat in Yukon. There has been relatively little human activity in this area in historical time and large parts of it are quite inaccessible and retain a true wilderness character. Southern areas of the Greenbelt have a warmer, moister climate, greater soil development, more lush forest and wetland vegetation, and a more diverse fauna. The Park's recreational facilities are concentrate3 in the south and access to interior areas is relatively easy.

The concepts of 'front country' and 'backcountry' provide further definition of the Greenbelt. Front country lies along the Alaska and Haines highways where visitor activity is concentrated with access directly from the highway. Access to 'backcountry' areas usually requires a long distance hike by the visitor from an access point *on* the highway. Backcountry areas **are** part of Kluane':, wilderness and no visitor facilities are provided other than rough trails from trailheads and a limited **number** of primitive campgrounds in areas where random camping would result in overuse of sensitive resources.

The very special nature of Kluane was recognized internationally in 1979 when the area was made a World Heritage Site by UNESCO confirming the Park, along with the adjoining Wrangell-St. Elias National Park *in* Alaska, as an outstanding wilderness area of global significance.

1.2 Natural Resource Management Process

Preparation of **a** Resource Description and Analysis is one step in the natural resource management process, as described in the <u>Natural Resource Management Process Manual - PRM 40-6</u> (Parks Canada 1979a). The manual presents **a** structured approach for the collection, analysis, synthesis, and evaluation of natural resource data and provides **a** generalized model for resource management in the broader context of Park Management Planning (Parks Canada **1972)**. Figure 1.3 illustrates the process, identifies the products to be prepared, and indicates the relationship of the resource management process to the park management planning process.

Natural resource management in national parks is defined as those activities directed toward the maintenance or modification of the biotic and abiotic resources of a park in order to achieve stated objectives of preservation and/or use (Parks Canada 1979b).

In Kluane, the Natural Resource Management Process (NRMP) has been undertaken to:

a) develop a resource management strategy that will promote the conservation of the Park **as** an outstanding example of the Northern Coast Mountains Natural Region;

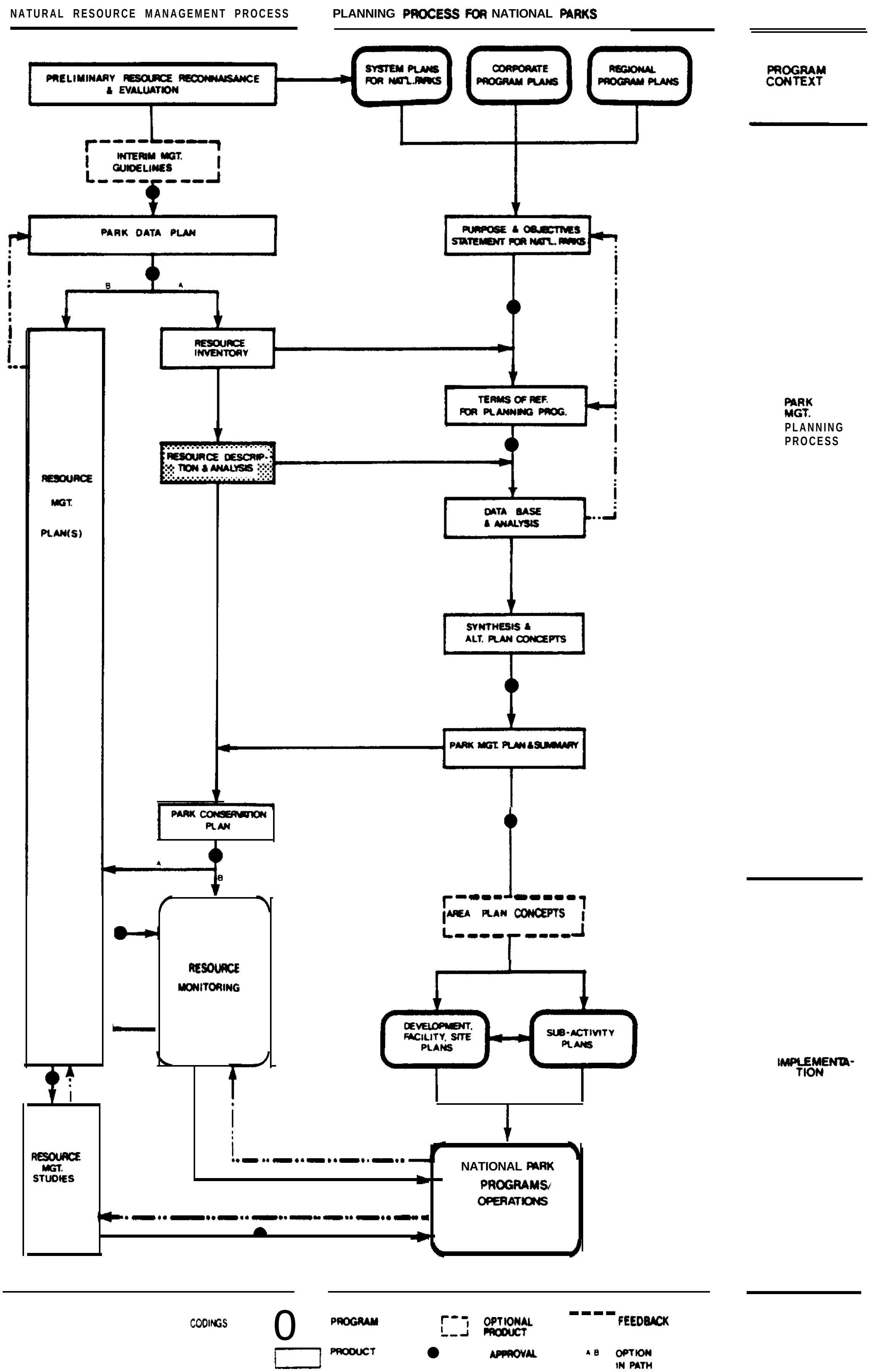

Figure 1.3 The Natural Resource Management and National Park Planning processes.

b) provide the products required for integration with the park management planning and other subactivity programs;

c) enable the integration of the Environmental Assessment and Review Process (EARP) with Park management planning and Park operations on an ongoing basis; and

d) identify requirements of natural resource management activities to aid Park managers in budgetting and allocation of human resources.

Prior to 1972, collection of natural resource information in the Park area was confined to the efforts of individuals and agencies interested in the features of the region. For example, since 1948 the Arctic Institute of North America has sponsored scientific expeditions in the St. Elias Mts. and from 1961 to the present has participated in the Icefield Ranges Research Project. This is perhaps the single most valuable source of information on all aspects of the natural environment of the southwest Yukon.

In 1973, Parks Canada initiated a resource inventory of Kluane to provide baseline data for the implementation of the Natural Resource Management Process. This work was undertaken by outside contractors, other government departments, and Parks Canada staff. To date the resource inventory is largely complete but problems with the database have limited its utility. These problems result from the thematic rather than integrated nature of most of the studies, the lack of a consistent mapping scale, and some lack of reliability and accuracy throughout. As a consequence, an integrated ecological land inventory does not exist for the Park.

A preliminary resource description of the park was prepared as a public information package for the park management planning program in 1977. Resource analysis and evaluation techniques were rudimentary and Park-wide assessments of the resources were not always produced. In 1980 the Park-wide resource description and analysis (scale 1:250,000) for Kluane National Park was begun by Park Warden staff. First drafts of a number of sections were prepared but the project came to a halt because of the lack of personpower resources in the regional office needed to provide advice and support and because of problems encountered with the resource inventory.

Ideally, the Natural Resource Management Process (NRMP) and the National Park Management Planning Process develop in an integrated fashion, each building on the products of the other (see Figure 1.2). In Kluane however, by the time the NRMP was approved in 1979, development pressures had forced the planning process to move ahead. As a result, by 1982 planning had entered the implementation phase with the Park Management Plan in place and the initiation of area planning in the Slims River Valley. Though out of phase, completion of this document remained as an important priority. The Management Plan is scheduled for a 5-year review in 1985 and the Resource Description and Analysis will provide valuable information for reassessment of Park development plans. It will also provide **a** framework for ongoing resource conservation activities and will be necessary when area planning is undertaken in the Mush-Bates lakes, Kathleen Lake, and Alsek Valley areas.

The Resource Description and Analysis has been prepared to achieve the following objectives:

a) To consolidate the Park resource information base and to provide a description of the natural resources of the Park as a major step in the Natural Resource Management Process;

b) To provide an evaluation of the Park's natural resources in terms of their limitations and opportunities for use, scientific importance, and ecological interrelationships:

c) To identify information gaps in the basic resource inventory of the Park;

d) To identify resource management objectives for the Park;

e) To identify park conservation requirements to mitigate identified resource management issues, concerns or problems; and

f) To serve **as** a public information document to assist in the presentation and subsequent understanding of the Park and its resources.

The Park Conservation Plan (Parks Canada 1984) was prepared concurrently with the Resource Description and Analysis and defines the resource conservation requirements, resource **management issues** and proposed solutions arising from preservation and use of Kluane's resources. It is the focal point for implementation of the **Natural** Resource Xanagement Process in Kluane and provides the framework for review of ongoing programs. The Park Conservation Plan is referred to repeatedly throughout the Resource Description and Analysis and should be consulted by readers as a companion document.

1.3 Program Parameters

There are a number of parameters within which the program of natural resource management must operate. These include: National Parks Act and Regulations, Parks Canada Policy, the role of the park in the National Parks System Plan, and the Kluane National Park Management Plan.

1.3.1 National Parks Act and Regulations

The general intent of the National Parks Act and associated regulations is to provide guiding principles for resource management planning activities within national parks. The Act states:

> "The national parks of Canada are hereby dedicated to the people of Canada for their benefit, education and enjoyment, subject to this act and the regulations, and the national parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations." (Canada 1974a).

The National Parks Act specifies a dual role for national parks: protection and preservation of heritage resources: while providing educational and recreational opportunities. The bridge that will best reconcile the user activities and the preservation mandate is a rigorous resource management program.

The following sections contained in the Act to Amend the National Parks Act, Chapter II of the Statutes of Canada, (Canada 1974b), also apply:

"II.(1) Subject to subsection (2), the Governor in Council may, after consultation with the Council of the Yukon Territory or the Council of the Northwest Territories, as the case may be, by proclamation, set aside as a reserve for a National Park of Canada, pending a settlement in respect of any right, title or interest of the people of native origin therein, the lands described in Part I, II or III of that Schedule, and upon the issue of a proclamation under this subsection, notwithstanding any other Act of the Parliament of Canada, and save for the exercise therein by the people of native origin of the Yukon Territory or Northwest Territories of traditional hunting, fishing and trapping activities, the National Parks Act applies to the reserve so set aside as it applies to a park as therein defined.

II.(3) Following a settlement in respect of any right, title or interest of the people of native origin in lands set aside as a reserve by proclamation issued under subsection (1), the Governor in Council may, by further proclamation, set aside such lands, or any portion thereof, as a National Park of Canada, and upon the issue of a proclamation under this subsection, notwithstanding any other Act of the Parliament of Canada but subject to the terms of any such settlement, the National Parks Act applies to the National Park of Canada so set aside as it applies to a park as therein defined."

Subject to these provisions, Kluane was formally set aside as a national park reserve on May 7, 1976 in an amendment to the National Parks Act. The Act further states that full National Park status may be proclaimed following the settlement of land claims.

1.3.2 Parks Canada Policy

Parks Canada Policy (Parks Canada 1979b) provides an integrated statement of broad principles to serve as a guide for future initiatives within national parks. The policy document re-emphasizes the general intent of the National Parks Act by establishing the following program objectives:

> "To protect for all time those places which are significant examples of Canada's natural and cultural heritage and also to encourage public understanding, appreciation and enjoyment of this heritage in ways which leave it unimpaired for future generations.".

The Program Policy section 1.1 states that:

"Parks Canada will make protection of heritage resources its primary consideration.".

To this end, Section 3.2 of the Policy (Parks Canada 1979b:41-42) provides guidelines for resource management activities within national parks. These guidelines cover manipulation of natural processes, preservation of critical habitat, extractive industries, and traditional land use by native people.

1.3.3 The Role of Kluane National Park in the Parks Canada System

The Park Purpose and Objective Statement highlights the significance of a national park's resources and describes its special features, themes, and representations. The purpose of this statement is to define the specific role of the park within the national parks system, and the park objectives consistent with the stated purpose of the park. In short, it defines the role of the park in terms of relative emphasis placed on preservation and protection, presentation and visitor use and its role in the region within which it exists. The Purpose Statement entails specific definitions of management philosophy and intent and provides direction for resource preservation, management practices, interpretation, and for integration of the park into its regional setting.

1.3.3.1 Kluane National Park Purpose Statement

Kluane National Park protects for all time a natural area of Canadian significance representative of the Northern Coast Mountains Natural Region. The Park is focussed on the high peaks and icefields region of the St. Elias Mountains which contain

Canada's highest peaks, including Mt. Logan, Mt. St. Elias and Mt. Lucania. The icefields are the source area for many large valley glaciers, such as the Donjek, Kaskawulsh and Lowell, which flow out into a surrounding area inhabited by a wide variety of plant and wildlife species. Communities of white spruce predominate in the montane zone, a wide variety of willow species in the subalpine and fescue and white dryas in the alpine. The major large animal species *are* Dall's sheep, grizzly bear, mountain goat, and moose. Smaller mammals characteristic of the Park include hoary marmot, porcupine, snowshoe hare and Arctic ground squirrel. Both the flora and fauna of the Park display unusual diversity for this latitude. This is due, in part, to the presence within the Park of a tension zone where species from the Boreal forest, Arctic tundra and Western Cordilleran biomes mix. Critical wildlife habitats such as those for Dall's sheep, grizzly bear, mountain goat, and kokanee salmon, rare plant species, and communities and representative ecosystem units require special protection.

The Park landscape is a result of a very complex series of geologic processes influenced by its position along a major tectonic belt:. However, the most predominant and most significant agent of landscape formation is glaciation, and Kluane displays many special and representative features. The Park is particularly significant for its alpine glaciers some with surging regimes, as well as for the presence of many rock glaciers.

The Park's recent human history is tied to the Klondike gold rush and to the building of the Alaska Highway. Tutchone settlement cf the area is an important link to the past. Also, evidence of man's earliest appearance on the North American continent following deglaciation is only beginning to be appreciated and investigated.

Kluane National Park will encourage public understanding of the meaning and value of its natural and human resources. Special features and associated interpretation themes include: Mt. Logan,. Canada's highest peak; the St. Elias Icefields, the largest: nonpolar icefields in the world; the wildlife of the Park and its relationship to the landscape and wilderness character of the area; valley glaciers, the largest and longest in Canada; many classic: examples of glacial landforms such as cirques, moraines, U-shape<. troughs and hanging valleys; examples of alpine and rock glaciers; and remnants of the gold mining activity at the turn of the century, in areas such as Bullion Creek.

Kluane encourages appreciation and enjoyment of its wilderness, rugged environment and unspoiled beauty. Visitors may experience the stark beauty and severity of an icefield or be inspired by the spectacular scenery and rugged nature of the Kluane ranges. These are the types of experiences the Park will offer through appropriate wilderness recreation activities (i.e. hiking, climbing, viewing, camping). They will serve to emphasize this primary role of bringing man closer to nature in the wilderness.

Kluane's location adjacent to the Wrangell-St. Elias National Park in Alaska provides an excellent opportunity for international co-operative planning and development. The Park will also encourage and develop cooperative programs with neighbouring land management agencies in Yukon to ensure a complementary approach to management and protection of resources, particularly along the Alaska/Haines Highway corridor and in the Kluane Game Sanctuary.

1.3.3.2 Kluane National Park Objective Statements

Kluane's most important attribute is its wilderness character and the primary management objectives are:

1. to preserve the wilderness areas of the Park in their natural state. Within this overriding precept, the following objectives will also be achieved;

2. to recognize and preserve the wide variety of unique and significant resources of Kluane including representative ecosystems of the Northern Coast Mountain Region, rare plant species and communities, rare and characteristic wildlife populations, and landforms characteristic of this glacier-dominated region;

3. to allow natural processes to continue without interference except to offset man's influence, or to protect unique resources or man-made facilities;

4. to control public access into Kluane for the benefit of preserving its wilderness character and natural features:

5. to develop an interpretive program which will emphasize appreciation of Kluane's wilderness character and the importance of preserving it:

6. to provide for compatible recreation activities and facilities. Priority will be given to non-motorized activities: and

7. to encourage the development, by private interests, of commercial visitor accommodation and related services outside the Park along the Haines/Alaska corridor. Such services will not be developed within the Park.

These objectives first appeared in the interim management guidelines prepared for Kluane in 1975 and were formalized in the Kluane National Park Management Plan (Parks Canada 1980). The Plan contains guidelines for the achievement of these objectives and provides a framework within which further research, development and the operation and use of Kluane will take place. It also describes conceptually the facilities and developments planned for Kluane for the next 10-15 years. These developments will be subject to the

Environmental Assessment and Review Process as planning for their implementation progresses.

1.4 Methodology

The Resource Description and Analysis was prepared by a single author, with the exception of the Cultural Resources chapter which was written by staff from the Historical and Archaeological Research sections in Prairie Regional Office. Prior workload committments precluded a multidisciplinary approach involving Resource Conservation staff from Regional Office and Kluane National Park. The author was available to Parks Canada through an Executive Interchange Agreement and was able to devote nearly all her time to the project. Prairie Regional Office and Park Warden staff reviewed and commented on the document and their contributions were extremely valuable. The project was initially coordinated by Jim Barlow, and subsequently by Bryan Lee and Mel Falk, all from Natural Resource Conservation in Winnipeg. cartography and production were handled by Susan Plenert.

The document is a compilation and analysis of existing information on the resources of Kluane National Park from published and unpublished sources. An initial section of each chapter provides an evaluation of the database and defines its limitations. A description of the resource follows, and each chapter concludes with an evaluation of limitations and opportunities for use, and a description of resource management issues or requirements arising in that area. Reference is usually made here to the Park conservation Plan (Parks Canada 1984) which deals in more detail with these issues and their proposed solutions. Chapters describing resource management objectives and requirements have been omitted as this information is contained in the Park Conservation Plan, which should be referred to as a companion document. Map 1.1 (in pocket) provides a base map for the Park and contains all place names referred to in the Resource Description and Analysis.

Knowledge gaps are identified primarily in relation to resource management problems, issues and concerns. The most important requirements include a truly integrated biophysical land classification and the need to analyse and evaluate the existing wildlife data base. The need for this type of information is emphasized repeatedly in the Park Conservation Plan in relation to specific resource management issues.

Updating of the Resource Description and Analysis will be necessary as knowledge gaps are filled as new information becomes available, and prior to each review of the Park Management Plan.

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CHAPTER 2

Present Land Use, Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

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2.1 Introduction

Kluane National Park is not an isolated entity - its boundaries serve to protect wildlife and other natural resources from direct exploitation but cross boundary movements occur both from and into the Park and events outside the Park affect the resources within. For example, wildlife which cross the boundaries to range outside the Park become vulnerable to hunting or predator control. Wildfire can burn into the Park or from it to other areas, and streams and rivers flow from and into the Park with the potential to carry silt or harmful substances, and affect fish habitat and water quality.

The management of land and resources within Kluane must therefore be accompanied by cooperative policy development with agencies responsible for land use activities in areas adjacent to the Park. In some instances this is the Yukon Territorial Government (YTG) and in other situations, various federal government departments (Canadian Wildlife Service, Canadian Forestry Service).

In the following sections present land use in the Kluane area is described as land use within the Park (over which Parks Canada has ultimate control), and land use in adjacent areas *in* which Parks Canada has a vested interest.

2.2 Land Use Within Kluane National Park

2.2.1 Historical Land Uses and Park Designation

In the early 20th century, the major land uses by non-native people in the Kluane area were placer gold mining and trophy hunting and outfitting. Designation of the Game Sanctuary and Park Reserve in the mid-1940's ended legal trophy hunting and outfitting but mineral exploration and extraction were encouraged as the basis for continuing economic development of the Yukon. These activites were not restricted under Game Sanctuary regulations. Park Reserve status had no legislative mandate under which to ensure natural resource protection, and manpower restrictions limited enforcement of what protection was available under the Game Sanctuary laws. Poaching was rampant and mining occurred legally throughout the Park Reserve making the area far from the pristine wilderness envisaged by planners. In the post war period, placer mining continued and small copper, nickel, and silver claims were staked in the Tatamagouche-Quill creek areas and near Sockeye Lake but none were operated commercially for more than a few years.

Through the 1960's these and other projects such as hydroelectric development were actively supported by vocal interests in the mining and business communities but their net economic value to the Yukon economy was probably minor or insignificant (Cottrell 1975). Meanwhile, park planning was proceeding slowly. Several studies were underway on potential Park sites in Yukon and Kluane was seen as a prime possibility (Fuller 1955, 1957; Ward 1958; Baker: 1963; Brooks and Eidsvik 1963). It was acknowledged that Park status and economic development of this type were incompatible and the conflict between park and mining interests was increasing as attempts were made to formally define the Park boundaries. In 1969, a compromise proposal was put forward to designate a core area with full Park status in the Kaskawulsh Glacier-Slims River area and adjacent reserve areas which would be added to the Park after a set period of time as they were freed from mining interests (National & Historic Parks Branch 1969). This proposal was rejected by all parties. The mining lobby would not support investment in areas eventually to be Park land and group supporting Park establishment felt the core area was too small and would not accept land which had first been ecologically disrupted by mining.

The present Park boundaries were finally established in 1972 as the result of a subsequent compromise designed to specifically exclude areas of existing and potentially viable mining claims from the Park area. This has excluded a large area of the northern Game Sanctuary including the ecologically interesting terminus of the Klutlan Glacier and extensive wildlife habitat in the Kluane Ranges and lower Donjek Valley. A few mining claims were still active in the Park in 1972 but these were subsequently bought out through negotiations and no claims exist within the Park area today.

During exploration and development of placer and quartz mining claims, about 250 km of rough access road were built within what are now Kluane's boundaries. Since Park establishment these roads have been abandoned and, in most areas, are gradually returning to their natural state. Where grades are particularly steep or the area is underlain by permafrost, natural rehabilitation is not, occurring and the Park may have to take action to stabilize these areas (Parks Canada 1984). The Sheep-Bullion creek roads are examples.

Construction of the Alaska and Haines highways and an associated system of pipelines was prompted by the threat of Japanese invasion of Alaska during the early years of the Second World War. The 2600 km Alaska Highway was built in only 9 months in 1942, and the Haines cut-off followed soon after. Highway improvements continue today to straighten the road and eliminate dangerous or hard to maintain sections. Considerable evidence of the past 40 years cf activity remains along the highway right-of-way and the need fcr clean-up and rehabilitation of abandoned sections of road, borrow pits and other disturbed areas were identified in the Park conservation Plan (Parks Canada 1984).

The Haines-Fairbanks pipeline parallels the Alaska and Haine; highways through the Kluane area. The line was built by the U.s. Army in the mid-1940's to carry petroleum products from Haines, Alaska to Fairbanks. It was a small diameter line laid directly o1 the surface or shallowly buried. The line was abandoned in 1968 but the pipeline and pumping stations (at Haines Junction and Destruction Bay) are still intact and the pipeline is visible on the surface just off the highway for much of the distance around the Park. In 1983, the easement for the Haines-Fairbanks pipeline reverted to Crown Land and the U.S. Army (the former easement holder) was given a two year grace period in which to remove or otherwise dispose of the pipeline. This period has recently expired with no further action by the Americans and the Canadian Government has offered to buy the physical assets for a nominal sum ($1). The material ultimately will be disposed of through Crown Assets and, if the original legal description of the Park included the easement, Parks Canada could now presumably have the pipeline removed.

At the time of Park establishment in 1972 there were 21 active airstrips in the Sanctuary used by outfitters for illegal big game hunting in the area. Strict enforcement of hunting restrictions by the Warden Service with cooperation from Alaskan authorities in the adjacent Wrangell-St. Elias National Monument has brought poaching under control.

The Park Conservation Plan (Parks Canada 1984) has identified the need to prepare an inventory of man-disturbed sites requiring rehabilitation throughout the Park, including highway sites, the pipeline easement, and airstrips and roads, with accompanying guidelines and plans for rehabilitation of these areas.

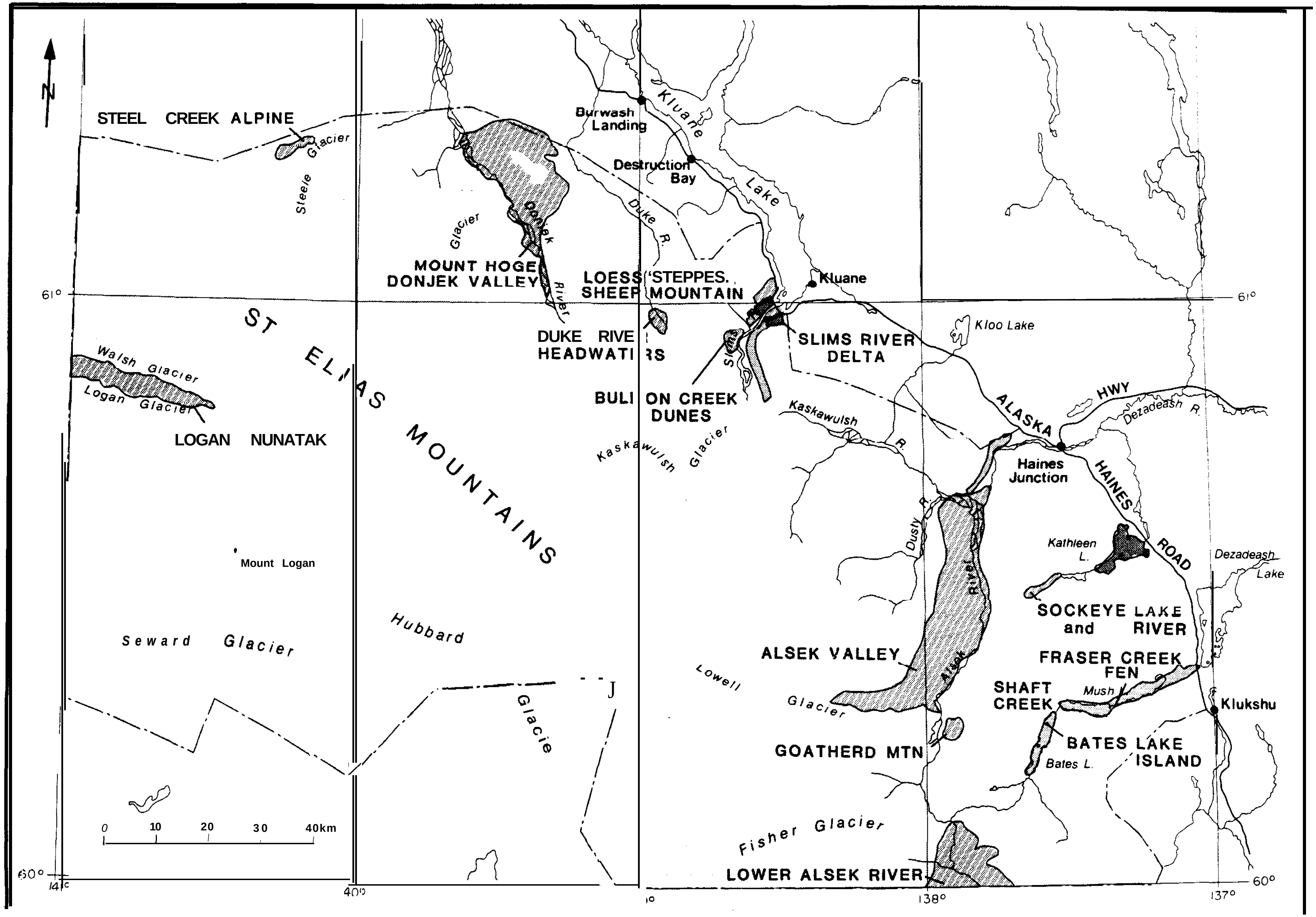
2.2.2 Kluane National Park Management Plan

The Rluane Management Plan (Parks Canada 1980) was approved in 1980 following an extensive program of public consultation. The plan "portrays the general character of Rluane. ..describes its role in the National Park system...provides detailed guidelines to show how the objectives for Kluane will be achieved...a framework within which future research, development, operations and use of Kluane will take place and outlines a broad strategy of implementation and direction for the next 10-15 years." (Parks Canada 1980:3).

2.2.2.1 Zoning

The Management Plan defines zones of protection and potential development in the Park (see Figure 2.1). Class 1 or Special Preservation Areas contain rare, unique, or endangered resources or the best examples of a particular feature within the Park area. Public access to these areas is strictly controlled and motorized access prohibited. Appendix 2.1 contains brief descriptions of the particular features of each site. The detailed mapping and description of these sites is identified in the Park Conservation Plan as a priority item for Resource Conservation staff in Kluane.

Map 1.1 Base map and place name references, Kluane Resource Description and Analysis.


N
STEEL CREEK ALPINE
Steele Glacier
Burwash Landing
Kluane Lake
Destruction Bay
Duke R.
Glacier
Donjek River
MOUNT HOGE DONJEK VALLEY
LOESS 'STEPPES. SHEEP MOUNTAIN
Kluane
61°
ST ELIAS MOUNTAINS
DUKE RIVE HEADWATI RS
SLIMS RIVER DELTA
Kloo Lake
Walsh Glacier
Logan Glacier
LOGAN NUNATAK
BULI ON CREEK DUNES
Slims
Kaskawulsh R.
Kaskawulsh Glacier
ALASKA HWY
Dezadeash R.
Haines Junction
HAINES ROAD
Dusty R.
Alsek River
Kathleen L.
Dezadeash Lake
Mount Logan
SOCKEYE LAKE and RIVER
Seward Glacier
Hubbard Glacie
ALSEK VALLEY
FRASER CREEK FEN
Lowell Glacier
SHAFT CREEK
Mush
Klukshu
BATES LAKE ISLAND
Bates L.
GOATHERD MTN
0 10 20 30 40km
Fisher Glacier
LOWER ALSEK RIVER
60°
141°
138°
137°

KLUANE NATIONAL PARK RESERVE

Figure 2.1 Zoning in Kluane National Park.

ZONE 1 SPECIAL PRESERVATION AREAS

1 Steel Creek Alpine
2 Mount Hoge, Donjek Valley
3 Duke River Headwaters
4 Bullion Creek Dunes
5 Loess Steppes, Sheep Mountain
6 Slims River Delta
7 Alsek Valley
6 Sockeye Lake and River
9 Shaft Creek
10 Fraser Creek Fen
11 Bates Lake Island
12 Goatherd Mountain
13 Lower Alsek River
14 Logan Nunatak

ZONE 2 WILDERNESS

ZONE 3 NATURAL ENVIRONMENT

ZONE 4 RECREATION AREAS

Most of Kluane is designated Class 2 or Wilderness. Preservation of the natural resources and character of the environment is the primary purpose in these areas. Non-motorized recreation of a primitive style is considered an acceptable use compatible with this designation.

Class 3 or Natural Environment areas offer specific recreation or interpretation opportunities to the general public but require limited man-made facilities. Non-motorized access is allowed but public transit is considered compatible and may be the only feasible means of reaching an area. The Slims East (Slims River Access Road) and Mush-Bates lakes proposals are examples of Class 3 land uses and areas.

Class 4 areas provide general recreation opportunities with private vehicle access and suitable visitor facilities. The Kathleen Lake campground and day-use area are designated Class 4.

Class 5 areas provide centralized Park administration and visitor facilities. At present, these facilities include the Visitor Reception Centre and Headquarters Offices at Haines Junction, the Park Operations Centre at the old Pine Creek Experimental Farm, and the trailer at the base of Sheep Mountain during the summer months. Warden residences at Dezadeash and Destruction Bay provide some services to the public as well.

2.2.2.2 Proposed Development

The Management Plan (Parks Canada 1980) outlines a number of proposed developments for the Park. These are described in Table 2.1 and illustrated on Figure 2.2. All were approved in principle during the environmental assessment of the Management Plan (Mathers 1980) as a whole but each will receive a second assessment as specific Area Plans are developed.

To date, some of these projects have advanced, none has been completed, and others have been abandoned or deferred. A Resource Description and Analysis (Lopoukhine 1983), Area Plan (Parks Canada 1983), and Area Plan Environmental Assessment (Gray 1983) have been prepared for the east Slims Valley. Planning and design are now well advanced and preliminary clearing of the access route was completed in 1984 but further work on the project has been deferred for up to two years as a financial restraint measure.

Area planning for the Mush-Bates - Alder Creek valley proposal was set to begin in 1985 but has similarly been deferred. Redevelopment of the Kathleen Lake campground and day-use area will go ahead in the summer of 1985. Private cottages on the lake are gradually being acquired. Proposals for access at Quill Creek, Alsek Pass, and the Slims West have not been pursued. An extensive system of hiking and cross-country ski trails is currently available in the southeast part of the Park. Further development

Table 2.1 Proposed developments in Kluane National Park.

Activity or Area	Description
• hiking and cross-country ski trails	- primary access system to Kluane's wilderness areas • trail construction limited and primitive, old mining roads used where desirable.
• primitive campgrounds	. located at trailheads and other areas of concentration • 10-12 campsites only at each • no backcountry shelters will be provided • random camping permitted except in areas of sensitive resources or possible overuse.
• Alder Creek Valley (also referred to as Mush-Bates lake development)	• public transit access from the Alaska Highway to Mush Lake • a shuttle boat system to transport visitors to the head of Mush Lake where they hike a short distance to board another shuttle boat which takes them to the head of Bates Lake and access to backcountry hiking trails and primitive campgrounds.
• St. Elias Lake	• wilderness recreation area • picnic area and primitive campsite • access by hiking trail only from Alaska Highway
• Quill Creek*	• trail head and parking area at the Alaska Highway to allow access to the Auriol Range upland area.
• Slims River East	• public transit access along the east side of the Slims Valley to a high elevation outlook over the terminus of the Kaskawulsh Glacier • visitor reception centre on Kaskawulsh Knob with access to self-guiding trails near the terminus and a hiking trail up Vulcan Ridge.

Table 2.1 Proposed developments in Kluane National Park. (Concluded)

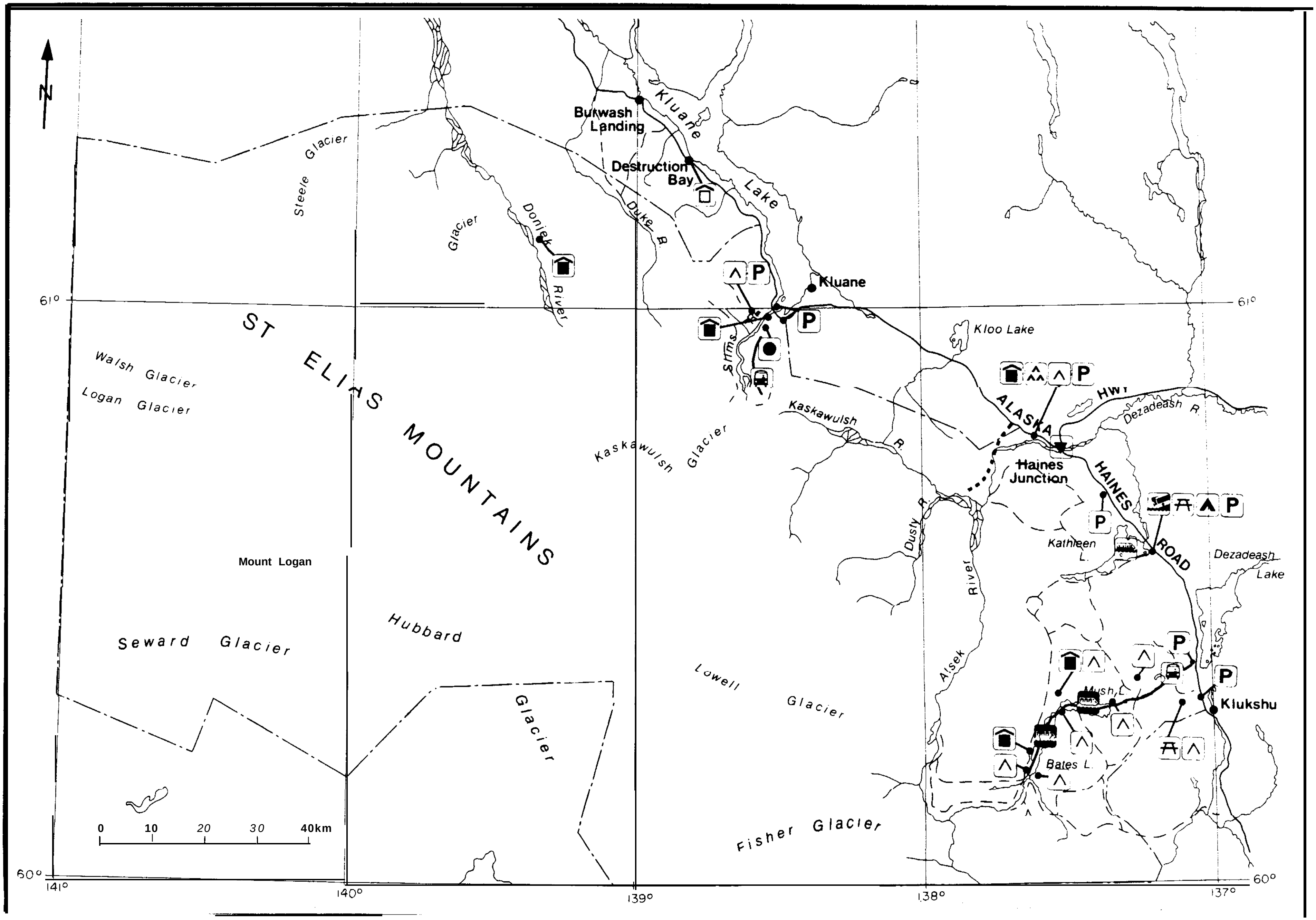
Activity or Area	Description
- Kathleen Lake	- recreational focus of Kluane National Park - only semi-serviced campground in the Park - campground will be expanded to 72 sites - day-use and picnic areas will be expanded and improved - access to day-use and backcountry hiking trails - boat launching facilities.
- Slims River West*	- public access to a trailhead from which tours of the mining sites on Bullion Creek will begin (guided).
- Alsek Pass*	- maintain existing road for interpretive tours only - no public vehicle access.

Source: Parks Canada 1980.

* - indicates proposals which are indefinitely deferred as of March, 1985.

Figure 2.2 Proposed developments in Kluane National Park.

- **Visitor Orientation/ Interpretation Centre**
- **Visitor Reception/ Administration Lodge**
- **Warden Cabin**
- **Area Office**
- **Campgrounds:**
  - **Semi-serviced**
  - **Group**
  - **Primitive**
- **Picnic Area**
- **Boat Launch (Public)**
- **Boat Tours**
- **Shuttle Boat**
- **Public Transit**
- **[P] Parking**
- **Roads:**
  - **—— General Purpose**
  - **••••• Special Purpose**
  - **- - - Trail**


N
Burwash Landing
Kluane Lake
Destruction Bay
Duke R.
Steele Glacier
Glacier
Donjek River
Kluane
Slims
Kloo Lake
ALASKA HWY
Dezadeash R.
Haines Junction
HAINES ROAD
Kathleen L.
Dezadeash Lake
Kaskawulsh R.
Kaskawulsh Glacier
Dusty R.
Alsek River
Mush L.
Bates L.
Klukshu
ST ELIAS MOUNTAINS
Walsh Glacier
Logan Glacier
Mount Logan
Seward Glacier
Hubbard Glacier
Lowell Glacier
Fisher Glacier
0 10 20 30 40km
61°
60°
141°
140°
139°
138°
137°

of the trail system and establishment of overnight primitive campgrounds are also proposed in the Management Plan.

The Management Plan will undergo its first S-year review in 1985 and these developments will be reassessed at that time. Issues arising from increased backcountry use, such as horse use, aircraft access, man-bear public safety concerns and many others and their proposed solutions are addressed in the Park Conservation Plan (Parks Canada 1984).

2.2.2.3 Current Use

visitor use statistics have been recorded in Kluane since 1976 and show a steady increase in activity to an average of about 60,000 recorded visitors in recent years. Table 2.2 summarizes these figures. The Visitor Reception Centre at Haines Junction opened in 1980 and is a popular stop for bus tours and individual travellers, providing an award-winning audio-visual presentation on the Park, interpretation and information services, and rest facilities. The sheep Mountain information trailer is extremely popular and most travellers along the highway stop to talk to Park staff, observe Dall's sheep, and stretch their legs along the shore of Kluane Lake.

Hikers overnighting in the Park and using backcountry areas are required to register with the Park Warden Service for their own safety. These data are summarized in Table 2.3.

2.3 Adjacent Land Use

Most of the Yukon is Federal Crown Land administered by the Department of Indian Affairs and Northern Development (DIAND). The Yukon Territorial Government has control of Commissioner's Lands and land designated as a development control zone under the Area Development Ordinance, usually the area surrounding communities. Federal Crown Land and Commissioner's Lands are available to individuals under lease or sale agreements, usually for residential, recreational, commercial or agricultural purposes. Short term land use operations associated with development on Crown Land fall under the Territorial Land Use Regulations and require a land use permit, issued and enforced by DIAND. Figure 2.3 shows land uses in areas adjacent to Kluane, based on maps from the East Kluane Planning Study (Dept. of Renewable Resources 1980).

2.3.1 Residential and Commercial

Three major communities are located on the periphery of Kluane National Park - Haines Junction (pop. 500), Destruction Bay (pop. 50), and Burwash Landing (pop. 50). Services and year round accommodation are available in these communities and at intervals along the Alaska and Haines highways.

Table 2.2 Visitor Use Statistics - Kluane National Park, 1976- 1984

Year	Number of Visitors			** Total
	Haines Junction	Sheep. Mt. Info. Centre	Kathleen L. Campground	
1976	1348	942		2290
1979	2230	2328		4558
1978	4383	3380	994	8737
1979	2669	4347	803	9817
1980	27621*	6986	930	35337
1981	40896	10126	1371	52393
1982	50103	15190	1239	66512
1983	30128	19389	1194	50709
1984	28372	29898	1451	59921

* VRC building opened in 1980.

** These figures are "party nights" - # persons X # of days stay.

Table 2.3 Registered hikers - Kluane National Park, 1977-1984.

Year	urwash-Hoge Donjek			Sheep-Dixon-Duke-Halfbreed			Slims West			Sheep Bullion Plateau			Slims East			Alsek			Cottonwood		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1977	5	15	70	2	4	16	20	38	230	54	133	322	25	92	322	12	20	55	11	34	228
1978	16	51	404				35	74	348	44	103	331	30	85	320	23	38	138	16	36	222
1979	14	71	744	5	9	72	62	166	909	26	73	191	28	110	436	11	21	72	15	38	314
1980	21	93	724	13	23	126	35	120	520	41	9	239	122	293	1136	18	36	105	32	57	502
1981	20	51	494	6	23	176	34	70	365	20	36	134	57	125	597	22	43	139	19	46	437
1982	28	94	1088	10	24	201	45	126	620	86	123	385	101	280	1165	16	51	15	28	63	567
1983*																					
1984*	8	24	106	3	11	52	29	55	266	24	59	153	83	192	648	12	29	125	18	44	173

• no data

• * 1984 - May-September only

A Parties
B Persons
C Days

Table 2.3 Registered hikers - Kluane National Park, 1977-1984 (Concluded).

Year	Kathleen Lakes			Auriol			Mush-Bates			Shorty Creek			St. Elias			Quill Creek		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1977	8	13	68	1	1	3	11	26	96				2	4	10	2	13	30
1978	22	40	222	2	4	8	12	43	167				12	44	102	10	23	110
1979	12	27	119	1	9	18	8	18	89				2	4	11	5	20	106
1980	39	79	325	12	44	102	19	40	179				2	4	18	9	18	48
1981	45	101	477	2	2	12	12	26	191				2	4	14	9	18	61
1982	25	67	329	17	47	194	23	60	252				12	48	107	10	27	111
1983*																		
1984**	13	29	75	35	19	104	21	64	211	1	14	14	7	12	18	4	9	18

* no data

** 1984 - May-September only

A Parties
B Persons
C Days

Figure 2.3 Land use adjacent to Kluane National Park.

Native settlements are located at Klukshu, Kloo Lake, Champagne, and Canyon Creek. Silver City on the southeast end of Kluane Lake is an abandoned gold rush mining town. Its old buildings are an attraction for bus tour operations and other sightseers. Private residences are located along the highway as shown on Figure 2.3.

2.3.2 Mining

Placer gold mining continues in areas near the Park, predominantly along the creeks draining northeastward from the Kluane Ranges into Kluane Lake, along Jarvis River, and in the south along the Tatshenshini River. There are currently no commercial mines operating in the vicinity.

2.3.3 Outfitting and Hunting

Outfitting, hunting, and trapping occur outside the Sanctuary to the east of the Alaska and Haines highways. Registered traplines and outfitting areas are shown in Figures 2.4 and 2.5. Hunting and fishing are locally signficant to native people and are an important part of lifestyle and recreation for all local residents.

2.3.4 Agriculture

Agricultural and grazing leases have been granted along the Alaska and Haines highways outside the Sanctuary. Most cattle and horses are allowed to free range and Parks Canada has discouraged grazing by domestic animals in the Park as they provide unnecessary competition for wild species.

2.3.5 Recreational uses

Territorial campgrounds are maintained at Kusawa Lake, Pine Lake, and Congdon Creek and proposals have been made for additional facilities as demand grows. Kathleen Lake, Kathleen River, Dezadeash Lake and Kluane Lake are all popular destinations and scenic boating, fishing, and general outdoor activity recreation areas. Kathleen Lake is inside the Park and subject to Park fishing regulations and limits.

Commercial river rafting has become a popular wilderness activity. American operators offer a trip from Dalton Post down the Tatshenshini to the Alsek and ultimately to Dry Bay in Glacier Bay National Park on the Alaska coast. These tours pass through the Park for a short distance and the rafters camp overnight near the mouth of the Bridge River, inside the Park. U.S. authorities currently allow only 16 launches per year by U.S. operators but they propose to offer another 16 dates to Canadian companies. These activities are governed in the U.S. by the Alsek River Interim Management Plan (National Park Service 1982) which sets out objectives, policies and resource protection measures for the river.

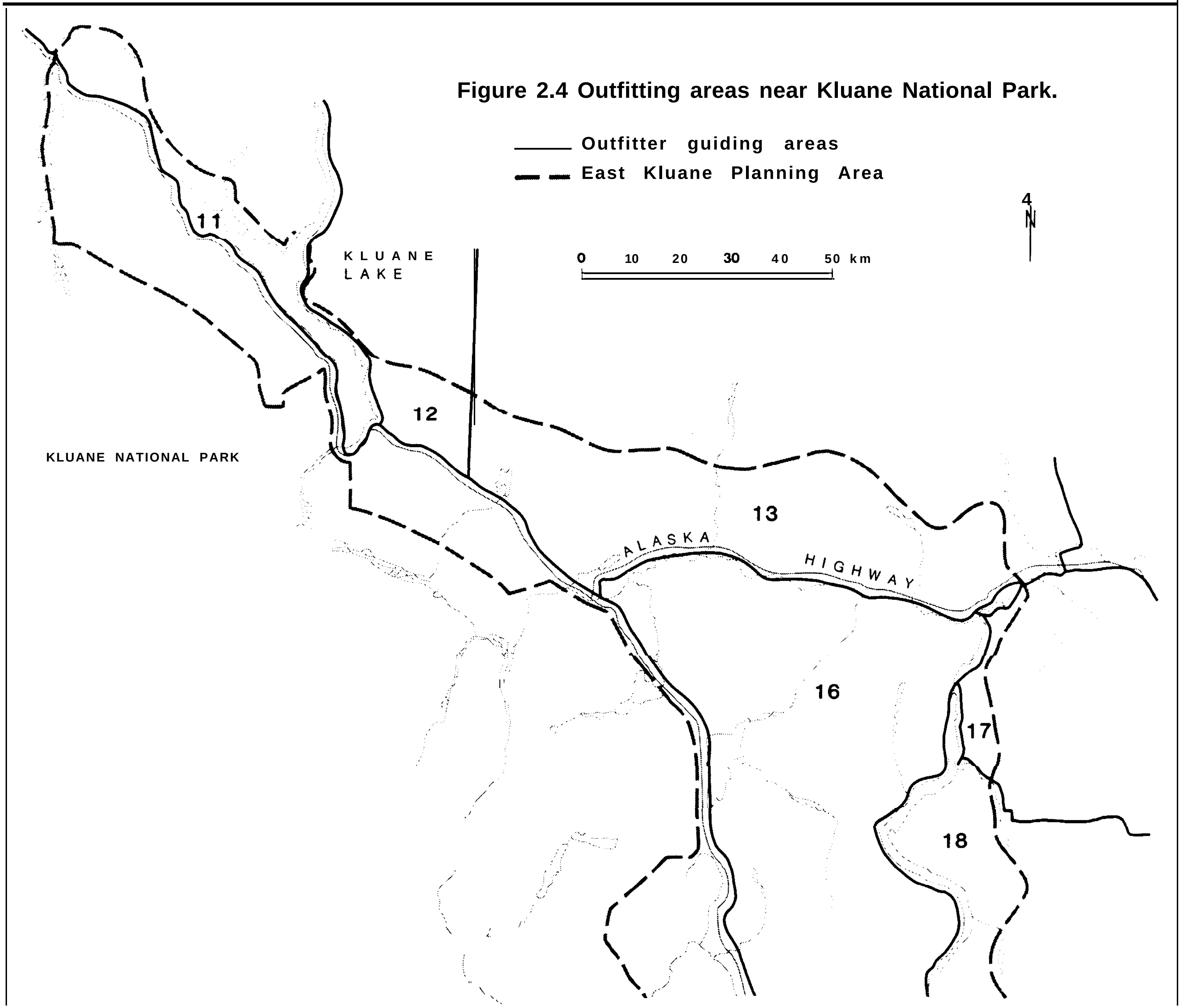
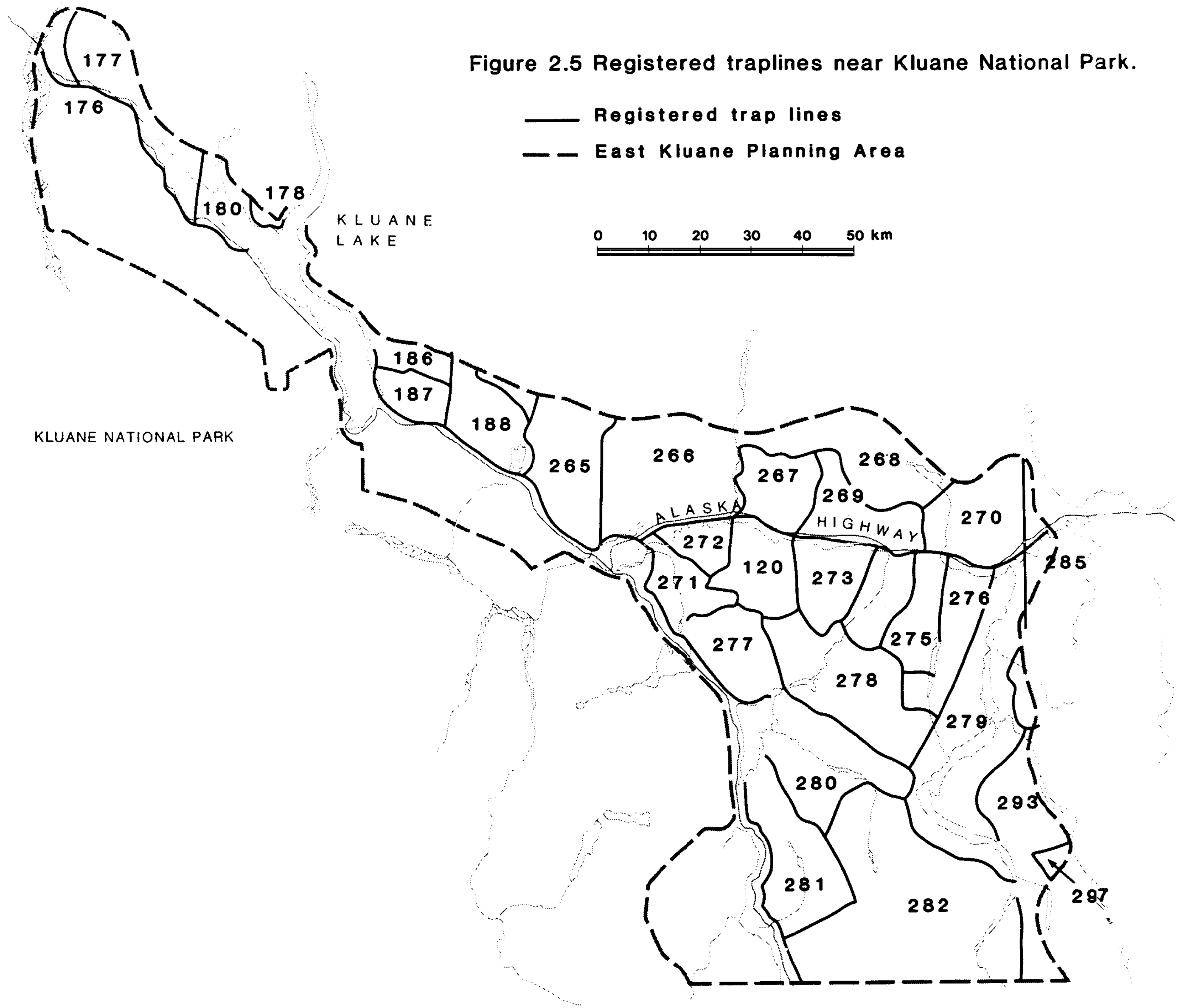


Figure 2.4 Outfitting areas near Kluane National Park.

Figure 2.5 Registered traplines near Kluane National Park.



Parcs Canada Parks Canada

SP PRO 85

Infrequently private rafters float the Alsek through the Park, starting on the Dezadeash River near Haines Junction. There trips are restricted by an extremely hazardous canyon area at the terminus of the Tweedsmuir Glacier south of the Park in B.C.

Commercial aircraft operators in Burwash Landing offer short overflights of the Icefields in fixed wing craft.

2.3.6 Alaska Highway Gas Pipeline Project

From 1978 to 1983, a moratorium on land development was in effect over an 8-km wide strip of land following the proposed route of the Alaska Gas Pipeline in Yukon. No new dispositions of land were allowed within this strip. The freeze was in effect to allow the pipeline company, Foothills Pipe Lines (Yukon) Ltd., flexibility in locating the line to deal with discontinuous permafrost and other geotechnical conditions which could not be anticipated before construction. In 1983, the corridor was narrowed to 240 m after an intensive geotechnical drilling program, an easement was granted to Foothills, and the land freeze lifted.

Near Rluane, the route follows the northside of the Alaska Highway and the Haines-Fairbanks Pipeline right-of-way. It crosses beneath Kluane Lake and passes through the Park on the west side of Kluane Lake for a very short distance before once again following the highway northward. The future of the project is uncertain at this time. Figure 2.3 shows the proposed route and the location of facilities associated with construction and operation in the Kluane area.

2.3.7 Research Facilities

The Arctic Institute of North America and the University of Calgary maintain a research station and airstrip at the south end of Kluane Lake. This basecamp was established for the Icefields Ranges Research Project in the early 1960's and has continued to provide logistical support to scientists operating in Kluane and nearby areas.

2.4 International Recognition of Kluane's Resources

2.4.1 world Heritage Site

In 1979, Canada and the United States jointly nominated Kluane National Park and the adjoining Wrangell-St. Elias National Monument as a World Heritage Site, an area of international cultural and natural significance encompassing over 16 million hectares in the Yukon and Alaska.

This program began in 1972, when the member nations of UNESCO adopted the International Convention for the Protection of World Cultural and Natural Heritage. This Convention recognizes the following principles:

- **that each nation holds** in trust for the rest of Mankind those shares of the World's patrimony found within its frontiers;

- that the international community will make it a point of duty to help any nation which finds it difficult to discharge this trust through lack of resources; and

- that man must exercise the same responsibility **towards** the work; of nature **as** towards the works of his own hands.

These principles complement Parks Canada's own charge to preserve the resources of our National Parks unimpaired for the enjoyment of future **generations.** Protective status in the U.S. part of the site may change if a bill to allow recreational and trophy hunting in parts of Wrangell-St. Elias National Park is passed. This would affect several big game species which currently migrate across the International Boundary.

2.4.2 Canadian Heritage River System

A 90-km stretch of the Alsek River in Kluane National Park has been nominated **to the Canadian** Heritage River System (CHRS). This designation is based on the occurrence in the **area of** outstanding features of natural and cultural significance. These include the terminus of the Lowell Glacier and its features of active glaciation, active geomorphological and fluvial processes, the features of Recent Lake Alsek, successional vegetation and rare plants, diverse wildlife habitat including mountain goat and grizzly bear range, as well as outstanding scenic beauty. To keep this nomination, Parks **Canada** must develop a river management plan for the Alsek by 1987, defining boundaries for the area, describing the heritage resources, and establishing policies and practices for use and management of the river. The plan will be developed as part of the wilderness **management** plan.

2.4.3 International Biological Programme

In 1965, as part of the International Biological Programne (IBP), the Canadian Committee for the IBP formed 10 regional Panels comprised of government and university scientists. They were directed to identify special sites throughout the country which were representative of natural ecosystems or man-disturbed areas in recovery. Many of these sites contained biotic and abiotic elements that were rare, endangered, or unique and which deserved special status to ensure their protection and to provide opportunities to study the ecosystems in their natural state.

Panel 10 - Subarctic-Boreal Forest - identified 4 sites inside Park boundaries (Payne 1975):

16a - Sheep Mountain - Mount Wallace
16b - Mount Archibald - Mount Decoeli area
16e - Lowell Glacier
16f - Kaskawulsh Glacier.

The features of these areas are described briefly in Table 2.4 These sites all lie partly or wholly within Kluane National Park and are thus afforded a degree of protection unavailable to other areas.

The push for meqascale northern development in the mid-1970's made protection of IBP sites an urgent task and DIAND was actively lobbied for some form of special status. With the decline of development pressure and the end of the IBP in the late 1970's, interest in these areas also declined. While special status has not been negotiated, documentation of the importance of these sites remains and presumably influences the land use permit process and other activities that must pass regulatory review.

2.5 Native Land Claims in the Kluane Area

Kluane's status as a National Park Reserve will remain at least until settlement of native land claims in Yukon, allowing for the possibility of changes to the Park boundaries at that time. Negotiations between the Federal Government, the Yukon Territorial Government, and the Council for Yukon Indians have been ongoing for some time. An agreement-in-principle has been signed on land selection. The location of these blocks of land is confidential at this time but it is likely that some land will be selected within the Park boundary. Should this occur, the Park boundary will change and the land lost will probably be 'replaced' with land in another area adjacent to the Park (J. Masyk pers. comm.). In December 1984, David Crombie, Minister of Indian Affairs and Northern Development, suspended the negotiations when native groups failed to comply with a government deadline. The next steps are unclear at this time.

2.6 Evaluation

A number of issues affecting Kluane arise from current land use activities in and adjacent to the Park. These are addressed in detail in the Park Conservation Plan (Parks Canada 1984) and are mentioned in subsequent chapters of the Resource Decription and Analysis. Cooperative action with agencies in adjacent jurisdictions is required on:

- bear management;

- wildlife monitoring;

- fisheries management;

Table 2.4 International Biological Programme sites in Kluane National Park

IBP Site	Description
16a Sheep Mountain/Mount Wallace	- well-studied boreal white spruce communities, alpine tundra: Dall's sheep winter range; grizzly bear population.
16b Mount Archibald/Mount Decoeli	- subalpine vegetation and alpine tundra; protected viable grizzly bear population.
16e Lowell Glacier	- active calving glacier; diverse coastal flora; relect grassland: grizzly and black bear, moose and mountain goat populations.
16f Kaskawulsh Glacier	- periqlacial ecosystem on dry, lee side of Icefield Ranges. Origin of loess steppe of Slims River flood-plain and Sheep Mountain.

source: Payne 1975.

- water quality control;

- fire control; and

- forest insects and **disease** control.

Programs within the Park in these areas are affected by the land management policies of agencies with jurisidiction outside the Park.

Within the Park, increasing visitor use and park facilities development require that policy action be taken in the following areas to ensure protection of Kluane's wilderness character and resources. These include:

- protection of Special Preservation Areas and cultural resource sites;

- public safety primarily with respect to bear management but also in general backcountry use:

- vegetation and fire management to promote a healthy natural forest ecosystem in Kluane and protect wildlife habitat; and

- polices to ensure wildlife protection in public use areas such as Sheep Mountain and other areas liable to experience heavy visitor use in the future.

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APPENDIX

2.1 Special Preservation Areas in Kluane National Park.

Appendix 2.1 Special Preservation Areas in Kluane National park.

1. **STEELE CREEK ALPINE**

The Steele Creek Alpine area best represents the Northern Alpine ecosystem in Kluane. The region also contains several rare plants.

2. **MT. HOGE/DONJEK VALLEY**

This pristine area has a wide variety of special resources that are significant to the national park system and the biological systems of North America. Included in this area is part of the finest undisturbed Dall's sheep population and all-season range in North America. The area also includes wolf denning areas and portions of year round range; excellent grizzly bear habitat; and the most northerly mountain goat range in North America. Many birds frequent the area and also nest here, such as eagles, falcons, and a variety of upland species. A number of rare and fragile plants and plant communities have been found in the area such as the Oxytropis viscida community, a species of sage (Artemisia rupestris), a newly discovered member of the Draba family, and many others.

3. **DUKE RIVER HEADWATERS**

The plant Braya purpurascens (R.BR.) Bunge, found in the Duke River headwaters, has only been collected in this particular area of the Yukon. This plant species is **also** very rare in Canada.

4. **BULLION CREEK DUNES AND**

5. **LOESS STEPPES-SHEEP MOUNTAIN**

Wind blown material is being deposited continuously along the slims Valley with the thickest deposits occurring on the north and west sides of the valley. This loess occurs as a veneer or blanket on the bedrock, on the moraines, and on the fans. The soils on the loess deposits are very droughty and are highly susceptible to wind and water erosion if disturbed. These wind-formed features are excellent representative examples worthy of protection in the national park system.

6. **SLIMS RIVER DELTA**

The plant communities in the Slims River delta are usually influenced by a high water table. Three delta community types may be considered rare:

1) Aster yukonensis

2) Puccinellia nuttalliana

3) Taraxacum ceratophorum

The vegetation of the delta is characterized by a sparse cover of plants with only 28 species occurring on the delta proper, These species are adapted to both periodic flooding and highly saline soil conditions.

7. **ALSEK VALLEY**

This **area** is representative of prime grizzly habitat and maintains a signficant bear population throughout the year. The lush vegetative cover provides these animals with an abundant food source from early spring until late fall. Six active denning sites are known in this area with numerous other ideal sites which have not been definitely identified as being active at this time. Combined with the general topography and isolated location, this **area** provides the grizzly with an ideal habitat that is recognized as important for supporting an undisturbed grizzly bear population in the Park. Other special features in this area include:

a) dunes

The Alsek Valley acts as a funnel for surface winds,. producing impressive dust and sand storms. These result in aeolian landforms notably sand dunes along the east side of the valley and at the north end. This particular location is a good representation of such active dune formations.

b) vegetation

The vegetation community which occurs on the inactive sand dunes near the junction of the Dezadeash and Kaskawulsh rivers is **a** rare plant community. The dominant species, Carex sabulosa, is known only from one other location in North American - near Carcross in Southern Yukon.

c) Profile Mountain

Kluane contains both the coastal and northern vegetation **systems.** Because of their proximity (climate, soil, etc.) there is some overlap which is referred to as the "middle ecosystem." Profile Mountain best represents two such ecosystems, the "middle" alpine and subalpine.

8. **SOCKEYE LAKE AND RIVER**

This **area** includes the critical spawning grounds and freshwater habitat of kokanee, the permanent freshwater form of the sockeye salmon (Oncorhynchus nerka). This population originated from **a** sea-running stock which has been denied access to the sea, thus adapting to a land-locked existence for survival. Their distribution within Kluane is confined to sockeye, Louise and Kathleen lakes and the Kathleen River immediately below the lake. This population of kokanee is of interest to the natural history of Yukon and provides a special opportunity for interpreting the geological and biological evolutionary story of the region.

9. **SHAFT CREEK**

This area is forested by a particular white spruce community type, locally common only at the northeast end of Bates Lake. It is characterized by scattered tree growth of primarily white spruce and a continuous mat of mosses with almost no shrub growth.

10. **FRASER CREEK FEN**

The marsh-swamp complex of the Alder Creek Valley is extremely productive in comparison with other ecosystems and its importance **as** a genetic and ecological reservoir is increased by this factor as well **as** by the scarcity of such wetlands in the Kluane region.

11. **BATES LAKE ISLAND**

Small colonies of herring gulls and Arctic terns are found nesting on this island.

12. **GOATHERD MOUNTAIN**

The alpine area of Goatherd Mountain best represents the coastal alpine ecosystem in Kluane National Park. A local mountain goat population and excellent habitat are also found here.

13. **LOWER ALSEK RIVER**

The southern portion of Kluane is influenced by the more moderate coastal climate, resulting in different combinations of plants and animals. This particular area best represents these ecosystems in Kluane and the national park system and protects a landscape and various plant species not common to the Yukon.

14. **LOGAN NUNATAK**

The nunataks of Kluane are important islands of life surrounded by an extensive inhospitable environment. Their existence and evolution are thus extremely interesting. This area is designated for special preservation because of the diversity of plants and animals inhabiting the area and because of its isolation.

Source: Parks Canada 1980.

CHAPTER 3

Climate of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

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3.1 Data Limitations

Accurate descriptions of regional climate must be based on reliable weather records of considerable length from a network of stations located throughout the study area. Such descriptions imply a degree of regional homogeneity which allows generalization. In Kluane, a description of regional climate is difficult because a suitable station network and length of record do not exist. Also, the rugged varied topography results in marked differences in climate and weather over short distances, largely defying generalization and making extrapolation of weather data from adjacent stations invalid. The location within the Park of the climatic divide between maritime and continental climates further limits extrapolation.

The climatic database for the Park is derived from hourly and twice-daily reporting stations widely spaced along the Alaska Highway (see Fig. 3.1) and from the observations of scientific research parties, usually recorded only in the summer. Since 1961, the Arctic Institute of North America has collected summer weather data at Kluane Lake and at a number of high altitude stations in the Icefield Ranges, but our knowledge of weather in the backcountry and in the Icefields is still extremely limited.

The Atmospheric Environment Service (AES) station record is contained in Appendix I. Only Haines Junction and Whitehorse Airport have been recording for the 30-year period required for calculation of unadjusted climatic normals or long term averages. For most other stations with records 5-19 years in length, AES has applied standard adjustment techniques to the raw data and published the adjusted figures as 'normals' for short record stations.

Given the limitations described above, these records are really only representative of an area immediately surrounding the station itself. To overcome some of these deficiencies, models of temperature and precipitation were developed for the Park. These are useful at the descriptive or overview level but the values generated by the model cannot be relied upon in the absolute sense.

Reliable information must await the development of a network of automated weather stations for selected areas of the Park. A pilot program of this type was initiated in 1976, but the data record has been of limited use as a result of frequent instrument failure, the difficulty of servicing stations in inaccessible areas, and wildlife-related damage to the equipment. Only two stations are still operating - one on Sheep Mountain and one on the Sheep-Bullion Plateau. Recently, technologically superior equipment has been developed capable of remote data collection and able to function for longer periods without servicing. Two new stations

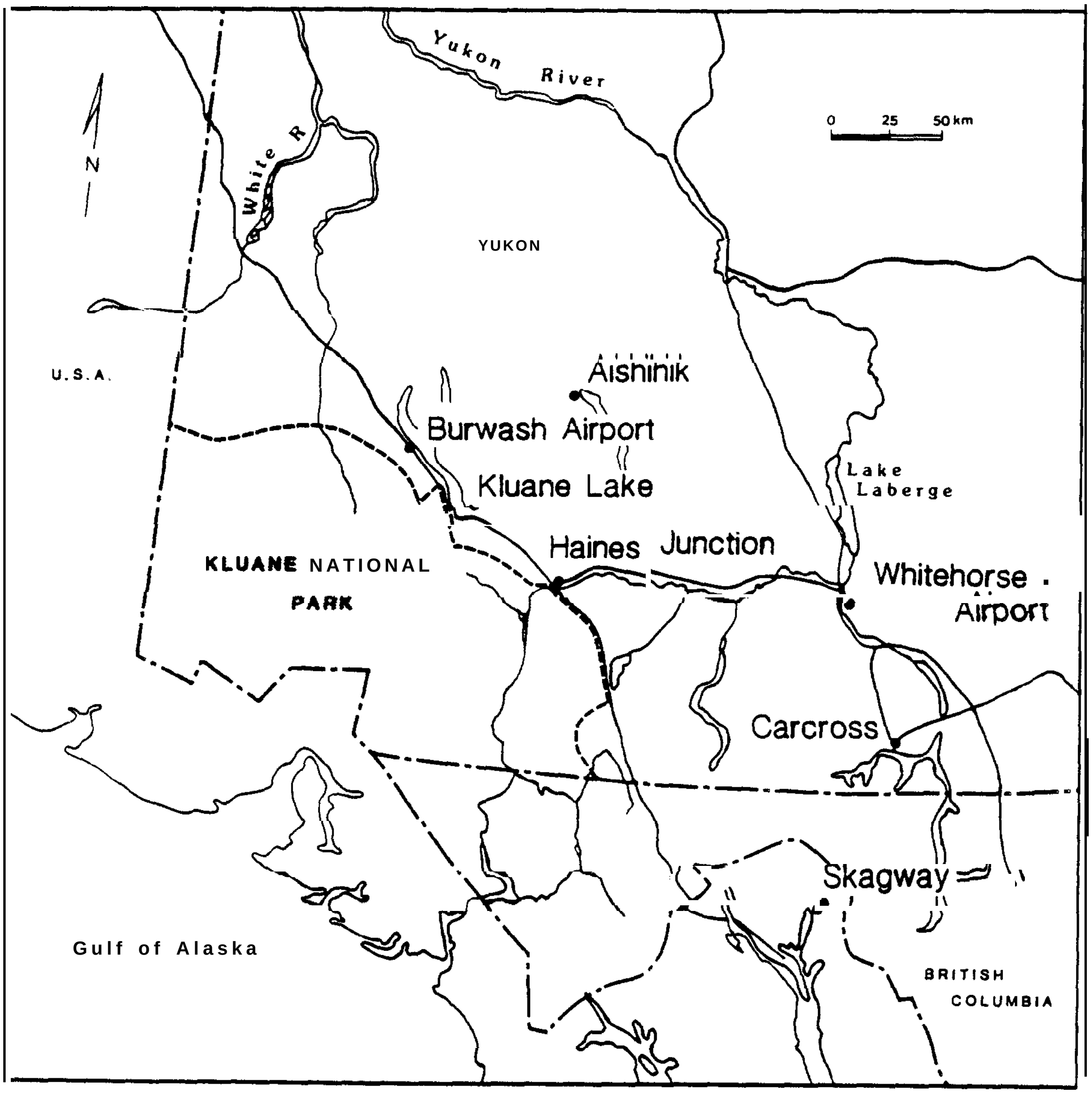


Figure 3.1 Climate station network - Kluane National Park.

using this type of equipment, are proposed for the Slims River Valley. These should provide much needed weather information for *visitors* and will also provide a database for study of geomorphic processes influenced by weather (eg. landslides) and a documented understanding of the influence of weather on wildlife.

The description of climate and weather to follow focusses on the synoptic scale patterns which influence the Park. Station records are presented where available for a more detailed picture of the climate in a particular area. This is followed by a discussion of the limitations which climate imposes on visitor use of the Park and a brief description of some of the more important ways in which climate influences other elements of the ecosystem.

3.2 General Climatic Controls

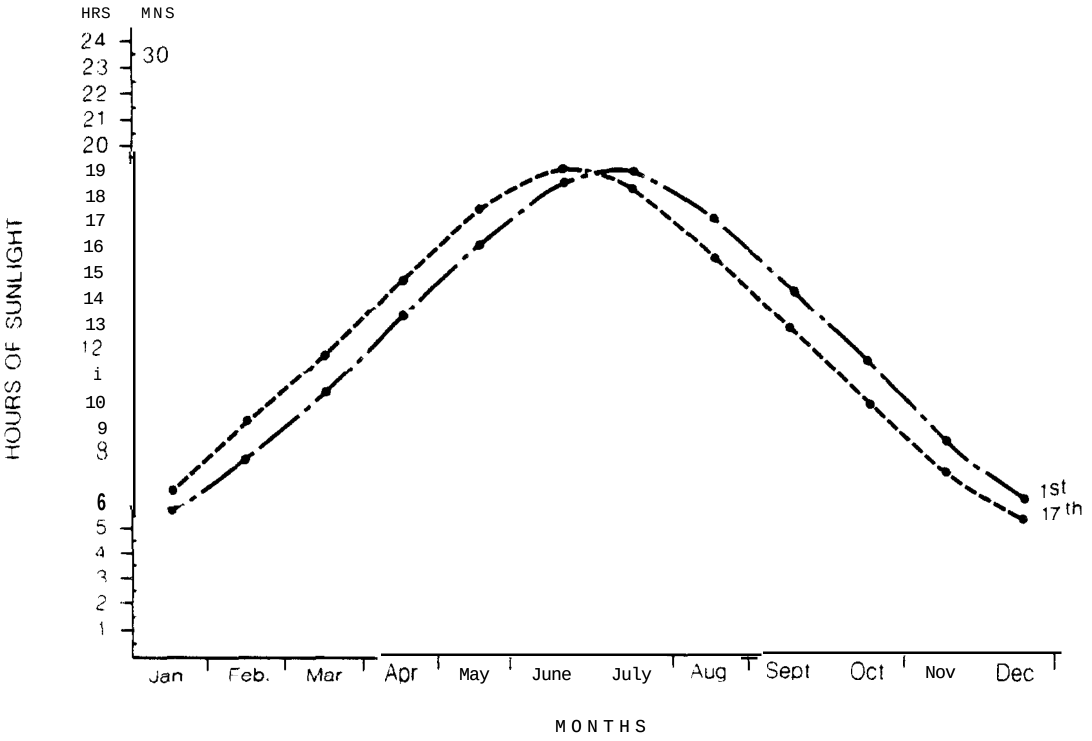
There are four general factors which determine the climate of an area - latitude, topography, altitude, and **the general** atmospheric circulation.

3.2.1. Latitude

Latitude is the major external control on climate and determines the amount of solar radiation available at the surface. In high latitudes, as in Kluane National Park at about 61°N, there are marked seasonal contrasts in day length and receipt of solar radiation. At winter solstice, the day is only about six hours long, while at summer solstice, the sun is above the horizon for over nineteen hours (Figure 3.2). Latitude also determines. the intensity of the sun's rays at the surface. Near the equator, the sun is directly overhead for long periods and heating is intense. In high latitudes, the sun is never very high above the horizon even in mid-summer and so, while the daylight period may be long, the sun's rays strike the surface at an oblique angle and are much less intense. In mountainous areas such as Kluane the generally low sun angle results in persistent shade conditions in some valleys and can markedly affect the microclimate of an area.

3.2.2 Topography

Climate and weather conditions in the Park are directly related to the presence and influence of the St. Elias Mountains. Cyclonic storms transporting moist air from the Gulf of Alaska are moved inland by the predominantly westerly circulation and are forced to rise over successive ranges of the St. Elias Mountains which stand generally perpendicular to the flow of air. Heavy cloud and precipitation result producing a distinctly maritime climate in coastal areas. This regime extends into the mountains nourishing the icefields and valley glaciers of the central areas of the Park. Maximum precipitation occurs at about 1370 m on the windward slope (Marcus & Ragle 1970) though maximum accumulation of snow is



Latitude 61°N	Jan	Feb.	Mar	Apr	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Day of month
	05 43	07 48	10 24	13 20	16 10	18 39	19 07	17 05	14 16	11 27	08 34	06 11	1st
	06 35	09 15	11 55	14 51	17 34	19 16	18 16	15 39	12 46	09 58	07 11	05 34	17th
	HR MN												

source: List 195 1.

Figure 3.2 Hours of sunlight - Kluane National Park.

at higher elevations (1500-3000 m) where cooler temperatures ensure that most precipitation falls as snow. Precipitation decreases rapidly with distance inland as the moisture content of the air declines. As the air descends the lee slope of the mountains, it warms adiabatically and becomes very dry, producing a rainshadow effect, occasional chinooks, and a generally semi-arid continental climate in the eastern parts of the Park. This rainshadow effect is quite pronounced. Yakutat, Alaska on the coast receives 3226 mm of precipitation annually while Haines Junction, Yukon receives only 292 mm. The rainshadow effect can also occur on a smaller scale and to a lesser degree in valley areas between the ranges of mountains.

The differences in the two climatic regimes are reflected in the extent of active glaciation in the St. Elias Mountains. On the windward slopes in the maritime climatic zone, glaciers extend to sea level in the Gulf of Alaska and the equilibrium line on the glacier surface (where winter accumulation is equal to summer ablation) is located at about 1100 m. On the continental slope, where the annual temperature range is greater and the climate generally drier, ice extends down to 900-1200 m and the equilibrium line lies at about 2100 m.

On a smaller scale, the mountains and valleys of the Park channel air masses and produce local winds which can greatly influence the climate at a particular site. For example, air masses channelled up the Alsek valley experience less modification than those passing directly over the St. Elias Mountains and therefore bring moister air and a more maritime climate to the Mush-Bates lakes area at the south end of the Park. In other areas, cold stable air becomes established in deep mountain valleys and cannot be dislodged by passing disturbances resulting in prolonged cold periods and temperature inversions.

In general,

> "the effect of rugged topography is to create countless topoclimates which differ widely from one another in response to slope and aspect effects. Thus, windiness is highly variable over short distances and the amount of solar radiation or moisture received in a particular locality may bear little relation to measured or expected values for that altitude." (Barry & Van Wie 1974).

3.2.3 Altitude

In general, air temperature delines with height at an average rate of 0.65°C per 100 m. Application of this empirical relationship to extrapolate temperature data from valley stations to interior mountainous areas is complicated by the presence of temperature inversions in deep valleys and by marked temperature variations caused by aspect, local wind patterns, and proximity to glaciers. Changes in vegetation patterns with altitude are an expression of the relationship between altitude and other climatic variables , predominantly temperature and wind. Ascending from the valley floor, the boreal forest or montane vegetation changes to subalpine, alpine, and eventually to nival associations. The elevation of these zones and their boundaries in any location Is site specific and dependent on microclimatic factors.

3.2.4 Seasonal Synoptic Patterns

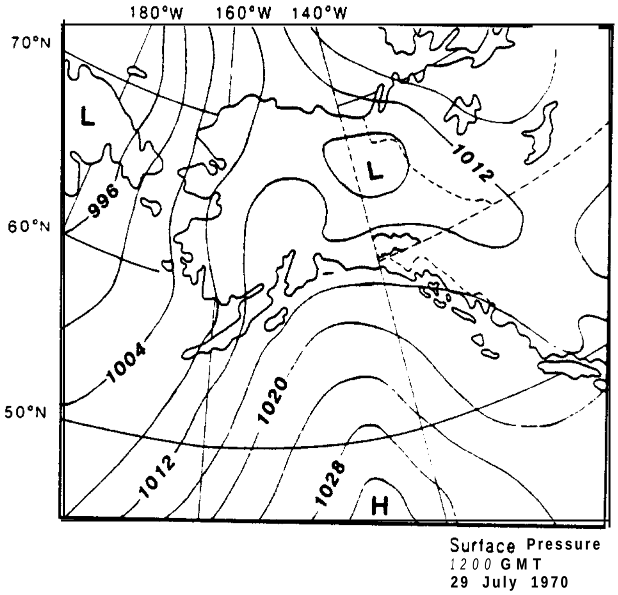
The Park lies in **a** zone characterized by development of an intense winter low pressure cell over the Gulf of Alaska (the Aleutian Low) and by seasonal changes in predominant pressure systems over land. In winter the dominating Mackenzie High pressure cell floods the Yukon east of the mountains with cold stable air which settles in deep valleys and the Shakwak Trench. At this time, strong cyclonic storms which bring precipitation to the coast and icefields are generally unable to dislodge this cold stable air and pass over the park with little surface effect. Temperature inversions often result and persist for long periods. Winter precipitation east of the mountains is generally low. In summer, the Aleutian Low weakens and the Mackenzie High is replaced by several weak low pressure cells. The synoptic pattern becomes more complicated with three conditions likely to occur (Marcus 1974, Kolberg 1974):

1. The Pacific or Hawaiian High moves north in late spring and summer and brings warm, dry weather to the Park when it dominates (Fig. 3.3a).

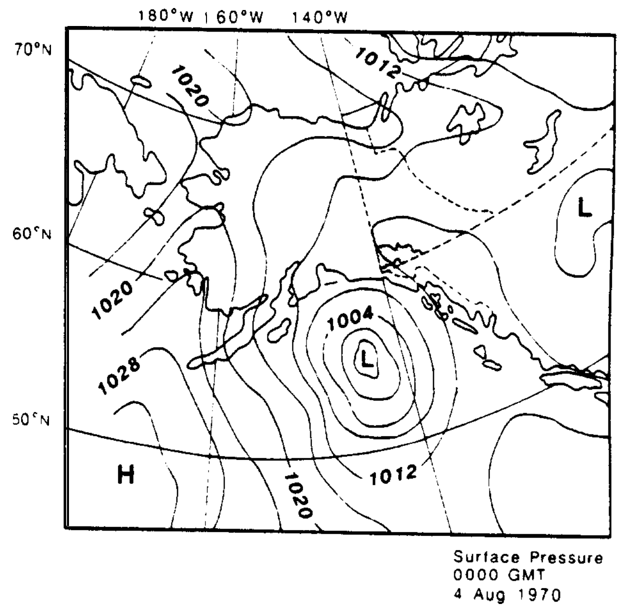
2. The weak low pressure cells which form over continental Alaska and Yukon provide source areas for cyclonic storms which track southwestward bringing percipitation to the interior valleys and continental slope (Fig. 3.3b).

3. The more common pattern of cyclonic activity, orographic precipitation, and rainshadow still occurs when the weak remnants of the Aleutian Low settle in the Gulf of Alaska and replicate the winter circulation pattern (Fig.3.3c). These storms tend to occlude over the mountains and only become surface features to the east of the Park in the Whitehorse area.

An exception to these general patterns occurs at the south end of the Park in the Mush-Bates lakes area. Here weather systems moving from the south side of the Aleutian Low are often channelled up the Alsek Valley, undergoing significantly less modification than those passing directly over the mountains. As a result, the climate in the Mush-Bates area is wetter and cloudier in all seasons and less continental and severe than the rest of the Greenbelt. This synoptic pattern is the major source of storm precipitation for the

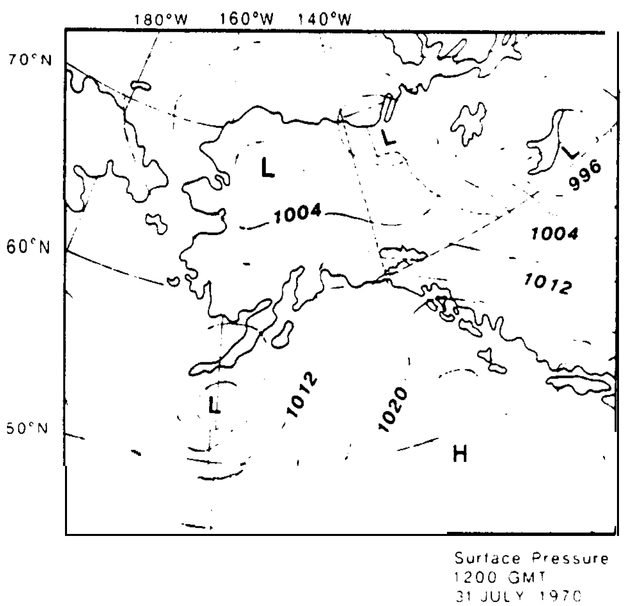


3.3a Typical Placement of the Pacific (Hawaiian) High pressure cell during poleward summer migration. Zonal flow IS blocked and deflected along a continental vector.



3.3b Classical summer disposition of the Aleutian Low into the Gulf of Alaska. Onshore flow brings clouds and precipitation to ' the panhandle.' the Fanweather Range, and the St. Elias and Chugach Mountains.

source: **Marcus 1074.**



3.3c A sequence of low-pressure cells tracks the continental side of the coastal mountain ranges Inland storms are often carried by this zonal flow The two low-pressure cells straddling longitude 160" W are products of the summer disruption of the Aleutian Low source region

Figure 3.3 Predominant summer synoptic patterns - Kluane National Park.

Greenbelt and continental slope areas of the Park in summer (Taylor-Barge 1969). Precipitation is caused when air masses channelled up the Alsek are moved by easterly winds against the continental slope of the St. Elias Mountains producing cooling, cloud and orographic precipitation in a general pattern similar to that experienced on the marine slope.

3.3 Annual Temperature Regime

3.3.1 Greenbelt

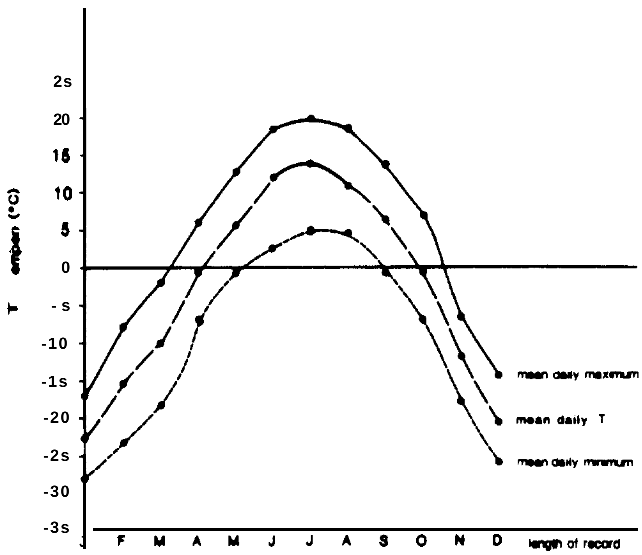
Climate stations nearest to the Park are Burwash Airport, Kluane Lake, and Haines Junction. All lie generally east of the Park and , though they may reflect conditions which are slightly warmer and more continental, they are probably representative of much of the Greenbelt. Their station records reflect characteristically low mean annual temperatures, large annual temperature ranges, cold dry winters, short warm wetter summers and generally low total precipitation. Figure 3.4 shows the annual temperature patterns for these three stations. Data for Whitehorse are also included for comparison. Mean daily maximum temperatures are usually above 0°C from March through October, and range from 15 - 20°C in July and August. The warmest period of the year is mid-July. Although frost can occur in any month, mean daily minimums are generally above 0°c from May through September. The coldest period of the year is January. On a daily basis, the minimum temperature is usually recorded near sunrise (in winter 8 am; in summer 4 am) and the maximum temperature is recorded around 4 or 5 pm. The range of daily temperatures average 12-15°C in summer and 8-12°C in winter. The higher values relate to more northerly areas of the Park.

Temperature extremes for Burwash, Kluane Lake and Haines Junction are also given in Figure 3.4 and represent, in the case of extreme minima, some of the coldest temperatures ever recorded in Canada.

Tables 3.1 and 3.2 summarize the data on frost occurrences, frost free periods and the probability of frost. Only 40 minutes of latitude separate the most northerly and southerly stations but the frost free periods vary from 82 days at Whitehorse to 21 days at Haines Junction and 30 days at Burwash Airport. These differences are due largely to topographic influences. Haines Junction and Burwash Airport experience cold air drainage and channelling and persistent inversions from the Alsek and Duke river valleys respectively. Proximity to Kluane Lake moderates the climate of the Kluane Lake station partially offsetting the topographic influences created by its location near the mouth of the Slims River Valley, while Whitehorse Airport experiences a frost climate more representative of the latitude in general.

Haines Junction YT - mean annual temperature -3.2°C

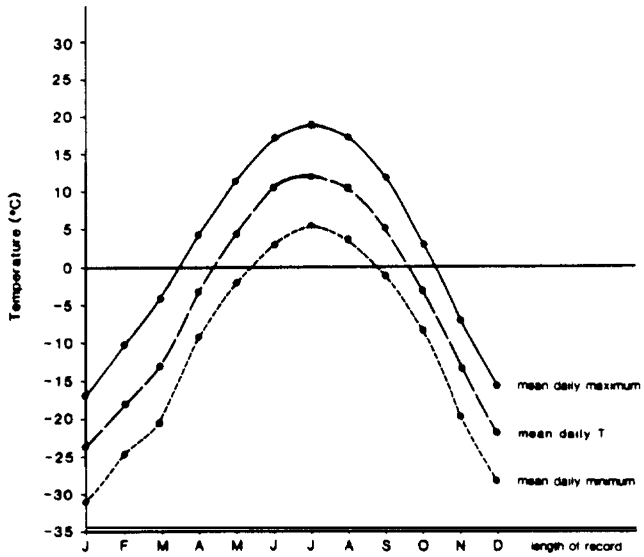
	J	F	M	A	M	J	J	A	S	O	N	D
mean daily maximum	-17.0	-8.0	-1.9	5.9	12.8	18.1	19.9	18.6	13.1	4.5	-6.5	-14.7
mean daily	-22.9	-15.6	-10.0	-0.6	5.4	10.3	12.5	10.8	6.2	-1.3	-12.2	-20.5
mean daily minimum	-28.6	-23.1	-18.1	-7.1	-1.9	2.5	5.0	3.0	-0.9	-7.1	-17.9	-26.2



	J	F	M	A	M	J	J	A	S	O	N	D	length of record
[illegible]	12.2	15.0	16.8	20.6	27.8	32.8	31.1	31.0	26.6	18.9	13.9	10.6	35-37 years
[illegible] minimum	-58.9	-58.9	-43.9	-30.6	-12.2	-6.7	-3.3	-11.1	-17.2	-30.6	-47.2	-53.9	35-37 years

Burwash Airport YT - mean annual temperature -4.4°C

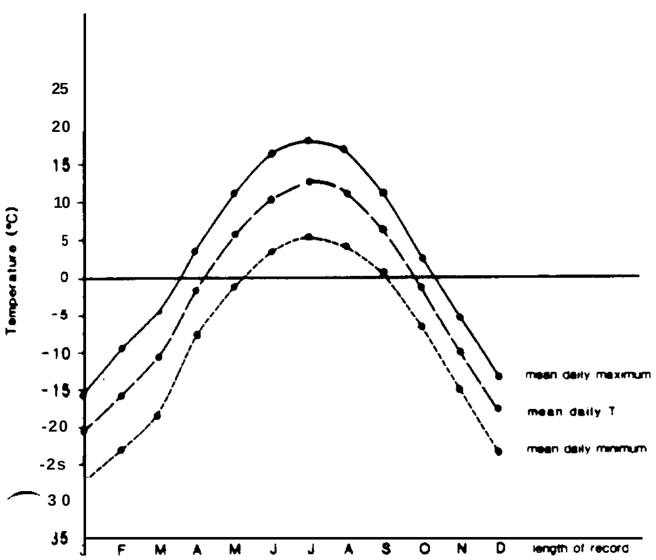
	J	F	M	A	M	J	J	A	S	O	N	D
mean daily maximum	-17.3	-10.1	-4.0	4.4	11.4	17.3	18.1	17.3	11.6	2.7	-7.0	-15.4
mean daily T	-24.4	-18.0	-12.9	-2.3	4.9	10.3	12.3	10.4	5.1	-3.2	-13.4	-22.0
mean daily minimum	-30.9	-24.7	-21.7	-9.4	-1.7	2.6	5.5	3.6	-1.2	-8.6	-18.6	-27.9



	J	F	M	A	M	J	J	A	S	O	N	D	length of record
Extreme maximum	6.9	10.6	10.4	20.3	21.1	31.7	27.8	28.4	23.3	15.7	10.6	11.1	14-15 years
Extreme minimum	-54.4	-56.0	-46.9	-31.7	-12.8	-3.9	-3.3	-7.8	-17.8	-32.8	-40.0	-51.1	14-15 years

Kluane Lake YT - mean annual temperature -2.7°C

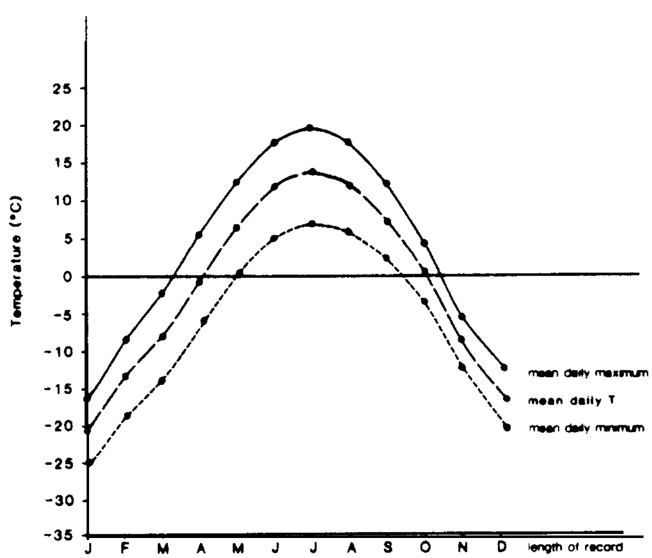
	J	F	M	A	M	J	J	A	S	O	N	D
mean daily maximum	-15.3	-9.2	-4.4	3.7	11.1	16.7	18.6	17.1	11.6	2.9	-5.3	-13.7
mean daily T	-20.5	-15.4	-10.6	-1.8	5.4	10.3	12.8	11.2	6.3	-1.6	-9.7	-18.5
mean daily minimum	-27.3	-23.0	-18.8	-7.4	-1.1	3.8	6.0	4.6	0.5	-6.7	-16.1	-24.2



	J	F	M	A	M	J	J	A	S	O	N	D	length of record
Extreme maximum	7.2	8.3	8.6	19.5	20.0	26.1	27.2	27.8	22.2	14.0	11.1	3.9	7-10 years
Extreme minimum	-48.9	-46.0	-41.1	-23.9	-6.7	-3.3	0.0	-4.4	-11.1	-21.1	-31.7	-46.1	6-11 years

Whitehorse Airport YT - mean annual temperature -1.2°C

	J	F	M	A	M	J	J	A	S	O	N	D
mean daily maximum	-16.4	-8.3	-2.3	5.6	12.7	18.4	20.3	18.4	12.4	4.4	-6.3	-12.5
mean daily T	-20.7	-13.2	-8.2	0.3	6.7	12.0	14.1	12.6	7.5	0.6	-8.8	-18.6
mean daily	-25.0	-18.1	-14.0	-6.1	0.6	5.5	7.9	6.5	2.6	-3.1	-12.3	-20.7



	J	F	M	A	M	J	J	A	S	O	N	D	length of record
Extreme maximum	9.0	11.7	11.7	20.6	30.0	34.4	32.8	30.0	26.7	18.9	11.7	8.3	?
Extreme minimum	-52.2	-51.1	-40.6	-27.8	-11.7	-2.8	0.0	-4.4	-11.7	-28.3	-40.6	-47.8	?

Source: A.E.S. 1982.

Figure 3.4 Annual temperature regimes - Kluane region ,Yukon

Table 3.1 Frost data – Greenbelt stations, Kluane region, Yukon.

Station	1951-80 Normals				Extremes							
	# Years	Average Frost Free Period	Last Frost (spring)	First Frost (autumn)	# Years	Last Frost (spring) earliest	Last Frost (spring) latest	First Frost (autumn) earliest	First Frost (autumn) latest	Frost-free period (days) shortest	Frost-free period (days) longest
Burwash A 61°22'N 139°03'W 799 m asl.	4	30	Jul. 1	Aug. 1	14	Jun. 19	Jul. 15	Jul. 16	Aug. 20	11	50
Haines Junction 60°46'N 137°35'W 599 m asl.	0	21	Jul. 6	Jul. 26	36	Jun. 16	Jul. 15	Jul. 16	Aug. 19	0	63
Kluane Lake 61°01'N 138°24'W 786 m asl.	8	59	Jun. 19	Aug. 18	8	Jun. 9	Jul. 3	Jul. 22	Aug. 31	18	82
Whitehorse A 60°43'N 135°04'W 703 m asl.	9	82	Jun. 8	Aug. 30	46	May. 13	Jul. 4	Jul. 30	Sept. 20	25	126

Source: AES 1982.

lima

ge

Table 3.2 Probability of frost - Greenbelt stations, Kluane region, Yukon.

Station	Last Spring Frost		First Autumn Frost	
	50% on or after	25% on or after	50% on or after	75% on or after
Burwash A	Jun. 30	Jul. 30	Jul. 30	Aug. 11
Haines Junction	Jul. 9	Jul. 14	Jul. 25	Aug. 5
Whitehorse A	Jun. 5	Jun. 19	Aug. 29	Sep. 3

Source: AES 1982.

Temperature inversions have an important effect on the climate of the Park, often making valley bottoms several degrees colder than nearby areas upslope and influencing patterns of animal movement: and human activity. In winter, inversions occur under clear sky conditions when loss of radiation by the snow-covered ground surface exceeds incoming solar radiation, and net cooling of the surface and the air immediately above it occurs. Under high pressure ridges these conditions can persist for long periods and are augmented by downslope drainage of cold air. Marcus (1974) states that the winter inversion layer can be 1000 m deep. As mentioned earlier, in winter disturbances usually pass over the Park at too high a level and are too weak to dislodge these very stable air masses from deep mountain valleys. Inversions are dissipated gradually by the formation of low level cloud which reflects and reradiates escaping ground radiation back to the surface and by light steady winds which mix the stable layers with warmer air above. Similar conditions can also produce temperature inversions in summer, sometimes leading to frost in valley bottoms. They are not as persistent however as winter inversions and tend to break up in mid-morning as winds increase. These patterns are reflected in the data contained in Table 3.3, showing that while nighttime inversions occur with similar probability throughout the year, they persist into daytime only in winter. Figures for the Park are probably similar.

Cold air drainage in mountain valleys is another important aspect of Kluane's climate. The phenomenon occurs throughout the year under stable calm conditions but is most pronounced in winter. Actual data from the Park are not available, but under persistent high pressure conditions in January 1980 Harris (1982) recorded a temperature of -71°C at 751 m in a valley bottom near Fort Nelson, B.C. At the same time a nearby station at 1540 m recorded only -38°C. Harris postulates that similar temperature conditions occur frequently throughout the southern Yukon when topography and the prevailing synoptic weather pattern are conducive to intense cooling and cold air drainage.

3.3.2 Icefields

While the Icefields are theoretically under the influence of the maritime climatic regime, their extreme altitude offsets any amelioration of climate and they experience a severe high alpine temperature regime.

Summer weather conditions in the Icefields were investigated from 1963-1971 as part of the Icefields Ranges Research Project. Several of the twelve stations were established in the Park proper (see station catalogue reproduced in Table 3.4); the Mount Logan station at 5360 m is the highest weather station ever operated in North America. The extreme maximum daily temperature never exceeded 0°C in three years of summer operation at this station.

Table 3.3 Frequency of ground based inversions at Whitehorse Airport, Yukon (expressed as percent time).

Time	Dec. - Feb.	Mar. - May	Jun. - Aug.	Sept. - Nov.
2 p.m. YST	42	1	0	0
2 a.m. YST	60	54	66	50

Source: Munn et al 1970.

Table 3.4 Weather stations - St.Elias Mountains, 1963-1971.

Station	Latitude (N)	Longitude (W)	Elevation (m)	Type of surface	Period of Record (year)	(days)
Kluane Lake (base camp)	61°01'	138°25'	786	gravel	1963	June 5 - Aug. 24
					1964	June 1 - Aug. 26
					1965	May 14 - Aug. V
					1966	June 16 - Aug. 20
					1967	June 15 - Aug. 24
					1968	May 18 - Aug. 19
					1969	May 27 - Aug. 14
					1970	May 23 - Dec. 31
					1971	Jan. 1 - Aug. 30
Divide [illegible] •	60°46'	139039'	2640	snow	1963	June 19 - Aug. 25
Divide Station B.	60°47'	139'42'	2637		1964	June 10 - Aug. 17
	60°46'	139'42'	2670		1965	June 4-Aug. 8
	60'46'	139042'	2652		1966	July 1 - Aug. 4
	60°46'	139°42'	2652		1967	June 13 - Aug. 20
	60°46'	139°42'	2652		1968	June 5 - Aug. 16
	60'46'	139°42'	2652		1969	June 10 - Aug. 14
	60°46'	139'42'	2652		1970	June 29 - Aug. 3
Divide Station C •	60°45'	139'42'	2674	rock (nunatak)	1965	June 13 - Aug. 16
Divide Station D •	60°45'	139°41'	2741	snowridge (nunatak)	1965	June 13 - Aug. 15
Kaskawulsh	60°44'	139°09'	1768	medial ice-covered moraine	1964	July 4 - Aug. 22
					1965	May 28 - July 25
					1966	July 4-Aug. 5
Seward *	60°20'	139'55'	1'360	nunatak	1964	June 18 - Aug. 14
					1965	July 7 - July 25
Chitistone Pass	61°36'	142°03'	1774	alpine tundra	1967	June 9 - Aug. 20
					1968	May 31 - Aug. 16
					1969	May 25 - Aug. 14
Rusty Glacier •	61°14'	140°15'	2165	dirt-covered ice	1967	July 1 - Aug. 17
					1968	July 6 - Aug. 16
Mt. Logan *	60°36'	140°30'	5360	snow	1968	July 2 - Aug. 2
					1969	June 28 - July 29
					1970	June 24 - July 24
Gladstone	61'21'	138'20'	ccl740	alpine tundra	1967	June 29 - Aug. 23
					1968	June 19 - Aug. 23
Terminus •	60°49'	138°38'	826	outwash (sand and gravel)	1963	July 15 - Aug. 23
					1964	June 1 - Aug. 18

• Within Kluane National Park

Source: Marcus 1974.

The Kaskawulsh station, at the confluence of the north and central arms of the Kaskawulsh Glacier (1768 m) recorded mean daily summer temperatures consistently above freezing, placing it climatically below the firn line in that part of the Icefields. Mean daily temperatures at the Divide stations (at about 2650 m) ranged from a high of +1.4°C in June 1969 to -6.7°C in June 1965. Data for several of these stations are abstracted in Table 3.5. Winter data for the Icefields have never been collected because the severity of the climate makes instrument operation unreliable and because of the general inaccessibility of the area.

3.3.3 Temperature Modelling

In an attempt to overcome some of the problems created by the general lack of climatic data for the Park area and the difficulties of extrapolation from existing stations in such a climatically and topographically diverse area, Webber (1974) developed a model describing the variation of temperature with altitude in the Park. The model used radiosonde data collected at Whitehorse airport and at Yakutat, Alaska. These data were then modified to correspond to the temperatures expected to prevail just above mountain surfaces. The result was a graph of the change of projected surf ace temperature with altitude. Using a smoothed elevation map of the Park and taking into account aspect, surface cover, temperatures from low level stations and Icefield Ranges Research Project data, these can be portrayed as a series of maps of mean monthly temperatures over the entire Park area. Maps for January, April, July and October are included as Figures 3.5 a, b, c, and d. Temperatures portrayed on the maps are approximations and are subject to errors due to local influences which cannot be accounted for in the model. However, they represent the best approximations available for high altitude areas above 3000m (Webber 1974).

3.3.4 Freeze-up and Break-up

Table 3.6 indicates freeze-up and break-up dates for Kluane Lake at Burwash and for the Yukon River at Whitehorse. Long term observations have not been made for rivers in the Park. The Warden service has collected ice thickness data for several lakes in the Park (see Table 3.7). Small, high altitude lakes which develop a deep snow cover have less variation in ice thickness than the larger lakes which tend to be windblown.

3.4 Annual Precipitation Regime

3.4.1 Local Effects

Precipitation is the most difficult climatic parameter to measure and to represent accurately in the spatial sense. Even on a flat plain, precipitation will vary over short distances. When

Table 3.5 Selected weather data - Icefield stations. Kluane National Park.

Date	Length of record (days)	Temperature (°C) Mean max.	Mean min.	Mean	Extreme max.	Extreme min.	Precipitation (mm H_2O equivalent)	Wind speed (m/sec)	Cloudiness (tenths sky dome)	Pressure (milli-bars)	Relative humidity (%)	Insolation (langleys) Mean	Extreme max.	Extreme min.	Q_2Q_2
DIVIDE STATION A (1963) AND DIVIDE STATION B (1964-1970)															
1963															
June	11	-0.4	-10.9	-5.6	7.2	-15.6	275	2.5	7.2	728.5	83.5	873.0	102.30	724.0	0.88
July	31	4.1	-5.7	-1.3	10.9	-16.3	340	1.7	6.8	733.6	83.6	811.0	985.0	576.0	0.87
Aug.	23	2.9	-5.4	-1.2	10.9	-15.1	356	2.7	6.1	737.7	81.4	775.0	839.0	571.0	0.87
1964															
June	21	0.7	-6.8	-3.0	5.6	-10.5	53	2.7	7.4	739.8		762.2	-	-	0.77
July	31	1.5	-6.5	-2.6	10.6	-14.6	27	2.2	6.6	740.5		790.0	-	-	0.84
Aug.	17	1.7	-7.3	-3.2	6.1	-11.1	13	1.7	7.0	740.5		672.8	-	-	0.84
1965															
June	26	-2.6	-12.1	-6.7	3.3	-17.2	77	2.9	6.9	740.5	83.4		-	-	-
July	31	3.1	-5.6	-1.4	12.8	-15.0	108	2.2	6.8	738.2	88.6		-	-	-
Aug.	8	7.9	-5.6	-0.6	10.0	-8.9	23	2.5	4.3	743.0	74.8		-	-	-
1966															
July	31	4.8	-3.9	0.0	11.1	-8.3	89	2.2	6.2	742.9	85.4		-	-	-
Aug.	4	-0.7	-6.5	-3.7	-0.3	-7.2	T	3.5	8.8	743.6	96.6		-	-	-
1967															
June	16	3.9	-4.0	-0.8	10.6	-7.2	-	2.6	6.3	-	78.2		-	-	
July	31	2.9	-4.8	-1.5	8.3	-10.0	-	3.0	7.3	-	77.8		-	-	-
Aug.	20	2.3	-4.2	-1.4	5.2	-6.6	-	3.6	6.5	-	87.0		-	-	-
1968															
June	30	0.7	8.1	-3.1	8.3	-21.9	-	2.8	5.8	741.9	86.3		-	-	-
July	31	4.1	-4.7	-0.1	10.3	-9.4	-	2.0	4.7	739.6	90.1		-	-	-
Aug.	16	4.3	-5.2	-0.9	7.8	-7.2	-	2.2	5.3	741.2	88.3		-	-	-
969															
June	20	7.2	-3.3	1.4	14.0	-9.0	27	2.3	5.0	741.2	76.0	587.0	722.4	399.6	0.59
July	31	3.0	5.8	2.1	12.1	-15.8	38	2.9	7.1	735.8	86.0	560.3	673.2	380.4	0.60
Aug.	14	-0.8	-10.1	-5.4	9.9	-21.1	56	3.0	8.0	730.7	88.1	500.7	592.8	421.2	0.61
1970															
June	3			4.1	-1.7	-7.2	15	3.4	7.2	726.5	84.8		-	-	-
July	31	-0.1	-7.2	-3.9	4.4	-20.4	19	2.9	7.0	730.2	86.9		-	-	-
Aug.	3			-3.8	0.6	-6.2	18	3.7	9.0	732.9	92.5		-	-	-
DIVIDE STATION C															
1964															
June	18	-0.6	-5.1	-2.9	3.2	-6.8	-	-	-	-	-	-	-	-	-
July	31	0.6	-5.4	-2.8	7.9	-8.3	-	-	-	-	-	-	-	-	-
Aug.	16	1.0	-5.4	-2.7	4.4	-7.9	-	-	-	-	-	-	-	-	-
DIVIDE STATION D															
1964															
July	16	3.2	-3.2	-0.6	12.9	-6.0	-	-	-	-	-	-	-	-	-
Aug.	15	0.2	-6.6	-4.0	5.4	-10.2	-	-	-	-	-	-	-	-	-
KASKAWULSH STATION															
1964															
July	28	8.3	0.9	4.5	14.5	-1.2	29	2.6	6.0	-	75.1	-	-	-	-
Aug.	22	7.5	0.8	4.2	10.2	-1.0	2	3.0	6.9	-	79.3	-	-	-	-
1965															
June	30	2.8	-3.7	0.4	8.8	-10.0	6	4.6	5.9	824.4	76.2	-	-	-	-
July	25	3.4	6.4	3.7	13.3	-2.2	13	4.2	6.6	855.7	81.6	514.1	657.2	223.2	0.54
1966															
July	27	9.4	2.5	5.8	12.2	0.0	2	-	-	-	76.2	-	-	-	-
Aug.	5	-	-	3.6	6.1	-1.0	T	-	-	-	70.2	-	-	-	-
MT. LOGAN STATION															
1968															
2 July															
2 Aug.	31	10.8	22.2	-17.2	-3.4	-28.3	50	3.4	6.0	528.6	-	802.4	945.2	550.5	0.88
1969															
29 June															
29 July	31	-11.2	-23.9	-17.4	-3.6	-26.6	75	2.6	4.9	511.5	73.0	744.2	993.4	566.4	0.78
1970															
24 June															
23 July	30	15.1	25.4	19.9	-6.9	-34.2	30	3.9	6.6	505.6	86.9	678.4	811.0	507.0	0.70
SEWARD STATION															
1964															
June	13	3.1	-2.6	-3.3	7.8	-5.6	43	2.1	9.1	810.4	85.0	-	-	-	-
July	31	6.4	-0.9	2.4	12.2	-4.5	25	1.5	5.9	808.3	89.9	-	-	-	-
Aug.	14	6.4	-1.3	2.2	11.1	-3.0	26	1.2	7.6	810.3	83.6	-	-	-	-
1965															
July	18	3.4	-0.6	2.8	15.6	-4.4	15	1.2	8.0	814.0	88.8	520.0	750.0	278.0	0.57

Source: Marcus, 1974.

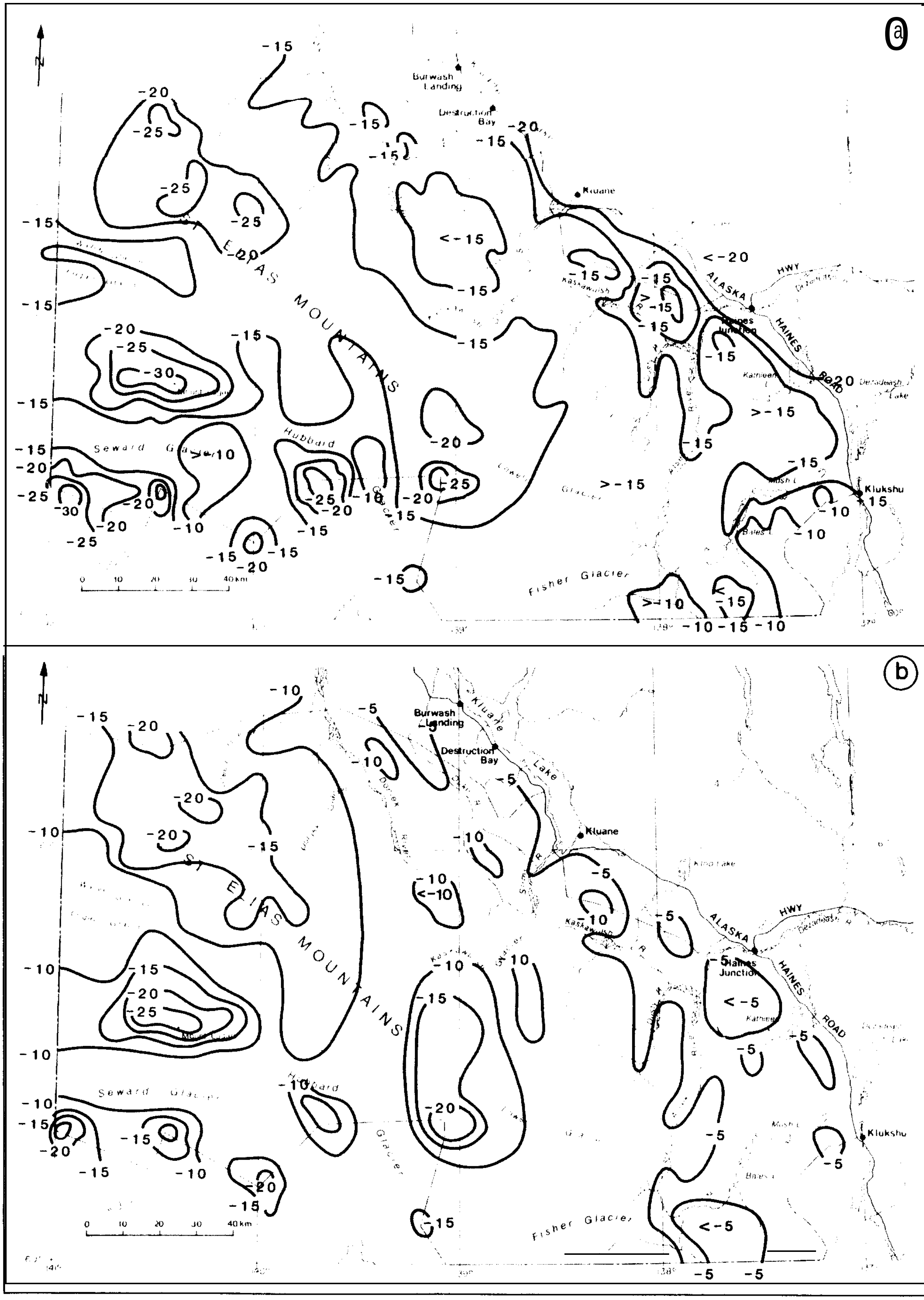
3.5

modelled temperatures-Kluane
al Park:

uary - °C

il - °C

Source: Weber 1974.



KLU

Figur

Mean
Natio

a) Jar

b) Apr

; 3.5

modelled temperatures-Kluane
ıal Park: (concluded)

' - °C

ɔber - °C

Source: Weber 1974.

KLU

Figur

Mean
Natio

c) Jul

d) Oc

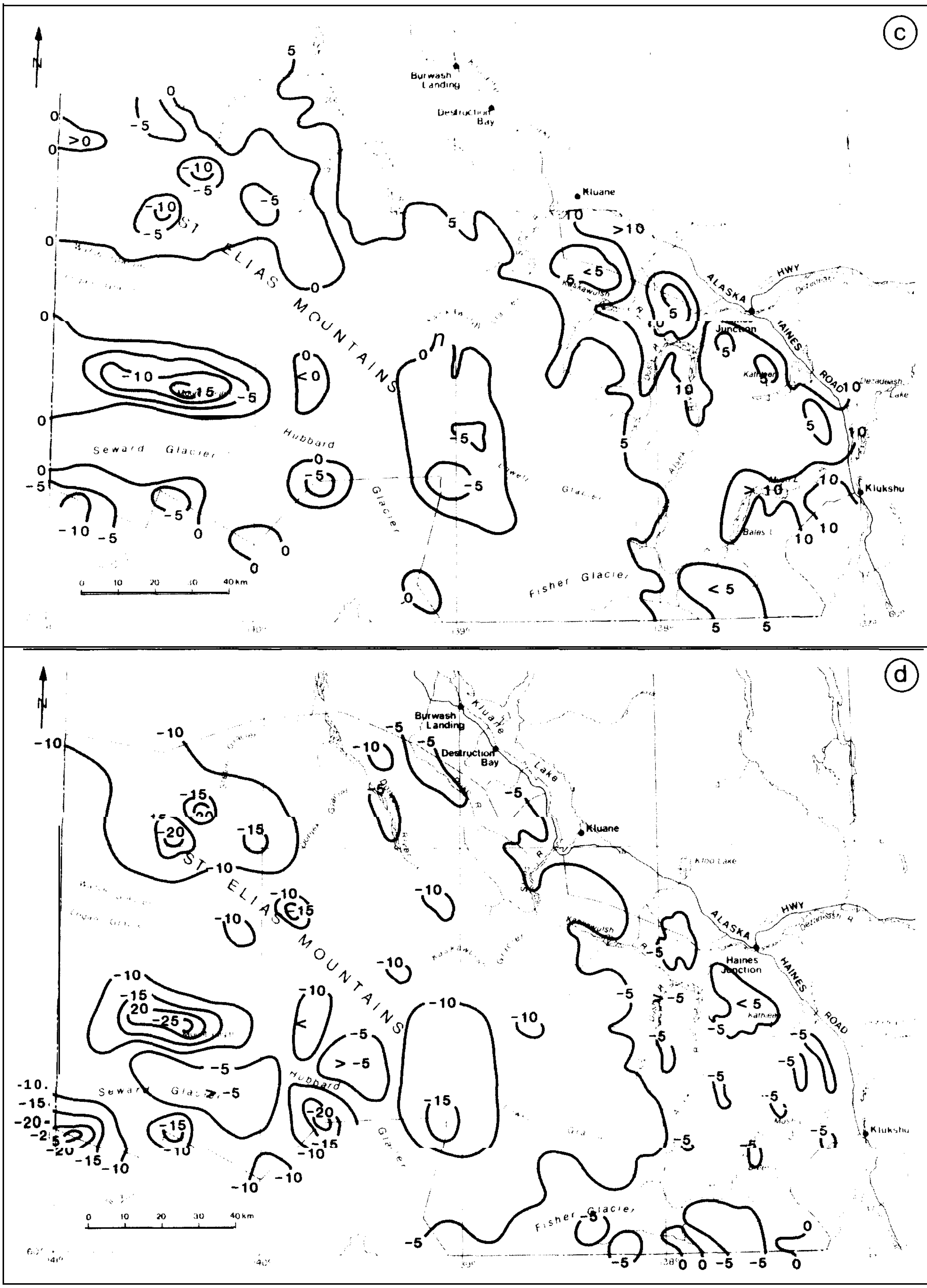


Table 3.6 Freeze-up and break-up observations - Kiuane region, Yukon.

	First Permanent Ice	Complete Freezeover	Ice Safe For Traffic	Ice Unsafe For for Traffic	First Deterioration of Ice	Water Clear of ice
Kluane L. (1966-74)						
earliest	Oct. 12	Nov. 6	Nov. 8	May 1	May 1	May 25
mean	Nov.6	Nov. 23	Nov. 29	May 12	May 20	June 7
latest	Nov. 29	Dec. 6	Jan. 14	Jun. 5	Jun. 15	Jun. 20
Yukon R. at Whitehorse (1901-1974)						
earliest	Oct. 7	Nov. 1	no data	no data	Mar. 13	Apr. 14
mean	Nov. 7	Dec. 3			Apr. 19	May 5
latest	Dec. 10	Jan. 21			May 6	May 24

Source: Allen 1977.

Table 3.7 Maximum ice thickness - Kluane National Park 1976-1980.

	Onion Lake (1976-80)	Bates Lake (1976-80)	Mush Lake (1976-80)	Sockeye Lake (1976-80)
min.	91	70	76	80
mean	94	79	86	94
max.	95	89	94	98

	Louise Lake (1977-80)	Kathleen Lake (1979-80)	Kluane Lake* (1966-69)	
min.	98	94	91	
mean	102	108	129	
max.	115	118	170	

data (cm)

Sources: * Webber 1974.
- Others, Warden Service data.

complicated by topographic features of considerable relief and compounded by the inherent inaccuracies of precipitation measurement, the representativeness of any data set is questionable and at best only useful for the immediate station area.

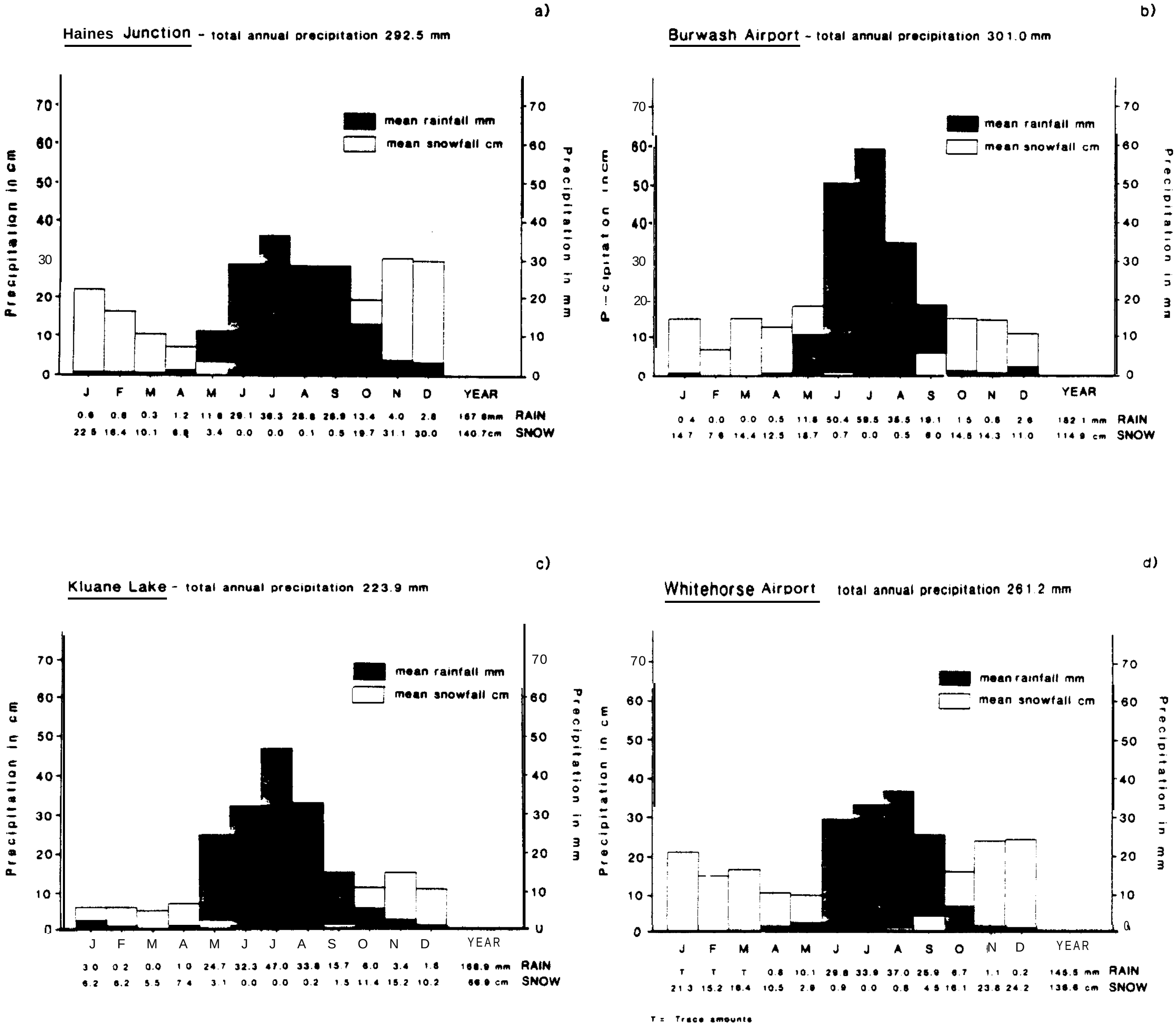
In many areas in the Park, the patterns described in sections 3.2.2 and 3.2.4 are modified by local effects related to topography and proximity to waterbodies. In valleys open to the windflow, covergence and uplift can produce heavy precipitation; sheltered valleys may receive considerably less. Convective cloud and showers may result when solar heating over snow-free areas causes local uplift of air. In summer, proximity to cold lakes or snow and ice-covered surfaces tends to counteract this effect resulting in the cooling and stabilization of the air immediately above the surface. In the fall, however, snowfall often increases downwind of waterbodies prior to freeze-up as the open water tends to steam increasing the moisture content of the air. These lake-related effects are prevalent in the Kluane Lake area.

3.4.2 Greenbelt

Figures 3.6a, b, c, d and Tables 3.8a, b, c, and d present precipitation data for Haines Junction, Burwash Airport, Kluane Lake and Whitehorse Airport.

All stations receive 300 mm or less total annual precipitation, characteristic of a semi-arid continental climate. Snowfall makes up about 38% of the total at Burwash, 49% at Haines Junction, 30% at Kluane Lake, and 50% at Whitehorse. Snowcover is generally light (usually less than 30 cm) and is influenced by other factors such as temperature, evaporation, vegetation type, and particularly wind. Snow is deepest in forested areas of the Park, particularly in the Mush-Bates area where the weak maritime influence produces heavier snowfalls. Windswept, exposed areas such as the Slims Delta seldom have more than a few centimeters on the ground with drifting in hollows and sheltered areas. Snow cover data are collected by the KNP Warden Service at 5 stations in the Park as part of a cooperative program of Snowcourse maintenance sponsored by DIAND. Table 3.9 lists the stations in the vicinity of Kluane National Park. This information is particularly valuable as it provides the only climatic data available for the southern end of the Park. Freezing rain occurs on average 2 days each winter at Whitehorse most commonly in December (Webber 1974).

The annual precipitation maximum occurs in mid-summer (July, early August) at all stations, when 10-12 days per month will have measurable precipitation. These rainstorms are usually generated in interior Alaska or Yukon and track southwesterly till they encounter the Kluane Ranges, producing orographic precipitation. Days with precipitation are at a minimum in late winter when high pressure systems and clear cold weather dominate. Thunderstorms and associated lightning and heavy rain occur on average 6 days a year at Whitehorse, usually in June and July.



Source: AES 1982.

Figure 3.6 Mean precipitation - Kluane National Park.

Table 3.8 Precipitation regime – Kluane National Park a) Haines Junction.

Paraneter Measured	Month												Total	Record Length (yrs)
	J	F	M	A	M	J	J	A	S	O	N	D		
Total Precipitation (mm)	21.9	15.9	9.5	7.6	14.9	29.1	36.3	28.9	29.4	33.1	34.1	31.8	292.5	
Standard Deviation on Total Ppt. (mm)	13.4	9.8	7.1	6.5	10.9	16.6	22.5	17.0	17.0	17.9	34.2	20.5	72.5	
Mean Rainfall (mm)	0.6	0.6	0.3	1.2	11.6	29.1	36.3	28.8	28.9	13.4	4.0	2.8	157.6	
Mean Snowfall (cm)	22.5	16.4	10.1	6.9	3.4	0.0	0.0	0.1	0.5	19.7	31.1	30.0	140.7	
No. of days with measurable ppt.	9	7	5	4	5	7	9	8	8	9	10	11		
Greatest rainfall in 24 hrs. (mm)	12.7	10.2	3.8	12.7	20.6	33.0	28.4	25.0	32.5	55.1	51.6	58.4		35.37
Greatest snowfall in 24 hrs. (cm)	33.3	29.2	14.2	12.7	10.0	3.6	0.0	3.0	7.6	67.3	35.0	23.9		35.37

Source: AES 1982.

Table 3.8b Precipitation regime - Kluane National Park b) Burwash Airport.

Parameter Measured	Month												Total	Record Length (yrs)
	J	F	M	A	M	J	J	A	S	O	N	D		
Total Precipitation (mm)	19.0	7.7	15.8	16.7	22.3	45.4	61.5	38.4	23.9	18.3	18.2	13.8	301.a	
Standard Deviation on Total Ppt. (mn)	12.3	5.8	15.8	11.6	14.8	25.1	28.9	23.3	9.1	6.7	10.7	10.5	56.1	
Mean Rainfall (mm)	0.4	0.0	0.0	0.5	11.8	50.4	59.5	35.5	19.1	1.5	3.8	2.6	182.1	
Mean Snowfall (cm)	14.7	7.6	14.4	12.5	18.7	0.7	0.0	0.5	6.0	14.5	14.3	11.0	114.9	
No. of days with measurable ppt.	9	7	6	5	7	10	12	9	7	8	9	8		
Greatest rainfall in 24 hrs. (mn)	T	0.3	T	2.0	10.7	36.8	38.4	26.6	18.5	5.8	2.5	T		14-15
Greatest snowfall in 24 hrs. (cm)	12.2	5.3	22.9	11.2	22.1	8.9	0.0	7.1	11.2	9.1	15.0	14.7		14-15

Source: AES 1982.

Table 3.8c Precipitation regime - Kluane National Park c) Kluane Lake.

Parameter Measured	Month													Record Length (yrs)
	J	F	M	A	M	J	J	A	S	O	N	D	Total	
Total Precipitation (mm)	7.2	5.9	5.2	7.9	22.1	32.3	47.0	34.1	17.2	16.3	17.7	11.0	223.9	
Standard Deviation on Total Ppt. (mm)	5.0	7.0	5.2	6.1	11.6	21.7	24.6	34.0	15.4	14.2	14.3	7.9	22.1	
Mean Rainfall (mm)	3.0	0.2	0.0	1.0	24.7	32.3	47.0	33.8	15.7	6.0	3.4	1.8	168.9	
Mean Snowfall (cm)	6.2	6.2	5.5	7.4	3.1	0.0	0.0	0.2	1.5	11.4	15.2	10.2	66.9	
No. of days with measurable ppt.	5	5	4	3	4	7	11	8	6	7	8	7		
Greatest rainfall in 24 hrs. (mm)	12.7	T	0	0	16.6	22.1	30.7	29.8	15.7	14.7	6.4	0.0		6-8
Greatest snowfall in 24 hrs. (cm)	6.4	11.4	11.4	8.9	10.0	0.0	0.0	0.8	7.9	11.0	37.0	8.9		6-8

Source: AES 1982.

Table 3.8d Precipitation regime - Kluane National Park d) Whitehorse Airport.

Parameter Measured	J	F	M	A	M	J	J	A	S	O	N	D	Total	Record Length (yrs)
Total Precipitation (mm)	7.7	13.3	13.5	9.5	12.9	30.7	33.9	37.9	30.3	21.5	19.8	20.2	261.2	
Standard Deviation on Total Ppt. (m-n)	9.2	8.6	7.5	8.0	10.0	21.6	19.4	21.7	16.7	10.8	8.8	8.1	48.4	
Mean Rainfall (mm)	T	T	T	0.8	10.1	29.8	33.9	37.0	25.9	6.7	1.1	0.2	145.5	
Mean Snowfall (an)	21.3	15.2	16.4	10.5	2.9	0.9	0.0	0.8	4.5	16.1	23.8	24.2	136.6	
No. of days with measurable ppt.	12	10	9	6	6	9	11	11	11	10	12	13		
Greatest rainfall in 24 hrs. (mm)	0.5	0.4	0.8	3.8	12.4	30.2	21.1	30.7	19.6	18.3	9.4	1.8		37-39
Greatest snowfall in 24 hrs. (cm)	14.0	10.4	17.2	16.3	12.2	12.7	0.0	8.6	21.6	12.2	14.6	27.0		37-39

Source: AES 1982.

Table 3.9 Snow courses relevant to Kluane National Park.

Drainage	Snow Course Number	Elevation m asl	Latitude	Longitude	Year Established
Yukon River Basin					
Duke River[1]*	09CA-SC4	1465	61°07'	138°53'	1978
Alsek River Basin					
Dezadeash[1]*	08AA-SC1	725	60°22'	137°04'	1980
Felsite Creek[1]*	08AB-SC1	762	60°34'	138°05'	1978
Bates River'*	08AB-SC2	686	60°09'	137°56'	1979
Takhanne[1]	08AC-SC2	762	60°07'	136°59'	1983
Canyon Lake[2]	08AA-SC1	1160	61°07'	136°59'	1980
Summitt[3]	08AB-SC3	985	60'52'	137°38'	1980
Stanley Creek[3]	08AC-SC1	925	59°56'	136°48'	1977

Source : DIAND 1983.

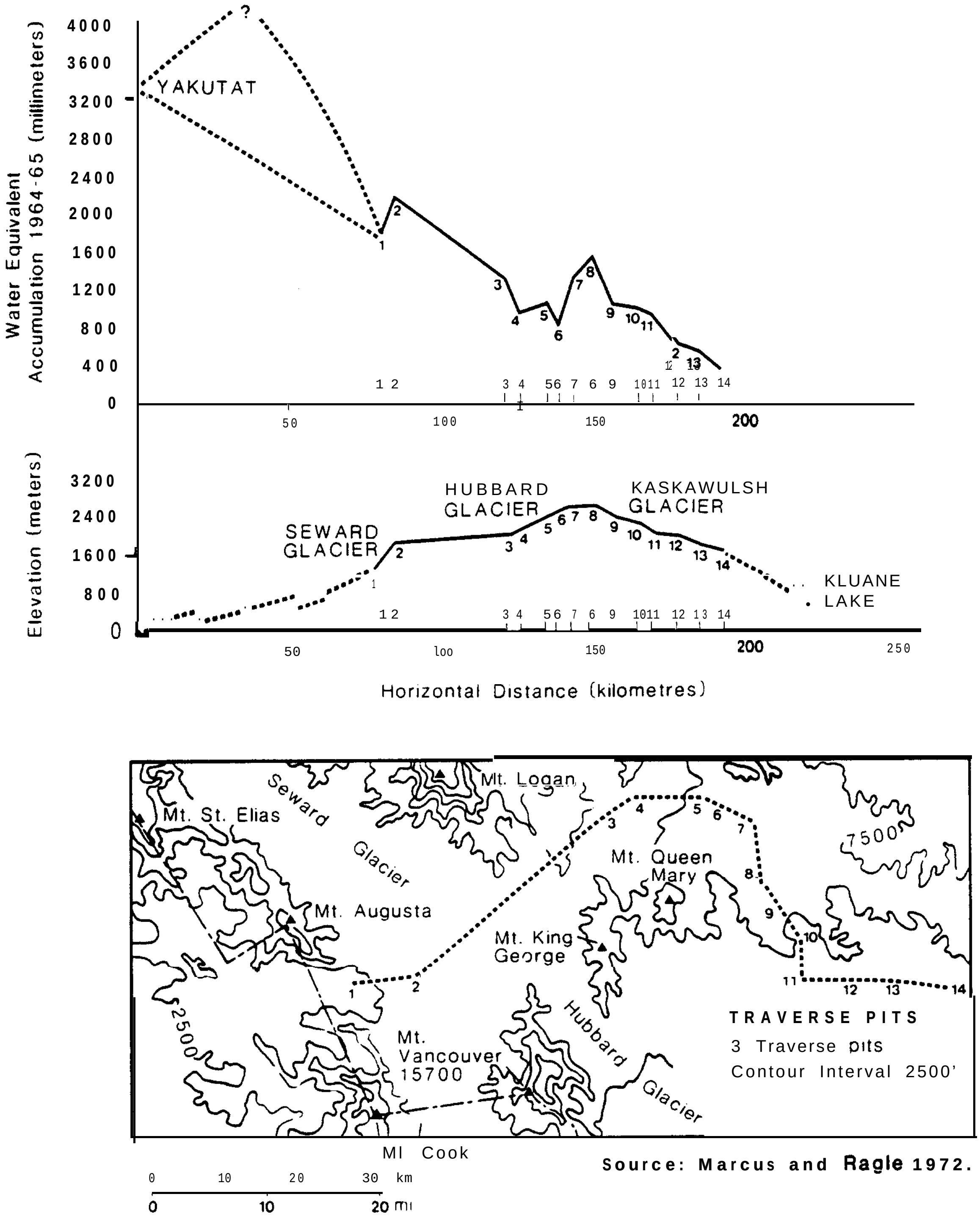
Notes:

1: Measured by Parks Canada
2: Measured by Northern Canada Power Commission
3: Measured by DIAND, Northern Affairs Program
*: Snow courses located in Kluane National Park

3.4.3 Icefields

Precipitation measurements were taken in the Icefields for several summers during the Icefield Ranges Research Project. These data are included in Table 3.5. The most outstanding feature is the variability of the data from year to year and station to station. Marcus and Ragle (1970) state that precipitation in high alpine areas is greatly dependent on the atmospheric circulation pattern and air mass characteristics in the particular year. Extrapolation of low altitude data to mountainous areas is extremely inaccurate in part because of strong topographically-induced variability and also because systems which cause heavy precipitation at low elevations may cause very little higher up and vice versa (Marcus and Ragle 1970). In an ambitious field program, Marcus and Ragle (1972) investigated the effects of snow accumulation and topography, elevation, and distance from the sea along a traverse of the St. Elias Mountains from the lower Seward Glacier near the Yukon-Alaska border across the Hubbard-Kaskawulsh glacier divide to the lower Kaskawulsh Glacier. Snow pits were dug at 14 stations along this traverse in May 1965 allowing determination of the depth of annual snow accumulation and water equivalent. Their results are summarized in Figure 3.7. In general, their work indicated that the relationships between precipitation, elevation, topography and continentality are very complex and often do not follow previously assumed patterns. On the continental slope precipitation increased with elevation from Kluane Lake to 2640 m on the Kaskawulsh Glacier. Precipitation gradients of 1170 mm per km were measured between 1615 m and 2640 m and of 650 mm per km between 1000 m and 2500 m along this slope. Precipitation in the area is of orographic origin caused by storms moving westward from the interior. With only 220 mm of total precipitation at Kluane Lake station, it is apparent that elevation is a critical factor in maintenance of continental slope glaciers.

The Pacific slope patterns are less clear however, showing a more complex trend probably because precipitation shadows from major peaks such as Mount Logan and topographic channelling through passes affect the patterns of snow accumulation. On Mt. Logan Keeler (1969) concluded that above 2500 m elevation exerts little influence on precipitation largely because precipitation at extreme elevations is associated with frontal systems rather than orographic processes. Marcus and Ragle (1972) further concluded that while distance from the Pacific was undoubtedly an important factor it was difficult to separate the effects of continentality from those of topography. The evidence of continentality was seen in a comparison of a marine slope station and a continental slope station both at 1765 m. Snow accumulation was 3 times greater on the marine slope than on the continental slope with the difference increasing at lower elevations.



Source: Marcus and Ragle 1972.

Figure 3.7 Snow accumulation in the Icefields Ranges, Yukon.

3.4.4 Precipitation Modeling

To draw all of this information together, Webber (1974) developed a precipitation model for the Park based on the limited data available and extensive knowledge of the physical principles and processes involved. The Park was divided into zones characterized by windward slopes, lee slopes, precipitation shadow areas, and continental regime areas (see Fig. 3.8). Altitude-precipitation curves were developed for the various areas using IRRP data and scientific inference where unavoidable. The result was three maps showing estimated annual, winter, and summer precipitation (Figures 3.9 a, b, c). The model is a useful tool for describing high alpine precipitation patterns in the St. Elias Mountains. In the absolute sense, it should be used carefully as there is considerable annual variability and the data on which the model is based are subject to inherent errors caused by the difficulty in measuring precipitation accurately as well as the site-specific nature of the data.

3.5 wind (based on Webber 1974)

3.5.1 General Influences

The average wind flow at about 3000 m over Kluane National Park is predominantly from the southwest in all seasons (an onshore flow). The day-to-day flow aloft is determined by generally eastward-moving migratory pressure systems. The expression of this upper flow at the surface is strongly influenced by the topography and extreme relief of the Park and the great thermal contrasts generated due to differing slope orientations and due to the presence of icefields and glaciers.

(a) Anamolously strong winds occur in the following situations:

- funnelling through valleys, mountain passes, and around obstacles;
- exposure on hills and other unsheltered topographic features;
- location on the edge of large lakes;
- locations with low lying vegetation cover (tundra); and
- down-glacier wind flow (glacier wind). A layer above the glacier surface cools by losing heat to the ice. It therefore becomes denser than the air further from the cold surface and flows down the glacier to lower elevations.

Anomalously light winds occur in the following locations:

- wind shadows downwind of small hills;
- basins protected by high relief allowing the wind only indirect access; and
- areas with sheltering vegetation (forests).

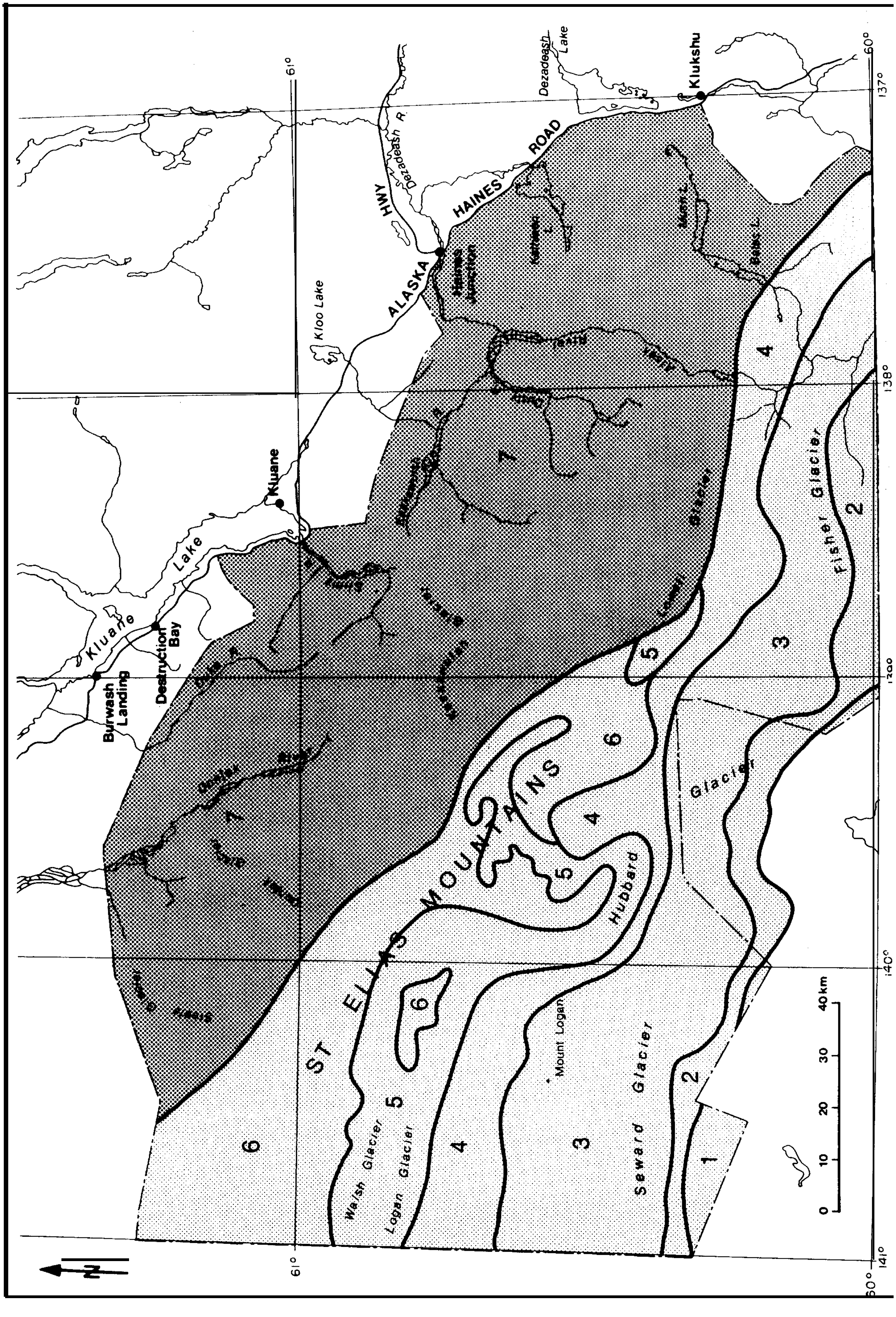
Figure 3.8 Precipitation zones - Kluane National Park.

ZONES 1-6 MARITIME

1. Windward slopes - First range
2. Lee slopes - First range
3. Windward slopes - Second range
4. Lee slopes - Second range
5. Main shadow area
6. Windward exposure - Third range

ZONE 7 CONTINENTAL

Source: Weber 1074.

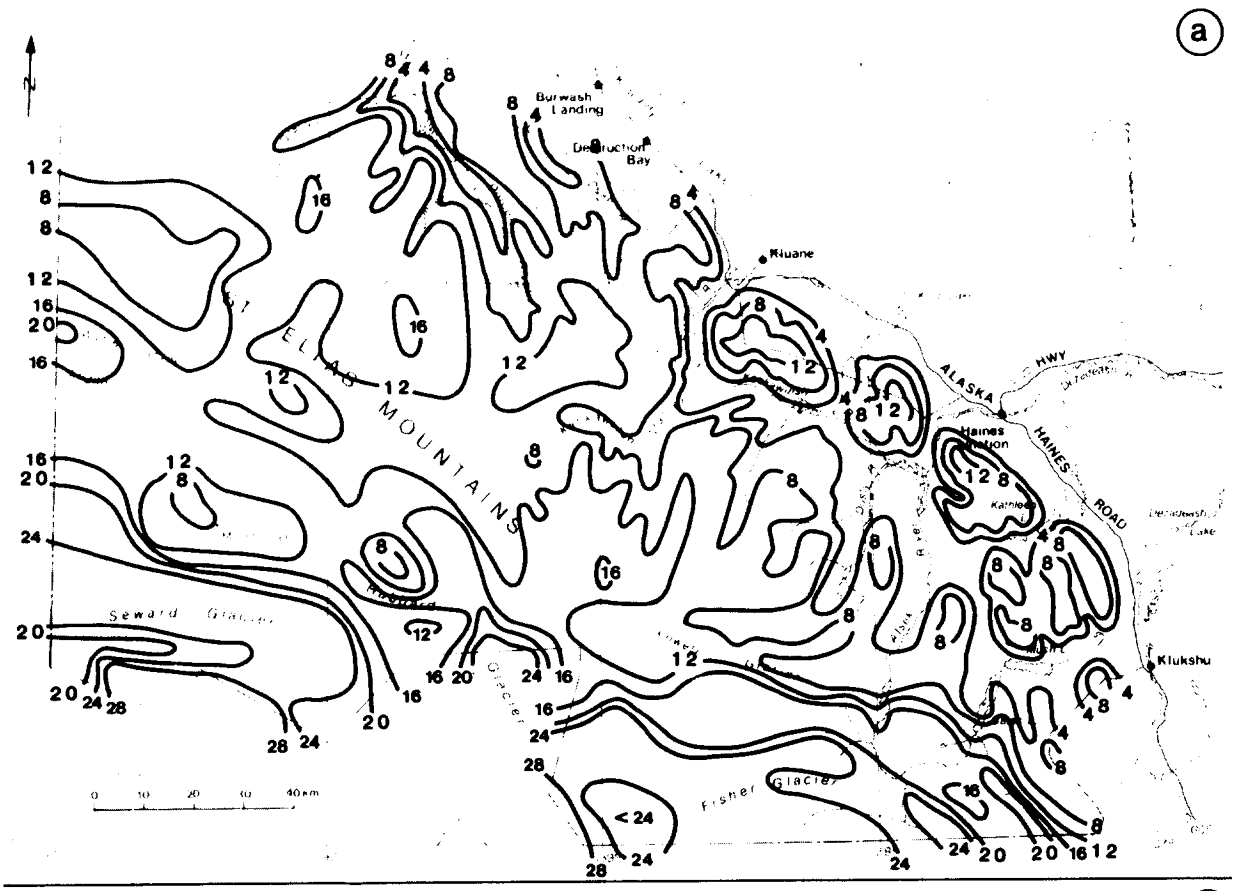

Kluane Lake
Burwash Landing
Destruction Bay
Kluane
Kloo Lake
ALASKA HWY
HAINES ROAD
Haines Junction
Dezadeash R.
Dezadeash Lake
Klukshu
ST ELIAS MOUNTAINS
Mount Logan
Walsh Glacier
Logan Glacier
Seward Glacier
Hubbard Glacier
Glacier
Fisher Glacier
Lowell Glacier
N
0 10 20 30 40km
61°
60°
137°
138°
140°
141°
1
2
3
4
5
6
7

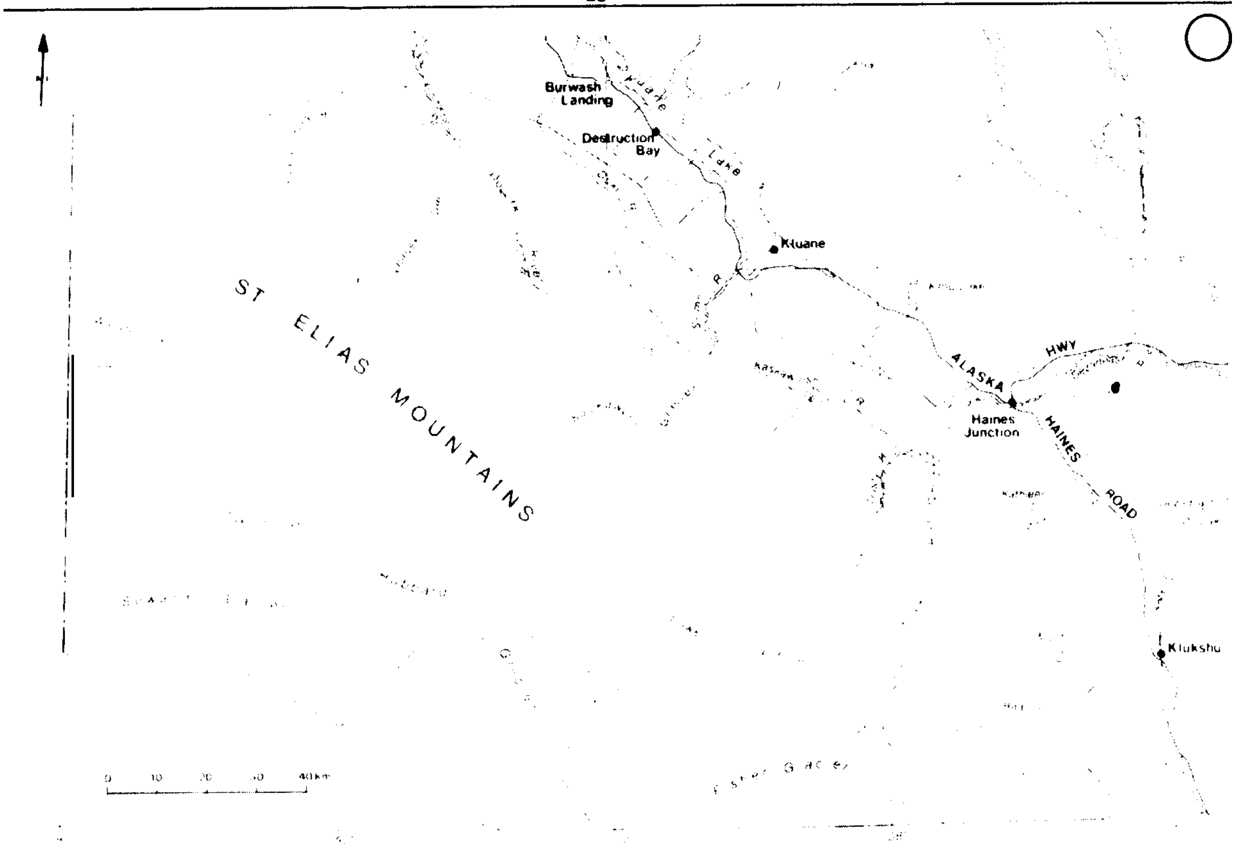
: 3.9

ated precipitation-Kluane
nal Park:

ual – Water equivalent – hundreds
of millimetres
100 mm = 3.937 (~4) inches

Source: Weber 1974.





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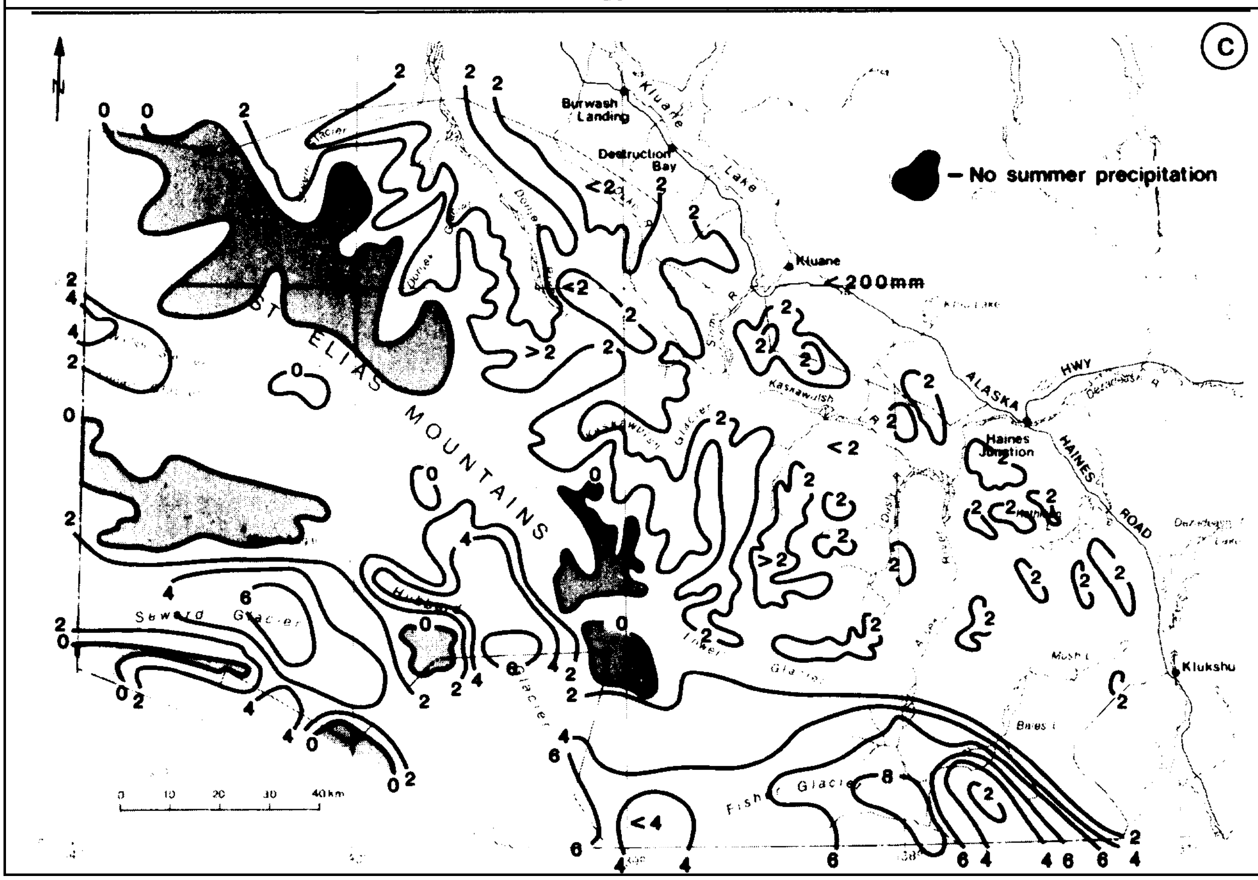

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'e 3.9

nated precipitation-Kluane ›nal Park: (concluded)

ıter - Water equivalent - hundreds of millimetres
100 mm = 3.937 (~4) inches

ımmer - Water equivalent -hundreds of millimetres
100 mm = 3.937 (~4) inches

Source: Weber 1974.

The wind direction is partially controlled by:

- funneling through and around topographic features; and
- the mountain-glacier configuration.

Diurnal changes in speed and direction can be explained by:

- Katabatic wind system:

  At night, air in contact with a radiatively-cooled, sloping surface is itself cooled and becomes denser than air at the same level but further from the slope. This mechanism produces winds in both the downslope and downvalley directions, known as katabatic winds. During the day, the air in contact with the heated slope becomes warmer than that at some horizontal distance from the slope and an upslope (anabatic) wind results. Upslope winds are insignificant on glacierized slopes because the ice surface reflects most of the incident solar radiation and consequently, is not heated appreciably.

- Glacier winds:

  Glacier winds are created in the same way as katabatic winds and are often called by that name. While they do not reverse direction because the glacier surface always remains colder than the surrounding atmosphere, wind speed varies through the day, reaching its maximum velocity on summer afternoons when the air-ice temperature difference is greatest. These winds produce spectacular dust storms in the large glaciated valleys of the Park.

The more rugged and varied the terrain, the more control the local topography exerts on the surface wind speed and direction. Consequently, the Park area is subject to a great variety of wind regimes, most of which have never been investigated.

3.5.2 Seasonal Patterns

a) Winter

Taylor-Barge (1969) discusses the major winter weather characteristics of the Park area; three of which have significant effects on the wind regime. The first is the change to a much stronger upper air circulation pattern. The mean winter flow, besides being stronger, is from the southeast and upvalley at the surface rather than cross-valley (from the southwest) as in the summer. Both effects will decrease the influences of topography on the surface wind.

The second winter influence becomes effective as the whole area changes to a more uniformly snow and ice-covered surface. Many climatic differences will be reduced and local thermal effects which cause certain wind regimes will be changed. For example, glacier winds, which are dependent on the temperature differences between the ice surface and the warmer air above it, will be greatly reduced and other influences, such as topographic channelling, will dominate since the ice is no longer colder than the air.

The third influence is the contrast between the direction of air flow on the west side of the mountains (a southerly flow controlled by the Aleutian Low and on the east (an easterly flow controlled by the Mackenzie High). Essentially, the winter continental high pressure cell generally has sufficient strength to block the eastward inland movement of migratory cyclones near the topographic divide. This creates a semi-permanent Arctic front in the region of the divide which is frequently seen on winter weather charts (Taylor-Barge 1969).

In the winter, periods of abruptly rising temperatures, and even snowmelt, can be expected from Chinook winds flowing downslope into the Shakwak Valley. Not all warm spells in winter can be attributed to Chinook winds (frontal systems encroaching from the Pacific will also bring periods of warmer temperatures). Haines Junction averages more than three warm spells from December through February with an average temperature during the spell a few degrees above freezing (Webber 1974).

b) Summer

Glacier and katabatic winds are best developed in summer when the greatest contrasts in surface cover types exist. All the major valleys of the Park experience winds of this type? usually compounded by topographic channelling. Kathleen, Dezadeash, and Kluane lakes are all subject to frequent sudden windstorms. Dust storms are another common occurrence in the glaciated valleys, particularly the Slims, Kaskawulsh, and Donjek where loess can be transported up to 300 m above the valley floor and has been deposited to varying depths throughout the valley.

3.5.3 Greenbelt

Tables 3.10a and b and 3.11 present wind speed and frequency data for Haines Junction, Burwash A, Kluane Lake, and Whitehorse. Wind characteristics at the first three stations are all affected by valley configuration. Haines Junction station is situated in a

Table) Wind speed data - Kluane region, Yukon)

a) Haines Junction

PERIOD 1963-80

Lat. 60°46′N Long. 137°35′W — Elevation 599 m Altitude

PERCENTAGEFREDUENCV

	JAN	FEB	NM	APR	NAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
N	125	135	125	128	129	123	137	126	130	141	120	11.9	12.8	N
NE	226	228	183	139	118	113	92	10.6	161	18.7	24.9	25.7	172	NE
E	106	75	70	60	48	41	39	55	8.4	9 1	135	10.8	76	E
SE	33	33	3.7	46	43	4.1	28	36	4.9	50	44	36	40	SE
S	18	22	19	27	32	28	30	42	42	31	21	20	28	S
SW	37	84	112	162	206	218	184	18 8	113	86	5.1	41	123	SW
W	40	93	143	169	179	198	215	160	118	99	56	41	126	W
NW	111	150	201	199	189	196	220	208	196	179	145	124	176	NW
Calm	304	180	110	70	56	42	55	79	107	13 6	179	254	131	Calm

MEAN WIND SPEED IN KILOMETRES PER HOUR

	JAN	FEB	NM	APR	NAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
N	53	60	55	55	55	55	51	52	52	54	51	4.4	53	N
NE	51	59	57	71	66	81	63	49	58	65	52	49	60	NE
E	4.2	38	4.1	42	38	44	33	31	31	32	37	39	3.7	E
SE	49	79	7.0	88	83	77	54	47	48	5.6	46	50	62	SE
S	40	38	41	56	52	50	40	37	37	35	37	29	41	S
SW	52	66	64	100	135	132	101	86	65	58	58	52	81	SW
W	39	42	57	91	118	108	94	87	6.4	46	32	39	68	w
NW	112	116	119	108	112	105	98	96	94	90	107	112	106	NW
All Directions	41	55	63	78	92	93	77	67	56	5.2	47	4.2	64	
Maximum Hourly Speed	48	51	42	63	45	35	39	31	40	43	58	45	63	
	NE	SW	NW	SW	NW	SW	SW	SVL	SW	SW	SW	NW	SW	

Height of rnemometer 10.1 m

STATION INFORMATION

Located at Whitehorse Experimental Farm in Shakwak Valley with northwest-southeast configuration Surrounding country mountainous peaks to 2500 m within 10 km of stations Combined valley effects gives preponderance of west-northwest winds at this station

b) Burwash Airport

PERIOD 1966-80

Lat. 61°22′N Long. 139°03′W — Elevation 799 m Altitude

PERCENTAGE FREQUENCY

	JAN	FE6	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEA6	
N	05	0.2	05	05	10	0.9	0.9	06	05	0.3	04	03	0.5	N
NYE	0.1	01	0.1	04	07	07	06	04	02	01	02	01	03	NNE
NE	01	02	02	05	05	06	04	03	02	01	01	0.2	0.3	NE
ENE	02	0.4	0.6	10	1.7	1.6	16	10	07	02	0.1	02	0.8	ENE
E	1.4	36	6.1	11.1	13 0	13 2	110	61	43	16	11	20	66	E
ESE	45	10.3	126	255	306	27 1	23 5	20.4	16.0	135	74	65	16 7	ESE
SE	31	7.4	8.5	15.4	13 9	13 6	14 7	16 1	19 9	10.6	11 1	5.3	12 4	SE
SSE	05	15	13	27	19	2.6	26	33	43	37	22	12	23	SSE
S	05	04	04	07	0.8	0.9	06	0.8	0.9	12	06	04	07	S
SSW	02	02	02	05	04	04	04	03	03	03	02	02	03	SSW
[illegible]	02	02	02	03	04	0.6	04	03	03	02	01	04	03	SW
WSW	0.6	1.0	1.1	OB	14	16	14	11	11	06	09	12	11	WSW
[illegible]	66	64	9.2	54	45	56	59	70	75	10 3	10 3	10 2	77	W
WNW	19 6	18 2	146	79	57	56	66	9 0	12 5	205	26 4	16 7	13 8	WNW
NW	65	50	48	34	36	34	44	52	5.6	70	62	60	53	NW
NNW	10	07	10	12	12	15	15	15	12	11	10	10	12	NNW
Calm	52 2	420	363	22 6	16 7	20 1	220	246	225	19 3	29 5	46 1	29.7	Calm

MEAN WIND **SPEED** IN **KILOMETRES** PEA NOUR

	JAN	FE6	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEA6	
N	8.0	71	76	9.6	10 2	107	9.6	9.1	63	6.9	64	6.5	65	N
NNE	5.9	9.1	70	9.5	9.0	64	9.0	86	65	66	5.9	66	60	YNE
NE	62	10.9	9.4	61	96	SO	66	77	74	65	66	75	65	NE
EYE	7.8	13 2	66	110	100	9.8	102	9.5	66	8.1	12 3	113	10 1	ENE
E	16 4	16 3	13 2	15 5	15 7	13 6	13 3	13 2	14 3	150	16 6	19 1	15 4	E
ESE	267	276	217	237	24.3	20.9	19 4	207	243	264	267	256	242	ESE
SE	323	311	256	267	261	21.8	205	215	245	275	272	29 8	262	SE
SSE	19 5	22 3	16 5	214	19 0	16 1	16 3	15 0	19 4	205	225	233	19 6	SSE
S	16 4	17 1	112	14 6	13 3	105	95	8 9	10 6	13 7	144	20 9	13 4	S
[illegible]	10 7	19 9	10 7	20 5	13 1	101	es	79	77	14 0	10 4	14 7	12 4	SSW
SW	66	112	10 1	156	114	102	66	73	9.8	91	66	64	9.8	SW
[illegible]	65	74	74	10 7	11.9	116	9.9	66	8.9	67	71	65	66	wsw
[illegible]	9.9	10 2	10 3	110	11 1	116	112	9.9	9.2	96	102	97	10 3	W
[illegible]	13 0	13 7	13 4	153	14.4	14 2	13 4	13 2	13 4	12 5	12 8	130	13 5	WNW
NW	13 3	14 2	14 3	156	14 2	14 6	14 0	14 5	14 2	13 4	12 0	13 6	14 0	NW
NNW	105	8.6	113	116	12 7	13 2	117	13 0	114	9.1	65	9.0	10 9	NNW
AN Directions	71	10 5	10 3	15 5	16 2	13 7	12 6	12 5	14 4	15 2	114	65	12 3	
Maximum Hourly Speed	78	90	71	100	64	70	56	61	71	85	84	100	100	
	S	ESE	ESE	SE	SE	E	ESE	SE	ESE	ESE	SE	S	SVL	
Maximum Gust Speed	116	135	113	143	103	132	90	116	109	117	117	171	171	
	ESE	ESE	ESE	SE	SE	SE	SE	SE	ESE	ESE	E	S	S	

Height of anemometer 10.1 m

STATION **INFORMATION**

On north side of Burwash airstrip 3 km west of Burwash Landing, opposite of the Alcan highway and near the northwest end of Kluane Lake The St Elias mountains extend from SE to NW Winds are subject to considerable valley effect with southeast direction dominated The valley floor is fairly smooth so that there are few other terrain effects Short trees and brush in vicinity

Table 3.10 Wind speed data - Kluane region, Yukon.

c) Kluane Lake

PERIOD 1974-80

Lat. 61°01'N Long 138°24'W

Elevation 786 m Altitude

PERCENTAGE FREQUENCY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
N	42	58	30	37	31	52	3.8	25	23	15	1.3	3.7	3.3	N
NE	8.1	134	7.0	7.0	8.3	9 8	8 0	7.0	8.1	4.2	4.6	106	6.1	NE
E	18.2	11.1	14.9	117	83	9.4	11.1	15.0	23.7	17.8	19.4	21.4	152	E
SE	204	140	14.3	165	164	10.3	114	11.4	17.5	29.1	23.5	20.5	17.1	SE
8	106	10 1	95	7.6	64	42	6.1	44	42	6.5	12.5	11.6	8.1	S
SW	14.1	182	28 1	299	324	39 1	405	33.1	22.3	26.3	17.7	12.4	26.2	SW
W	16	26	29	39	3.2	5.0	46	3.6	3.0	1.2	2.0	1.7	3.0	w
NW	66	11.3	13.0	173	19.1	156	12.9	206	167	10.2	17.8	9.2	143	NW
Calm	160	13.3	73	2.4	0.8	1.2	14	1.2	2.2	12	1.2	6.7	4.7	Calm

MEAN WIND SPEED IN KILOMETRES PER HOUR

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
N	5.3	7.4	47	60	5.9	69	6.0	56	66	51	6.7	7.9	6.4	N
NE	56	7.1	66	6.6	7.4	6.9	7.0	7.2	7 5	8 3	11.4	14.6	81	NE
E	72	73	73	7.2	7.2	6.6	6.0	66	7.6	79	8.8	76	73	E
SE	7.3	90	7.1	9.7	10.0	92	72	7 1	96	90	96	7.2	8.5	SE
S	54	8.0	8.1	a9	73	78	69	73	75	7.4	02	7.1	75	S
SW	6.3	96	11.4	118	10.6	110	103	101	103	11.4	11.0	6.4	10 2	SW
W	26	62	57	6.5	66	59	5.6	60	6.1	5.7	8.3	43	5.6	W
NW	143	14.0	117	115	103	85	66	143	16.7	17.6	163	159	13.5	NW
All Directions	60	7.6	0.4	9.6	93	6.9	62	9.4	99	99	11.0	84	6.9	
Maximum Hourly Speed	42 NW	50 S	37 NW	48 SW	31 SW	35 SE	39 NW	40 NW	50 NW	45 NW	45 NW	87 NE	87 NE	

Height of rnemomeler 10.1 m

STATION INFORMATION

Located on a flat bench on the southeast corner of Kluane Lake The St Elias Mountain barrier rises immediately to the south although the Slims River Valley to the south does crealesome outflows

d) Whitehorse Airport

PERIOD 1955-80

Lat. 60°43'N Long. 135°04'W

Elevation 703 m Altitude

PERCENTAGE FREQUENCY

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
N	80	1.2	1 0	5.6	4.1	66	6.1	6 3	5 6	4.3	5.0	1 2	6 0	N
NNE	6.3	0 2	0.4	0 1	1.2	1.7	1.6	12	0.1	0 3	0 2	0 2	0 1	NNE
NE	0 2	0 3	0 2	0.5	1.0	1.5	1.2	06	0.6	0 3	0 2	0.1	05	NE
ENE	0.1	0.1	01	0.2	0.4	0.4	0.4	0 3	0.2	0 1	0.0	01	02	ENE
E	0.6	0.6	0.5	0.0	1.5	1.6	15	0.9	0.1	0.4	0.4	0 6	0.0	E
ESE	0.6	0.0	1.8	2.6	3.9	4 3	4 2	2 6	2 0	1.4	0.1	0 6	2 2	ESE
SE	9.8	126	14.4	19.9	2 2 3	22.3	22.5	21.3	20 1	18.6	11.1	115	11 3	SE
SSE	15.3	16.6	16.9	19 6	20.6	19.0	16.6	19.5	232	21.0	16.3	15.2	106	SSE
S	14 1	16.9	14.6	1 5 2	12.6	112	12.0	12.6	16 1	19.2	224	104	156	S
SSW	0.8	13	2.0	3.6	4.4	3 6	3.0	2 1	2 5	2 2	1.5	1.2	24	SSW
SW	0 6	0.9	2 2	4 8	4.6	4.5	3.9	4 0	2 7	1.6	11	0 1	2 6	SW
WSW	0 4	0.5	1.7	2 3	2 6	2 5	2.0	2 0	16	09	0.8	03	1.5	WSW
W	1.5	1.1	3.1	3.1	26	3.0	2 9	3 4	2 6	2 3	2.4	15	2.5	W
WNW	2.6	2 5	2.2	1.1	16	1.4	15	1.6	14	14	2 1	2 2	1.6	WNW
NW	140	120	10.6	55	4.1	4.2	4 4	4 6	4 6	5 6	10.5	121	1 1	NW
NNW	11 a	102	6 6	4.2	3 0	3.1	3.5	4 2	3 6	4 5	9.0	11.0	6.3	NNW
Calm	16.1	133	133	91	0.0	9.8	10 3	116	116	9.7	12 1	159	12 1	Calm

MEAN WIND SPEED IN KILOMETRES PER HOUR

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
N	10 8	106	13.4	13.6	12 4	10 7	11 3	10 9	10 9	133	12 6	11.6	11.9	N
NNE	al	66	66	10.6	10 9	9.7	103	a6	8.6	8.8	6.9	6 2	8.7	NNE
NE	4 6	5 0	6 2	1.1	1.6	1 1	1.3	6 2	6 3	1 1	51	45	63	NE
ENE	6.9	5 4	9.3	6 2	6 2	7.9	6 4	5 9	4 1	5 8	6 3	61	66	ENE
E	5 0	7 4	101	9.3	9.0	63	8.8	72	6 1	a5	60	46	77	E
ESE	10 3	15 5	160	16 1	16 1	15.1	16 3	16 6	166	19 5	144	9.9	15 5	ESE
SE	1 1 1	2 0 0	16 1	16.1	166	16.9	16 9	17.5	18 8	22 1	212	213	19 0	SE
SSE	2 2 6	2 2 1	2 0 3	18 5	16 3	163	15.8	11 0	16 3	214	226	225	19 6	SSE
S	21.2	22 1	11 2	15 0	14 1	12 5	120	12 9	153	17.9	206	21 8	11 0	S
SSW	14 0	15 1	14 1	14 8	160	14 9	13 7	12 4	13 3	14 1	14 4	153	144	SSW
SW	9.6	9.9	120	12 1	154	13.9	12 2	115	10 I	10 1	10.0	a4	11.3	SW
WSW	a4	64	112	116	14 2	123	9.9	9.4	9.5	0 4	7.8	54	9.8	WSW
W	1 0	1 0	6 6	6 6	10.4	100	8.7	7.9	1.5	6.9	1 4	6 6	al	W
WNW	10.6	9.8	102	105	11.5	10.3	10 3	9.2	6 6	6.1	9.3	9.6	S D	WNW
NW	1 1 1	114	13 6	136	126	10.9	106	10 4	10 4	119	12 2	111	116	NW
NNW	12.7	13 1	14 4	14 3	13.2	116	12 2	11.8	12 6	14.0	14 2	13.3	13 1	NNW
All Directions	126	14.6	14 3	14.3	14 4	12.8	12 4	12.4	13.6	16.4	15 7	14 5	14.1	
Maximum Hourly Speed	72 SE	68 SSE	64 SE	60 N	64 SSE	56 SE	63 ESE	48 SVL	72 S	63 SE	68 SE	68 SE	72 SVL	
Maximum Gust Speed	100 SSE	106 SSE	93 SW	89 SVL	85 SSE	90 WNW	80 ESE	84 SVL	101 S	97 S	106 SE	97 SE	106 SVL	

Height of anemometer 10.1 m

STATION INFORMATION

Airport is located on the west side of a north-south mountain valley and is about 50-90 m above the river. There are ridges 500-600 m above the airport on both sides of the valley.

Table 3.1 1 Mean wind speed (km/hr) and prevailing direction:

Station	Month												Year
	J	F	M	A	M	J	J	A	S	O	N	D	
Haines Junction	4.1 NE	5.5 NE	6.3 NW	7.8 NW	9.2 SW	9.3 SW	7.7 NW	6.7 NW	5.6 NW	5.2 NE	4.7 NE	4.2 NE	6.4 NW
Burwash A	7.1 WNW	10.5 WNW	10.3 WNW	15.5 ESE	16.2 ESE	13.7 ESE	12.6 ESE	12.5 ESE	14.4 SE	15.2 WNW	11.4 WNW	8.5 WNW	12.3 ESE
Kluane L.	6.0 SE	7.8 SW	8.4 SW	9.6 SW	9.3 SW	8.9 SW	8.2 SW	9.4 SW	9.9 E	9.9 SE	11.0 SE	8.4 E	8.9 SW
Whitehorse A	12.9 SSE	14.9 SSE	14.3 SSE	14.3 SE	14.4 SE	12.8 SE	12.4 SE	12.4 SE	13.8 SSE	16.4 SSE	15.7 S	14.5 S	14.1 SSE

* highest percentage frequency for that month.

Source: AES 1982.

wind shadow due to the orientation of the surrounding mountains and the Alsek Valley. This configuration is responsible for a predominance of northwest winds at the station. Burwash Airport experiences strong winds due to proximity to Kluane Lake but the station also experiences a high frequency of calm conditions, up to 50% of the time in December and January. The Kluane Lake station measures strong predominantly southwest winds channelled down the Slims Valley.

3.5.4 Icefields

Wind in the higher regions of the Park is not well documented. As a general rule, wind speed increases with elevation due to greater exposure and greater control by the upper air circulation patterns.

The Arctic Institute of North America through the Icefield Ranges Research Project has obtained wind records from a few specific locations in the Park for one to three months in the summers since 1961. Descriptions of these stations and published data sources are included in Table 3.12. The short records and inconsistencies in some of the published data allow only very basic and general descriptions of the wind characteristics of the four locations.

The Divide and Seward stations are located in basins surrounded by extremely high relief. This topographic situation causes a breaking of the air flow over the basins with a consequent lowering of the wind speed in the sheltered areas. These two stations: therefore, experience much lower wind speeds than would be expected from a consideration of the upper air data. Wind directions were also strongly controlled by the local topography. Both speed and directional effects were especially noticeable at Seward station. The small amount of data available for this station reveals a large percentage of calms (32 per cent in July 1964) and very low average wind speeds (the season average is about 1.1 m/s). Prevailing directions of west and northwest are explained by the orientation of the Seward Glacier. In winter the shift of predominant wind direction to the southeast may overcome topographic sheltering to some extent (Taylor-Barge 1969).

The average and maximum wind speeds at Divide station (Table 3.13) are based on a synthesis of data for 1963-1965 and 1968. The influence of the strong upper winds of the winter season can still. be seen in June, the month with the highest average speeds. The gentler summer wind pattern becomes dominant in July and continues through August.

The Mount Logan station, at 5360 m, shows a direct correlation between the upper air flow and the wind currents at the mountain surface. However, the wind speeds at Mount Logan are less than those in the free air due to frictional effects. For the period July 4 to July 24, 1968, the average wind speeds at the

Table 3.12 Published sources, Icefield Ranges Research Project wind data.

Location	Latitude Longtitude Elevation	Description of Station Location	Periods with Available Wind Data	Information sources
Kaskawulsh	60° 44'N 139° 8'W c5800 ft. (1768 m)	"on the medial moraine at the confluence of the central and north-ern area of the Kaskawulsh Glacier"	Jul 4 - Aug 22, 1964	Marcus (1965) Taylor-Barge (1969)
			Jun 4-Aug 8, 1965	Benjey (1969) Taylor-Barge (1969)
Divide	60' 46"N 139' 40'W c8700 ft. (2652 m)	"near flat snow sur-face near the topogra-phic and flow divide of the Kaskawulsh and Hubbard Glaciers"	Jul 1-Aug 15, 1961	Wood (1963)
			Jun 20-Aug 23, 1963	Havens a-d Saarela (1964) Taylor-Barge (1969)
			Jun 10-Aug 17, 1964	Marcus (1965) Taylor-Barge (1969)
			Jun 4-Aug 8, 1965	Benjey (1969) Taylor-Barge (1969)
			Jun 1-Aug 16, 1984	Kolberg and Brazel (1969)
Mount Logan	60' 36'N 140' 30'W c17,600 ft (5364 m)	"on a broad glacier field near the centre of the summit plateau of the Mt. Logan masaif"	Jun 2- Jun 17, 1965	Alford and Keeler (1968)
			Jul 2-Aug 2, 1968	Kolberg ad Brazel (1969) Marcus and Labelle (1970) Marcus '(1971)
			Jun 28-Jul 28, 1969	Marcus and Labelle (1970) Marcus (1971)
			Jun 24-Jul 23, 1970	Marcus (1971)
Seward	60' 20'N 139' 55'W c6100 ft. (1859 m)	"on the ridge of a small nunatak (about 50 ft. from the nearest snow). This nunatak is near the eastern margin of the Seward Glacier Basin at the foot of Mount Vancouver.	Jun 18-Aug 14, 1964	Marcus (1965) Taylor-Barge (1969)
			Jul 7-Jul 25, 1965	Benjey (1969) Taylor-Barge (1969)

Table 3.13 Wind data - Divide station, Yukon:

Month	Average Wind speed (m/s)	No. of Observations	% Calm Av.	Min.	Max.
June	3.1	67	15.8	27.4	8.9
July	2.2	121	30.5	36.5	18.6
August	2.7	58	22.2	27.3	-
Season	2.6	246			

Year	Maximum Wind Speed (m/s)	No. of Observations	Prevailing Winds Directions for June - August
1963	12.5	65	W
1964	10.3	67	W
1965	17.9	66	W
1968	11.2	48	E

* Based on IRRP data 1963-65, 1968.

500-millibar level above Whitehorse and above Yakutat were 8.2 m/s and 10.6 m/s respectively, while at the Mount Logan station, the average speed was 3.3 m/s for that period (Marcus and LaBelle 1970). Using the same data, winds above Whitehorse and above yakutat average 4.9 m/s greater and 7.2 m/s greater, respectively, than winds at Mount Logan. The two summers in 1968 and 1969 had lower wind speeds and a greater percentage of calms than was usually experienced in this area. This was a reflection of the weak pressure system which dominated the area during the month of July in 1968 and 1969. The Mount Logan wind speed data for 1968-1970 are given in Table 3.14.

Much higher wind speeds were recorded at Kaskawulsh station than at Divide, Seward and Mt. Logan apparently due to a very persistent glacier wind. This wind occurs about 70 per cent of the time and flows from the west-southwest down the Central Arm of the Kaskawulsh Glacier (Benjey 1969). The average wind speeds at Kaskawulsh station for 1965 are about 0.9 m/s greater than the average speeds at Whitehorse A. for the same period (Table 3.15).

3.5.5 Windchill

Wind enhances the cooling effect of low temperatures. Wind chill estimates can be derived from temperature and wind speed measurements using the nomogram in Figure 3.10. This calculation takes into account body heat but not the effect of sunshine or body motion.

At Whitehorse Airport, the average winter wind speed is 4.5 m/s. A wind chill value of 1625 or greater will occur with this wind speed when the temperature is less than -18°C (see Figure 3.10). Dangerous levels of wind chill will therefore occur on the average about 20% of the time in November, about 40% of the time in December, about 50% in January, about 30% in February, and about 20% in March. Colder temperatures and greater wind speeds will increase the percentage of time when outdoor activity must be curtailed. Therefore, dangerous conditions should be expected frequently from November though March at lower elevations and for increasing periods of the year at higher elevations.

3.6 Cloud

Cloud cover in Kluane National Park is controlled by the same processes as precipitation. Therefore, cloud is more prevalent where moist ascending air condenses on the windward slopes of the mountains and least on the leeward sides, where subsiding air vaporizes available water droplets. On a large scale, this results in two distinct cloud regimes, one on each side of the mountain barrier, with differing frequencies and dominant cloud types (Taylor-Barge 1969). An illustration of this process on a local scale is the frequently observed pattern of cloud formation on the Kluane Ranges, dissipation over the Shakwak Valley and re-formation

Table 3.14 Average and maximum wind speed data - Mount Logan, Yukon.

	Jul 2 - Aug 2 1968	Jun 28 - Jul 28 1969	Jun 24 - Jul 23 1970	3 Sumners 1968-1970
Average wind speed (m/s)	3.4	2.6	3.9	**3.3**
Maximum wind speed (m/s)	23.6	8.9	23.1	**23.6**

Source: Marcus 1971.

Table 3.15 Average wind speeds (June 4-Aug.8.1965) - Kaskawulsh station, Yukon.

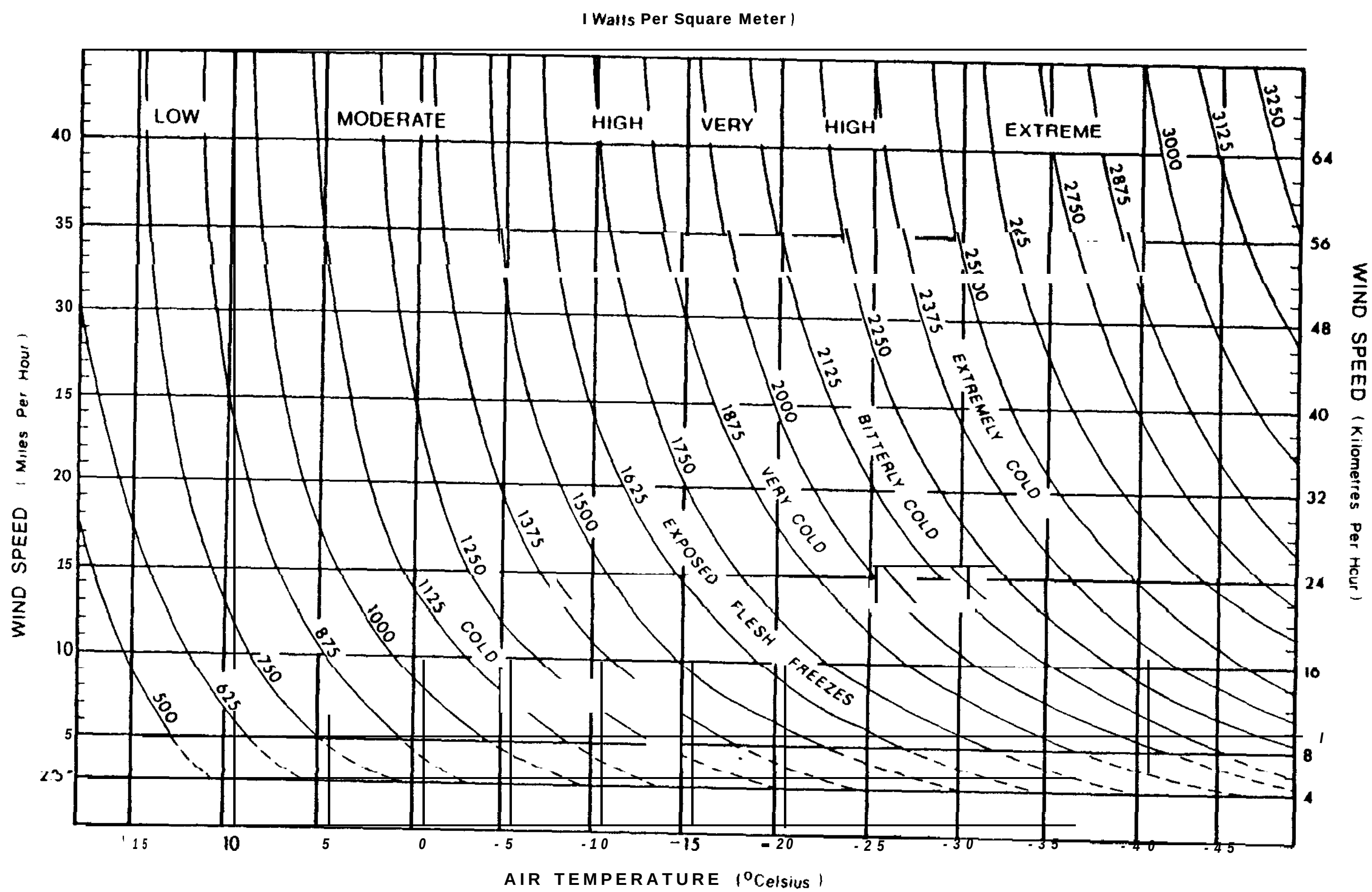
	June	July	August	Season
m/s	5.7	5.2	4.8	5.1

Source: Taylor-Barge (1969)

Table 3.16 Percentage cloud cover frequencies July 1969 - IRRP stations, Yukon.

IRRP Station	Clear	1 - 3 tenths	4 - 6 tenths	7 -9 tenths	Overcast
Kluane	1.1	10.2	18.9	44.9	24.9
Divide	13.6	8.1	10.8	37.8	29.7
Mt. Logan	15.1	36.4	8.3	18.2	22.0

Source: Benjey 1970.



To determine the wind chill factor follow the temperature across and the wind speed up until the two lines intersect. The value of the wind chill factor can be interpolated using the labeled wind chill factor curves.

For example, at -10°C with a wind speed of 20 miles per hour the point of intersection lies between 1500 and 1625, or approximately 1570.

It is not recommended that wind chill factors be calculated for wind speeds below 5 miles an hour, since it is difficult to determine wind chill factors at these wind speeds and because other factors such as relative humidity become important.

Figure 3.10 Wind chill cooling rates.

on the Ruby Ranges to the east. The subsidence which occurs over large glaciers in summer also reduces cloud cover. For example, clear skies at the Icefield Ranges Research Project station on the Kaskawulsh Glacier were frequently associated with dense cloud on the surrounding mountains (Taylor-Barge 1969). Cloud averages for the other IRRP stations further west show the expected increase in cloudiness with increased maritime influence (Table 3.5). A similar increase in cloudiness should be experienced from north to south beginning in the Mush and Bates lakes area due to the moist air which invades the southeast corner of the Park via the Alsek and Tatshenshini river valleys.

The stations at Divide, Mt. Logan, and Seward tend to be either completely overcast or clear depending on the synoptic situation. cyclonic (low pressure) systems and frontal passages bring extensive cloud and low visibilities to these glacierized areas, while anticyclonic (high pressure) systems are associated with clear skies and unlimited visibility. Table 3.16 compares cloud conditions at inland high altitude stations with those at Kluane Lake in July 1969.

The high-level areas of the Park (such as the Divide and Mt. Logan stations) are frequently above cloud and at times a condition of undercast occurs when lower areas are completely obscured by cloud.

Stratus clouds formed by orographic uplift of Pacific air are the most common cloud type on marine slopes of the St. Elias Mountains (based on summer reports from Seward and Divide stations). The continental areas (such as the Kluane station) experience more middle (altocumulus and altostratus) and high clouds (cirrus, cirrostratus and cirrocumulus), with a predominance of middle cloud. Orographic clouds, and associated strong winds, are the result of wave motions set up in a strong air current which has been disturbed by a mountain barrier. Lenticular clouds are a specific example of this process and often occur on the lee of the St. Elias Mountains.

The snow-free valley stations are generally cloudier in summer than in winter due in part to the development of summertime convective clouds over heated ground and because few cyclonic storms penetrate the high pressure cell over the area in winter (Taylor-Barge 1969). Thunderstorms are associated with convective systems and occur mainly in June and July. Low temperatures and cloudless skies are a feature of the Mackenzie High pressure system which dominates the winter weather east of the St. Elias Mountains. At Whitehorse, heavy cloud (8/10 or more of the sky obscured) occurs least frequently from mid-winter to early summer (see Table 3.17A). The area experiences a cloud cover of 2/10 or less about twice as often in March as in June or July (Table 3.17B).

Table 3.17 Percentage cloud cover frequencies - Whitehorse, Yukon.

	A Percentage Frequencies of Large Amounts of Cloud Cover (8/10 - 10/10)												
Station	J	F	M	A	M	J	J	A	S	O	N	D	Year
Whitehorse A	59	59	55	57	59	60	64	61	63	61	69	63	61
	B Percentage Frequencies of Small Amounts of Cloud Cover (0 - 2/10th)												
station	J	F	M	A	M	J	J	A	S	O	N	D	Year
Whitehorse A	23	23	26	20	17	14	11	15	18	19	15	17	18

Source: AES 1982.

Table 3.18 Bright sunshine hours - southwest Yukon.

	Month												Year
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	NOV	Dec	
Average Daylight Sours Per Day (60' 45'N): Adapted fran Burns (1973)													
	7	9	11	14	17	19	18	16	13	10	7	6	12
AVERAGE NUMBER OF HOURS WITH BRIGHT SUNSHINE PER DAY													
Haines Junction	0.7	2.7	5.2	7.0	8.0	9.0	8.4	7.2	4.0	2.9	0.8	0.1	4.8
Whitehorse A	1.4	2.9	5.2	7.7	8.6	9.0	8.1	7.3	4.5	3.1	1.6	0.7	5.0
PERCENTAGE OF MAXIMUM POSSIBLE BRIGHT SUNSHINE													
Haines Junction	l0.	30.0	47.3	50.0	51.8	47.4	46.7	45.0	36.9	29.0	11.4	1.7	39.0
Whitehorse A	20.0	32.2	47.3	55.0	50.1	47.4	45.0	45.6	34.6	31.0	22.9	11.7	40.0
TOTAL NUMBER OF HOURS WITH BRIGHT SUNSHINE PER MONTH (1941-1970)													
Haines Junction	21	75	161	210	272	271	260	224	144	90	24	2	1754
Whitehorse A	42	61	160	230	267	271	250	225	134	96	48	21	1825

Source: Yorke and Kendall 1972.

Winter cloud characteristics of the glacierized stations are unknown. However, the intensification of the Aleutian Low in the Gulf of Alaska and the decrease in incursions of dry, continental air westward over the topographic barrier during this season would suggest an increase in cloud on the marine slopes compared to summer (rather than a decrease, as is experienced for the continental areas of the Park). Winter cloud cover amounts are expected to exhibit a gradual change from the maritime to the continental regime, as in summer, rather than a sharp discontinuity near the topographic divide as is the case for such synoptic parameters as temperature, precipitation and wind (Taylor-Barge 1969).

3.7 Sunshine

The Haines Junction station receives an average of 1750 hours of bright sunshine each year, comparable to annual sunshine totals at: Banff, Alberta (1739 hours), Churchill, Manitoba (1789 hours) and Truro (1749 hours) and Yarmouth (1772 hours) in Nova Scotia. Although the Prairie Provinces are generally the sunniest region in Canada, with average annual bright sunshine totals of about 2200 hours, Haines Junction averages more bright sunshine from March through June than many of the Prairie locations. However, sunshine hours for the winter months at Haines Junction are much lower than that received in more southerly locations. Annual sunshine totals decrease significantly from northeast to southwest over the St. Elias Mountains, falling below 1200 hours per annum, the lowest average in Canada, near the southern boundary of the Park (Yorke and Kendall 1972). Haines Junction averages less than one hour of bright sunshine each day in November, December and January but over eight hours each day in May, June and July (Table 3.18). The percentage of the maximum possible bright sunshine received at whitehorse and Haines Junction varies from about 25 per cent in winter (September through February) to about 50 per cent in summer (March through August).

Sunshine hours at interior valley locations can be considerably reduced due to topographic shading and some areas can be in almost permanent shadow. This influences the vegetation pattern in the area and is conducive to the formation of permafrost.

3.8 Visibility

Visibility reduction is usually related to cloudiness in that the main obstructing elements are fog, rain, drizzle and snow. Other weather elements, such as blowing snow, ice fog, smoke, haze and blowing dust, may also reduce the visibility at a particular location.

A reduction in horizontal visibility, for whatever reason, is usually associated with a reduction in vertical visibility as well. The height above ground of the lowest layer of cloud at which the opacity equals or exceeds 60 per cent of the celestial dome is defined as the ceiling (Canada, Department of the Environment, 1971). Low visibility and ceiling conditions at whitehorse are most common in November (about 91 hours), December (about 113 hours) and January (about 92 hours). By contrast, a ceiling of 900 feet (274 m) or less and/or a visibility of 2½ miles (4.0 km) or less occurs, on the average, less than 1½ hours in July.

3.8.1 Fog

The high-level IRRP stations at Divide, Mt. Logan and Seward on the west of the topographic divide experienced frequent fog during the summer observation periods (Table 3.19). Much of this fog may actually be cloud which has run into the glacier surface (Taylor-Barge 1969).

The peripheral valley stations experience fog twice as often near sunrise as in the afternoon and more often in winter than'in summer (Table 3.20). Whitehorse A. reported fog from 4 to 8 per cent of the time from November through January (Table 3.21).

Ice fog is a common condition in winter at valley settlements, but occurs infrequently in other areas due to the lack of both moisture and ice crystallization nuclei, in the cold Arctic air. Anomalously large amounts of moisture are produced in settlements by such artificial sources as generating stations, car exhausts, household furnaces and aircraft engines. This water vapour, when discharged into cold air, sublimates onto freezing nuclei many of which are combustion products from the same sources, and consequently forms a fog of suspended ice particles. Ice fog is uncommon above -29°C. It is most prevalent at temperatures less than -35°C and is almost always present when the temperature falls below -46°C in the vicinity of a water vapour source (Bilello 1974). Under temperature inversion conditions, ice fog may persist for periods of a few days to as long as one or two weeks (Bilello 1974). Smoke from wood-burning fireplaces can accumulate to unpleasant levels under the same atmospheric conditions and in extreme situations can become a health hazard.

Visibility reduction from ice fog and smoke is an unfortunate aspect of modern community life in the North. Minute particulate matter and gaseous pollutants, from the same sources as the water vapour, are also trapped in the stable air above the community during an inversion and mix with the ice fog. The pollution which results is very unpleasant and is potentially hazardous to health and the ecology of the area. It has rendered Fairbanks, Alaska one of the most polluted places on earth (Hare 1970).

Table 3.19 Percentage frequency of fog - July 1969.

Station	Percentage frequency
Kluane	0
Divide	45
Mt. Logan	26

Source: Benjey 1970.

Table 3.20 Mean monthly and annual days with fog - Whitehorse, Yukon.

Station	Month												Year
	Jan	Feb	Mar	Apt	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Whitehorse A.	4	1	*	•	[illegible]	1	*	2	2	2	2	4	18

• less than 1/2 day

source* Hemmerick 1971.

Table 3.21 Percentage frequency of hourly observations with fog - Whitehorse, Yukon.

	Month												Year
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nw	Dec	
Percentage	8.1	1.0	0.2	0.1	•	0.2	0.1	0.8	0.6	1.0	3.8	7.4	2.0

*Less than 0.05 percent

3.8.2 Blowing Snow

Blowing snow is a common cause of winter visibility reduction, particularly in exposed areas with powder-fine snow and with wind speeds of 9 m/s or more. Consequently, it is frequently observed on mountain ridges and open areas but not so often in the sheltered valleys.

At Whitehorse Airport, blowing snow reduces the visibility to 6 miles (9.6 km) or less about 0.1 per cent of the time (approximately 10 hours) from November through April. This represents a very low incidence of blowing snow for such a northerly location. It may be that occasional Chinooks moisten the snow surface forming a crust resistant to wind movement.

3.8.3 white-out

Instances of white-out can be expected in an area with an unbroken snow cover beneath a uniform, low-level overcast sky. The condition is accentuated during the low-sun period (Burns 1974). Diffuse reflection and scattering from cloud and ground create a uniform, white glow which obscures all shadow, the horizon and the cloud. White objects and irregularities in the snow surface are invisible, and distances to dark objects are hard to judge. This is dangerous situation, since orientation and perspective are easily lost.

3.9 Evaluation

3.9.1 Visitor Use

Kluane National Park is a favoured destination for backcountry hikers and mountaineers who want to enjoy the wilderness and experience the challenges offered by the Park's mountainous terrain. Climbing parties regularly come to the Park to attempt some of Canada's highest peaks. The unpredictability of the weather is one of the dangers faced by those entering the interior valleys and the Icefields. The Kluane Warden Service maintained a special rescue capability for several years with a high altitude helicopter and trained personnel. Recently financial restraint has reduced this function, and today a rescue above 4000 m would probably not be attempted with the resources at hand. Since Park reserve establishment, 5 or 6 parties have been rescued successfully from Mt. Logan.

However, even with the best helicopter support, weather conditions can make a rescue or an evacuation impossible. Under some conditions, wind alone becomes a determining factor particularly in valleys where topographic channelling and glacier winds can produce extremely gusty conditions. These winds also produce dust storms in many of the glaciated valleys, although this is more of a nuisance to Park visitors than a hazard.

Summer is a particularly pleasant season in Kluane with long hours of daylight (19 hr. - June, 18 hr. - July and 16 hr. in Aug.) and bright sunshine (9, 8, 7 hr., respectively). Boating and fishing are favourite pastimes but visitors should be wary of sudden violent windstorms on the lakes in the Park and should remember that the water in these lakes is never very warm and accidental immersions could produce hypothermia very quickly. Freezing rain and snow can occur anytime throughout the summer in alpine and subalpine areas and can create potentially serious situations for poorly equipped visitors.

Wind chill is also an important consideration. In the warmer months it merely becomes unpleasantly cool under windy conditions; but in winter wind chill can be life-threatening. Frost and snow can occur at any time in the year and back country users should be prepared for almost any eventuality.

3.9.2 Scientific Research

Kluane offers interesting opportunities for scientific study of its weather patterns and phenomena. The Park spans the climatic divide between the marine and continental *regimes*, provides a variety of terrain situations which influence weather patterns, and experiences katabatic and glacier winds, Chinooks, etc. As well, the Park is subject to extremely active landscape processes in which climate plays an important and often controlling role (mudslides, frost-shattering, rock falls, etc.). It has been postulated for some time that large mammal behaviour is influenced by temperature inversions but no scientific proof of this has been obtained; opportunities for scientific study exist in these and many similar **areas.** Deep ice cores from glaciers in Kluane are currently being analysed in order to study past climates and patterns of climatic change.

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APPENDIX

3.1 Clixaatological Station Data Catalogue

CLIMATOLOGICAL STATION DATA CATALOGUE / CATALOGUE DE DONNÉES DES STATIONS CLIMATOLOGIQUES

Station Number (+ Indicates part of record under another name.)	Station Name	Province	Latitude ° '	Longitude ° '	Elevation (metres)	Periods with no change in programme, location, or name (*summer only: @ winter only) Began–year–mo.	Ended–year–mo.	synoptic / synoptique	hourly / horaire	temperature / température	precipitation / précipitation	rate of rainfall / intensité de la pluie	wind mileage / parcours du vent	soil temperature / température du sol	evaporation / évaporation	sunshine / insolation	radiation / rayonnement	ozone	upper air / en altitude	snow survey / relevé nivométrique	tower / tour	air quality / qualité de l'air	higher	1	2	3	Region / Région
	YUKON TERRITORY																										
2100100	AISHIHIK A	YT	61 39	137 29	966	1943 06	1943 11	X	P	X	X																W
2100100	AISHIHIK A	YT	61 39	137 29	966	1943 12	1944 08	X	X	X	X																W
2100100	AISHIHIK A	YT	61 39	137 29	966	1944 09	1966 09	X	X	X	X		B														W
2100182	BURWASH A	YT	61 22	139 03	799	1966 09	1974 07	X	X	X	X																W
2100182	BURWASH A	YT	61 22	139 03	799	1974 07		X	X	X	X	X											N				W
2100418	DESTRUCTION BAY	YT	61 15	138 48	785	1975 03	1975 08			X	X																W
2100430	DEZADEASH	YT	60 22	137 03	724	1974 07	1979 01			X	X																W
2100627	HAINES APPS #4	YT	60 49	137 44	846	1969 12	1970 06			X																	W
2100627	HAINES APPS #4	YT	60 49	137 44	846	1970 07	1971 09			X	X																W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1958 10	1958 10		D	X	X																W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1958 11	1959 04		D	X	X					S											W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1959 05	1961 09		D	X	X		B			S											W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1961 10	1962 02		D				B			S											W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1962 03	1962 08		D	X	X		B			S											W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1962 09	1963 04		D	X	X		B	D		S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1963 05	1964 06		D	X	X		B	D	A	S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1964 06	1969 12		D	X	X	X	B	D	A	S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1970 01	1971 10			X	X	X	B	D	A	S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1971 10	1972 09			X	X	X			A	S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1972 10	1973 09			X	X					S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1973 10	1973 12			X	X		B	D		S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1974 01	1974 05		D	X	X		B	D		S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1974 05	1979 12		D	X	X	X	B	D	A	S							N				W
2100630+	HAINES JUNCTION	YT	60 46	137 35	599	1980 01			J	X	X	X	B	D	A	S							N				W
2100630	KLUANE LAKE	YT	61 00	138 30	762	1946 05	1947 02			X	X																W
2100680	KLUANE LAKE	YT	61 01	138 24	786	1970 05	1970 08			X																	W
2100680	KLUANE LAKE	YT	61 02	138 24	786	1970 09	1971 05			X	X																W
2100680	KLUANE LAKE	YT	61 01	138 24	786	1971 05	1971 08			X	X					S											W
2100680	KLUANE LAKE	YT	61 01	138 24	786	1973 06	1974 05			X	X																W
2100680	KLUANE LAKE	YT	61 01	138 24	786	1974 06	1975 02			X	X		B														W
2100680	KLUANE LAKE	YT	61 01	138 24	786	1975 02	1975 03			X	X		B							X							W
2100680	KLUANE LAKE	YT	61 01	138 24	786	1975 04				X	X		B														W

CLIMATOLOGICAL STATION DATA CATALOGUE / CATALOGUE DE DONNEE DES STATIONS CLIMATOLOGIQUES

Station Number	Station Name (+ Indicates part of record under another name.)	Province	Latitude ° '	Longitude ° '	Elevation (metres)	Periods with no change in programme, location, or name (*summer only: @ winter only) Began year-mo.	Ended year-mo.	synoptic / synoptique	hourly / horaire	temperature / température	precipitation / précipitation	rate of rainfall / intensité de la pluie	wind mileage / parcours du vent	soil temperature / température du sol	evaporation / évaporation	sunshine / insolation	radiation / rayonnement	ozone	upper air / en altitude	snow survey / relevé nivométrique	tower / tour	air quality / qualité de l'air	nipher	1	2	3	Region / Région
2101296	WHITEHORSE	YT				1900 07	1990 08			X																	1M
2101290	WHITEHORSE	YT	60 45	135 00	632	19.4 11	1907 12			X	X																1M
2101290	WHITEHORSE	YT	60 4s	135 00	632	1909 01	1911 01			X	X																1M
2101290	WHITEHORSE	YT	60 43	135 03	636	1940 09	1942 03	X	P	X	X																1M
2101290	WHITEHORSE	YT	60 43	135 03	636	1999 02	1960 07			X																	1M
2101300	WHITEHORSE A	YT	60 43	135 04	103	1942 04	1942 06	X	P	X	X		B														1M
2101300	WHITEHORSE A	YT	60 43	135 04	103	1942 07	1946 04	X	X	X	X		B														1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1946 05	1957 02	X	X	X	X		B						X								1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1957 03	1959 07	X	X	X	X		B			S			X								1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1959 08	1961 09	X	X	X	X	X	B			S			X								1M
2101300	WHITEHORSE A	YT	60 43	135 04	to3	1961 10	1965 02	X	X	X	X	X	B			S			X				N				1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1965 03	1966 12	X	X	X	X	X	B			S			X	X			N				1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1967 01	1970 07	X	X	X	X	X				S			X	X			N				1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1970 07	1974 07	X	X	X	X	X				S	H		X	X			N				1M
2101300	WHITEHORSE A	YT	60 43	135 04	703	1914 01		X	X	X	X	X			A	S	H		X	X			N				1M
2101400	WHITEHORSE RIVERDALE	YT	60 42	135 02	641	1999 02	1970 08			X																	1M
2101400	WHITEHORSE RIVERDALE	YT	60 43	135 01	643	1970 08	1973 08			X																	1M
2101400	WHITEHORSE RIVERDALE	YT	60 43	135 01	643	1913 09				X	X																1M

CHAPTER 4

Permafrost of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

Date of preparation: March 1984.

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4.1 Introduction

Permafrost or perennially frozen ground is a thermal condition of rock or unconsolidated material in which the temperature does not rise above 0°C for at least twelve months (some definitions specify two years **as** minimum duration). The growth of permafrost reflects a negative heat balance at the surface in that there is insufficient summer heat to completely thaw ground frozen in the preceding winter. Permafrost thickness in any location is determined by a balance between the increase in temperature with depth (geothermal gradient) and the net heat loss from the surface. The geothermal gradient is virtually constant through time, so changes in the thickness of permafrost are functions of changes in climate or in the surface conditions which affect the heat balance (e.g. vegetation, snow depth, moisture content) and, therefore, the mean annual ground surface temperature. Rapid or catastrophic changes in the depth or distribution of permafrost are most commonly related to man-induced terrain disturbance. Over time, most undisturbed permafrost has reached a stable equilibrium condition with its climatic environment and changes in permafrost associated with long-term climatic change occur more slowly and result in gradual readjustment of equilibrium conditions.

4.2 Data Sources and Limitations

A detailed study of permafrost distribution in Kluane has not been done and therefore it is necessary to rely on isolated observations and an understanding of the factors which influence the occurrence of permafrost to determine its likely distribution. Some information **can** be gleaned from climatic data and knowledge of microclimatic interrelationships which are conducive to permafrost formation. Geomorphological studies and soil investigations can identify surface features which indicate the presence of permafrost. Vegetation patterns can also reflect underlying thermal conditions. Geotechnical drilling for roadways or development projects (e.g. Alaska Gas Pipeline) will provide actual data to confirm or modify the inferences made on the basis of surface indications. Some of these data **sources** are described in Table 4.1.

4.3 Distribution

Kluane National Park lies in the scattered discontinuous permafrost zone (Brown, 1967). The northern and southern limits of this **zone** correspond broadly with the -4°C and -1°C mean annual air temperature isotherms and, in general, permafrost becomes more common as one goes northward and mean annual air temperatures decline.

Table 4.1 Sources of information on permafrost distribution - Kluane National Park.

Citation	Description
Rampton 1981	- description of surficial geology and landforms of KNP
Ballard & Otchere-Boateng (in Douglas, 1980)	- reconnaissance soils survey as part of Biophysical Inventory of KNP
Harris 1981	- description of terrain components of the east Slims River Valley
Blood 1975	- detailed soil and vegetation study of 5 potential development corridors in KNP
Foothills Pipe Lines (Yukon) Ltd., 1981	- subsurface stratigraphic and permafrost distribution along proposed Alaska Highway Gas Pipeline route.

Whitehorse lies near the southern limit of the scattered discontinuous zone with a mean annual temperature of -1.2°C, while Burwash Airport at -4.4°C is near the northern limit (see Fig. 4.1).

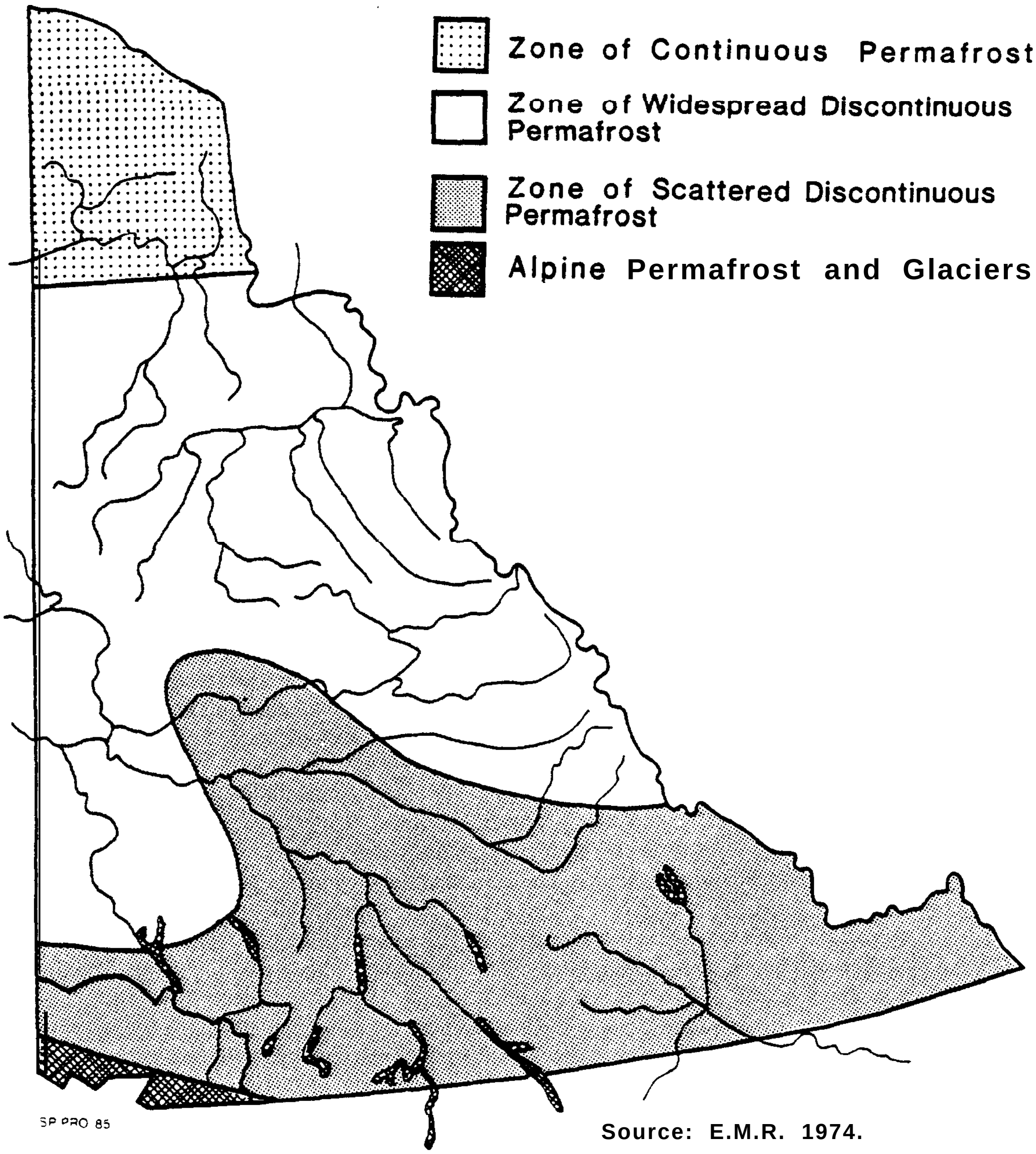
By definition, however, the presence or absence of permafrost in the discontinuous zone is due to site specific microclimatic factors. These factors include slope aspect, altitude, type of surficial material, soil moisture and drainage, and the distribution of snow cover and vegetation.

In general, south-facing slopes are permafrost-free while north-facing slopes, receiving less solar radiation, are likely to be perennially frozen. Mean annual air and ground temperatures decrease with altitude so that permafrost is more likely at higher elevations. Ballard and Otchere-Boateng (in Douglas 1980) report permafrost above 2000 m throughout the Park.

Permafrost is less likely to develop and be preserved in coarse-textured surface materials (gravel, coarse sand) than in fine silt. This relates in part to the differing thermal conductivities and moisture contents of the two types of material. Silt has a much higher thermal conductivity than gravel, thus in winter heat extraction is more rapid. In summer, however, because the silt has a much higher soil moisture capacity and therefore a higher heat capacity, the greater thermal conductivity is counteracted and in fact the summer heat gain may be lower in the silt than in gravel. Precipitation which normally percolates through gravel while running off in silt, also enhances heat transfer.

The pattern of snow accumulation is an important factor in permafrost distribution. In depressions, gullies, and on lee slopes where snow tends to accumulate, the ground is insulated from the penetration of winter cold, and permafrost is generally absent. Conversely, permafrost is more likely on exposed windswept slopes which are blown free of snow. However, a depression on a north-facing slope, where snow lies late in the spring and summer, may be underlain by permafrost. Heavy autumn snowfalls will inhibit freezing, while a thick snow cover in late spring will delay thawing. The relative frequencies of occurrence of these conditions will determine the overriding effect in any one location. Melting of late-lying snow creates cold wet soil and a shortened growing season. High soil moisture results in extensive frost action and disrupts or prevents vegetation growth.

Ground vegetation cover and surface accumulations of organic material greatly influence ground thermal regime and, in the discontinuous zone, may determine the presence or absence of permafrost. In this zone, peatlands are characteristically underlain by permafrost. This is due to the unusual thermal characteristics of peat. When dry (in summer) peat has a very low thermal conductivity and effectively prevents or limits the penetration of summer heat into the ground. During the autumn,



Source: E.M.R. 1974.

Figure 4.1 Permafrost distribution in southwest Yukon.

surface evaporation rates fall with falling temperatures and before freeze-up, the peat usually becomes saturated. The thermal conductivity of frozen saturated peat is very much higher and allows relatively rapid penetration of winter cold to the underlying layers. A considerable amount of heat is also required during the warm period to melt the ice and evaporate the water. The net result is a negative heat balance and conditions conducive to the formation and preservation of permafrost (Brown 1969).

Trees also play an important role in preserving permafrost by shading the ground from solar radiation, intercepting some snow and contributing to transpiration. Poorly drained areas, particularly in association with fine-grained soils and/or organic material, are usually underlain by permafrost. Permafrost is generally absent beneath large waterbodies which do not freeze to the bottom.

Small scale landforms and geomorphic features can point to the presence of permafrost. Solifluction lobes, stone stripes and polygons on colluvial slopes are all indicators of frozen ground. These features occur throughout the Park on moderate to gentle alpine colluvial slopes. Typical solifluction lobes occur on Observation Mountain and Goatherd Mountain and non-sorted polygons are present on the east side of Donjek Valley, indicating the presence of subsurface ice wedge networks (Rampton 1981). Periglacial features occur in the upper alpine zone in the southern areas of the Park, are less well developed in the drier central areas, and are common at lower elevations in the Duke and Donjek valleys.

Rampton (1981), in a description of the surficial geology and landforms of Kluane, indicates that at lower elevations permafrost is generally associated with areas of poor drainage, level topography, and accumulations of organic matter. Under these conditions permafrost occurs in almost all types of surface material, including colluvial deposits, aeolian material (sand dunes in Donjek Valley; loess on level areas where the fine texture impedes drainage), glaciofluvial deposits, lacustrine deposits (Alder Creek area), and morainal deposits. In the latter, permafrost becomes more common toward Donjek Valley and ice contents may be quite high locally, for example in the Burwash uplands. Geotechnical drilling carried out for Foothills Pipe Lines Ltd. (Foothills 1981) indicates that permafrost is quite widespread near Destruction Bay, to depths of at least 10 m with irregular taliks or unfrozen inclusions. High ice contents are present in the top 3-5 m. Southward along the Haines pipeline right-of-way, permafrost quickly becomes less common. Burned areas and the right-of-way itself have thawed; only forested areas are underlain by permafrost. Such degradation of permafrost is characteristic of the discontinuous zone, where permafrost may be relict from a previous colder climate and very near melting point, so that surface alteration, in this case associated with clearing of vegetation by fire and by man, can result in melting.

Table 4.2 describes landscape features in the discontinuous zone which are likely and unlikely to contain permafrost.

Table 4.2 Landscape features likely and unlikely to contain permafrost in the discontinuous permafrost zone.

omponent f andscape	Features where permafrost is usually less common or absent, the permafrost table depressed or the surface material likely to have a lower content of ground ice.	Features where permafrost is usually more widespread, the permafrost table nearer ground surface or the surface material likely to have a higher content of ground ice.
opography	South- and west-facing slopes.	North- and east-facing slopes. Summits of elevated plateaus, hills and mountains. Thaw slumps, akin flows and bi-modal flows on hill and valley slopes.
rainage	Below lakes, rivers, most vet thermokarst depressions and wet sedge meadows (wet fens) ; i.e. more water lies at or near the ground surface.	Imperfectly drained sites. Conifer covered river and creek flood plains in deep, shaded valleys. Subparallel rill drainage.
egetation	Net sedge meadows. Strings (reticulated, ribbed) fens. Willow belts bordering creak and river banks and thermo-karst features. Cleared lines in areas south of the -4°C mean annual air isotherm. Below tall, dense, nature stands of aspen. white spruce, lodgepole and jack pine on well-drained ground. Recent "deep" burns (fire history is an important factor that must be considered in the discontinuous zone).	Beneath open stunted black spruce-lichen woodlands. Beneath dense black spruce and white birch "islands" in south (shaded). Below dry lichen/Sphagnum/Labrador tea ground cover in southern fringe. Beneath elevated dry, wooded peat plateaus and palsas. Trees by themselves are not always a reliable permafrost indicator; and lic-hen and Sphagnum may also occur on bon-permafrost areas. "Drunken" forests are usually an indication of near- surface ice-rich silt and clay and frost-susceptible materials.
aterials	Bedrock; weathered shales may be ice-rich locally but the ice content is typically less in sandstones, carbonate rocks and crystalline metamorphic and igneous rocks.	Silty slopewash and post-glacial pond deposits. some scree (talus) with fines. Solifluction deposits. Rock and talus glaciers.
	Coarse-grained granular &posits (braided channels and floodplains, river terraces, glaciofluvial deposits, beach ridges). May contain "dry" permafrost. Perma-frost sporadic if present in southern fringe.	Windlaid silt (loess). Ice-rich permafrost in more northern areas, especially in thick shaetwash (water) re-transported loessial sediments.
	Windlaid sand (in dunes) usually contains no permafrost or "dry" permafrost.	Fine grained waterlaid sediments (lacustrine, glaciolacustrine, deltaic, vertical accretion floodplain. marine, glaciomarine). Mostly ice-rich permafrost in northern portion; ice content decrea-ses with depth and increases with latitude. Pre-Wisconsinan sedi-ments ususally have high excess ice contents.
	Compact logdment till, especially in glacier-streamlined Corms. Little or no ice below cleared trails and south facing slopes south of -4°C mean annual air isotherm. Typically lower ice contents below upper weathered layer (about 2 m).	Hummocky terrain associated with dead-ice moraine and some parts of end moraines.
	Peatland that is wet (areas of shallow standing or slow-awing water).	Closely spaced earth hummocks, mud hummocks, mudboils and nonsorted circles are indicators of frost-sensitive materials.
		Dry peatland sites. Peat plateaus, palsas and peat polygons. The high ice content in peaty palsas may extend into the underlying silty mineral soils. Whether the ground ice in peat plateaus extends into the underlying mineral soils depends partly on latitude (climate) and fire history. Peat plateaus and palsas may indicate former, now non-existent, permafrost, but this is uncommon in widespread discontinuous permafrost.

source : Johnston 1481.

rmaf

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4.4 Evaluation

The problems associated with human activity in permafrost areas are related to disturbance of surface vegetative cover and ground thermal equilibrium, and the resultant condition of the surface material if thawing occurs. Controlling factors are the presence of ground ice and the drainage properties of the material. By definition, permafrost does not necessarily contain ice. Indeed, **some** bedrock **areas** which are permanently frozen are virtually dry. In many cases, however, ground ice is present in some form. This may range from ice in the large voids in coarse-grained materials (gravel) to thin horizontal sheets between soil layers, to large wedge-shaped inclusions of segregated ice in silty material. In fine-grained material the properties of water in soil result in a situation in which not all water present freezes at 0°C. Technically frozen soil thus has a measurable hydraulic conductivity and the freezing process tends to **cause** water to migrate to the freezing front, producing excess ice and frost heave.

In coarse-grained saturated material, where only the soil voids are occupied by ice, thawing will probably have no discernible effect as the ice was merely filling interstitial spaces in the soil structure.

In fine-grained material with large bodies of segregated ice, thawing will result in settlement caused by loss of the weight-bearing mass of ice itself. The overlying material collapses forming a hollow which may collect water or become part of a drainage course. Drainage is slow in fine-grained material and the underlying permafrost acts as an impermeable layer. As a result, the surface soil becomes super-saturated. Any activity on such terrain causes destruction of the vegetation mat and churning of the surface; the kind of long-lived damage so commonly cited in Arctic regions. The presence of water in these hollows further changes the thermal regime and causes warming and melting to continue beneath and around the pond. Terrain characterized by these features is called **thermokarst.** The process of thermokarst development, once initiated is self-perpetuating and not reversible. When lowering of the permafrost table, usually by surface disturbance, results in thawing of ice-rich material it can be one of the most harmful construction-related effects in permafrost areas.

When planning development or construction, evaluation of the suitability of an area depends on avoidance of terrain susceptible to thermokarst. This is done firstly by broad scale identification of landforms which may be underlain by permafrost, followed by site investigation to confirm the subsurface thermal regime (usually by drilling or electrical resistivity methods). Tables 4.2 and 4.3 list some landforms and criteria which should be evaluated during planning and prior to any surface disturbance. Nearly every

Table 4.3 Terrain and landforms in permafrost areas which are
A- favorable;
B- unfavorable for construction.

, • Terrain and landforms favourable for construction.	B • Terrain and landforms unfavourable for construction.
) Smooth, low relief bedrock controlled terrain with or without a thin colluvial residual or drift veneer.	1) Glaciolacustrine and postglacial pond basins composed mostly of atratified silt, clay and fine sand; with or without a peat cover
2) Long, wide, sandy and gravelly raised beach ridges	2) Glaciomarine and postqlacial marine plains composed mostly of stratified silt, clay and fine send; with or without a peat cove,
3) Well-drained, granular alluvial terraces	3) Hummocky moraines generally containing ice-rich permafrost in the continuous permafrost zone
4) Smooth, low-relief send and gravel landforms (outwash plains, valley trains, glacial deltas, elongated kame deltas and kame terraces)	4) Smoothly rounded, sloping colluvial end wind-laid landforms containing silt, pebbly silt and organic silt
5) Glacier-streamlined forms composed of compact till, such as drumlins and drumlinoid features	5) Fluvial-lacustrine (deltaic) plains composed of stratified silt, clay end fine sand: often with a peat cover and widespread thermokarst features
6) Well-drained end moraine ridges, which contain appreciable granular material and may run for long distances with only short gaps	6) Very rough rocky (bedrock, frost-shattered rubble) terrain, which requires expensive blasting or construction of thick fills to provide a level surface
7) Large eskers and crevasse fillings (sinuous, sub-linear and linear ridges)	7) All types of peatland (muskeg); includes bogs (peat plateaus, palsas, peat polygons), fens and transitional peatland types
8) Well-drained fluted till plains and low relief ground moraine containing unweathered lodgment till at relatively shallow (1 to 3 m) depths.	8) Areas characterized by thermokarst depressions
9) Well-drained erosional terrace*, where not dissected by ravines and small tributary valleys	9) All finely lined slopes having subparallel (feather, horsetail) drainage patterns, commonly on silty slopewash deposits in the continuous and widespread discontinuous permafrost zone*
10) Well-treed, higher, gravelly and sandy floodplains, which are rarely subject to flooding	10) All slope failure, (falls, flows, slides and creep), including talus and *rock* glaciers
11) Narrow, well-drained, densely wooded stripe bordering the tops of creek and river banks and valley wells	11) Overbank (vertical accretion) floodplains, including backswamps and oxbows, in which a thick top stratum composed of organic silt and silty fine sand commonly overlies a coarser (granular) stratum at depth
12) Hard (e.g. Precambrian) bedrock for small building sites, even if the topography is somewhat irregular and requires blasing to level it	12) Fall fields (felsenmeer, block fields and rock streams), mostly at hiqh altitudes in mountains or in the Hiqh Arctic
13) Large send dunes (mostly *transverse* and longitudinal dunes, but including parabolic dunes in some areas)	13) Permafrost and frost-action generated mounds; e.9. mudboils (non-sorted circles), cemetery mounds and pingos
	14) Poorly drained ice wedge polygons, especially low centre polygons

Source: Johnston 1981.

activity associated with development will affect the ground **thermal** regime in the area concerned. It is essential to identify the **areas** where possible surface disturbance and melting of underlying permafrost will have the greatest impact and attempts made to locate on non-permafrost areas or on areas which, while frozen, do not contain excess ice. This applies to all scales of development from trail design to building **contruction.** Hiking trails can cross permafrost areas quite safely if care is taken not to allow hikers to channel over the same terrain, ultimately breaking down the vegetation cover (i.e. by identifying a general route rather than a marked trail).

Rampton (1981) lists the following landforms in Kluane on which surface disturbance could produce thermokarst:

- gentle colluvium-covered alpine slopes which exhibit periglacial features. In fine-grained material **(loess)** containing ground ice, disturbance may result in high solifluction rates and thennokarst.

- level stream terraces covered with silt or peat containing permafrost.

- flat **outwash** plain or valley train areas covered by silt or peat.

- depressions within kame complexes which may contain ice-rich fines.

- poorly drained swales within fluted moraine or ground moraine.

Thermokarst can occur naturally as well, usually **as** a result of forest fires. Fires alter the microclimate of the burned area by removing vegetation, changing the albedo of the surface, reducing the soil moisture content and reducing the roughness of the surface. All of these changes tend to increase the temperature of the soil surface and deepen the active layer.

4.5 Data Requirements

The current permafrost database is extremely limited, but given the discontinuous nature of permafrost distribution in Kluane and its extreme variability, a program to collect more data is not feasible. The Park offers excellent opportunities for scientific research into permafrost distribution and related processes and landforms. Information should continue to be collected opportunistically and through third party scientific research with detailed investigations undertaken by Parks Canada prior to any planned development.

4.6 Literature Cited

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CHAPTER 5

Geology of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

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5.1 Introduction

Kluane National Park lies within the North American Cordillera along the northwest edge of the continent in a zone of **active** tectonism or **crustal** deformation. The earth's crust is Comprised of several oceanic and continental plates in continuous motion relative to one another and along the northwest continental margin, the Pacific Ocean plate is colliding with and being forced beneath the North American Continental plate. This process is called subduction and the **movement** is reflected in the complex fault system which characterizes the area, and in the frequency of seismic and volcanic activity throughout the Pacific Northwest.

Recent investigations have revised previously-accepted theories on the geological history of the area. These studies indicate that much of the western Cordillera is comprised of a wsaic of 'suspect terranes' - geological units **formed** far from the continent in different environments unrelated to one another and transported and accreted to the continental margin by the collision of **crustal** plates with the North American **craton.** The terranes are termed 'suspect' because their paleogeographical setting with respect to North America is uncertain through much of geological time.

More than *50* suspect terranes have been identified in the Cordillera *(Coney* et al **1980).** Although only 4 or 5 occur in the Kluane area, the geological and tectonic history is still very complex and is only being deciphered at the present time.

Note that references to geological time are abbreviated in the text as my (million years ago) or million years **B.P.** (before present). A glossary of terms which may be unfamiliar to the reader are included as Appendix 5.1.

5.2 Data Sources and Limitations

Geological exploration in the southwest *Yukon* was prompted by the discovery of gold in the Klondike in 1896. Early geologists **were** primarily concerned with general observations of the nature of the terrain and **resources** and more detailed investigations of the economic mineral potential of the area.

In **1891,** C.W. Hayes and F. Schwatka (Hayes 1892) explored up White River to Copper River, **Alaska** and were the first to report the occurrence of native copper in the Kletsan Creek area, just north of the Kluane National Park boundary. W.J. Peters and A.H. Brooks of the U.S. Geological Survey also travelled through the Dalton Trail - Kluane Lake - White River **areas** in 1899 and commented on the occurrence of native copper (Brooks 1900). Brooks collected geological information during this trip and produced the first reconnaissance geological map of **the areas** through which he passed. J.J. **McArthur** of the Geological Survey of Canada made a reconnaissance of the Dalton Trail in 1897 and this work was continued by J.B. Tyrrell in **1899.**

Mapping was started in 1904 in the Kluane Lake area by R.G. McConnell of the Geological Survey of Canada (GSC), although his reconnaissance emphasized the locations of placer deposits. D.D. Cairnes visited the Kluane Lake and White River areas in 1913 and 1915, and expanded and revised the mapping begun by McConnell. W.E. Cockfield (1927, 1928) carried out geological exploration in the nearby Aishihik Lake area and along the Dalton Trail from Champagne to the British Columbia border, and this work was continued along the British Columbia portion of the Dalton Trail by J.T. Mandy. When the economic mineral potential of the area did not meet early expectations, exploration declined.

Exploration of a more academic and scientific nature began when R.P. Sharp (1943) accompanied the second Woods Yukon Expedition of 1941 and reported extensively on the geology of the Steele Creek area (at that time called Wolf Creek).

With the building of the Alaska and Haines highways in 1942 and 1943, access to the southwest Yukon was made easier and mapping and exploration activities were renewed. H.S. Bostock (1952) examined the area immediately adjacent to the Alaska Highway in 1945, and compiled all information available on the northwest Shakwak Valley. E.D. Kindle (1953) conducted field work in the Dezadeash map area from 1946 through 1950. Similarly, extensive fieldwork was carried out in the Kluane Lake map area by J.E. Muller (1967) between 1950 and 1957. Bostock's and Muller's works were the first to describe at any length the physical features, glacial history, and structure and stratigraphy of the bedrock of areas in and near Kluane National Park. Neither Kindle's nor Muller's report discussed the Icefield Ranges in any detail because of problems of accessibility. Operation St. Elias, Yukon Territory and British Columbia, led by R.B. Campbell of GSC, conducted field work in the St. Elias Mountains through the 1970's to fill some of the information gaps left by these workers and to describe the geology of the Icefield Ranges of both Yukon Territory and British Columbia (Campbell & Dodds 1975, 1978, 1979, 1982 a,b,c; Read & Monger 1975, 1976; Eisbacher 1975, 1976; Eisbacher & Hopkins 1977; Souther and Stanciu 1975). This program produced detailed mapping of most of the Park area at 1:125,000.

These investigations also provided information on the complex tectonic history of Alaska, Yukon, and British Columbia and contributed to understanding of the area in the context of the 'suspect terrane' theory. St. Amand (1957) described evidence for movement along various fault systems in northwestern North America. Members of the U.S. Geological Survey are currently conducting research along the coastal side of the St. Elias Mountains, and their reports include evidence of some very recent movements along faults south of the St. Elias Mountains. Proposals to construct the Alaska Highway Gas Pipeline prompted GSC to investigate the history of the Denali Fault System in southwest Yukon (Clague 1979).

The Greenbelt areas of the Park have been mapped in considerable detail and the data can be treated with confidence. Despite the work done by GSC in the St. Elias Mountains, the nature of the terrain precludes the same level of detail. In the Icefields, where only the highest peaks and most precipitous slopes are ice-free, data and field check points are more widely spaced and the bedrock geology of areas beneath the glaciers must be interpolated from nearby points and general structural trends.

Map 5.1 presents the GSC map and legend information generalized from 1:125,000 to 1:250,000. Considerable detail has been lost in this process and users are referred *to* the original maps from more complete information.

5.3 Geological History

From late Precambrian to late Triassic or early Jurassic time (see Figure 5.1) the margin of the North American continent was passive, a 'miogeocline', along which material was eroded from the ancient continent and slowly accumulated undisturbed in the paleo-Pacific Ocean. About 200 million years ago, the margin became active and the processes of convergence, collision, and subduction of crustal plates began to emplace the rocks of the present Western cordillera. Previously, geologists believed that the St. Elias Mountains were formed by uplift and compression of the miogeoclinal sediments as they *were* scraped up from the ocean floor when the oceanic crustal plate was forced beneath the continental plate. Recent investigations have altered this hypothesis and it is now recognized that the western margin of the North American continent formed over the last 200 million years by the impact and accretion of a series of oceanic crustal plates, each plate carrying material deposited and consolidated in an environment exotic to that of its final location. In many instances, these prefabricated blocks were carried thousands of kilometers north and east of their sites of origin in the Pacific basin.

> "Many of the blocks are of oceanic origin, consisting of oceanic crust, islands, plateaus, ridges, or island arcs. A few blocks are clearly fragments of other continents.... After making contact with North America the blocks were usually sliced by shear faults and drawn out into thin strips parallel to the continental margin."
> (Jones et al 1982:70).

These blocks are described today as 'suspect terranes' because their relationship to the North America continent through geological time is uncertain and because they often bear no genetic ressemblance to one another or to continental sediments.

Suspect terranes are internally homogeneous, are usually separated by known or suspected fault zones, and are recognized by marked discontinuities in geological age and stratigraphic sequence, fossil assemblages, and paleomagnetic characteristics across the fault contact, implying different geological histories and origins

Era	Period	Epoch	Time MY before present
Cenozoic	Quaternary	Recent	0.1
		Pleistocene	3.0
	Tertiary	Pliocene	5.0
		Miocene	22.5
		Oligocene	37.0
		Eocene	55.0
		Paleocene	65.0
Mesozoic	Cretaceous		140.0
	Jurassic		200.0
	Triassic		230.0
Paleozoic	Permian		280.0
	Carboniferous		346.0
	Devonian		395.0
	Silurian		435.0
	Ordovician		500.0
	Cambrian		570.0
Precambrian			3500 + ?

Figure 5.1 The geological time scale.

for adjacent terranes. The paleomagnetic data sets the position of terrane on consolidation with reference to the equator and the magnetic pole at that time, and in this instance, provides evidence for large latitudinal displacements and angular rotations (Irving & Yole 1972). Fossil information indicating that terranes now found on opposite sides of the Pacific basin contain the same fossil species provided some of the earliest indications that these rocks might not be formed from material eroded from the adjacent continental margin.

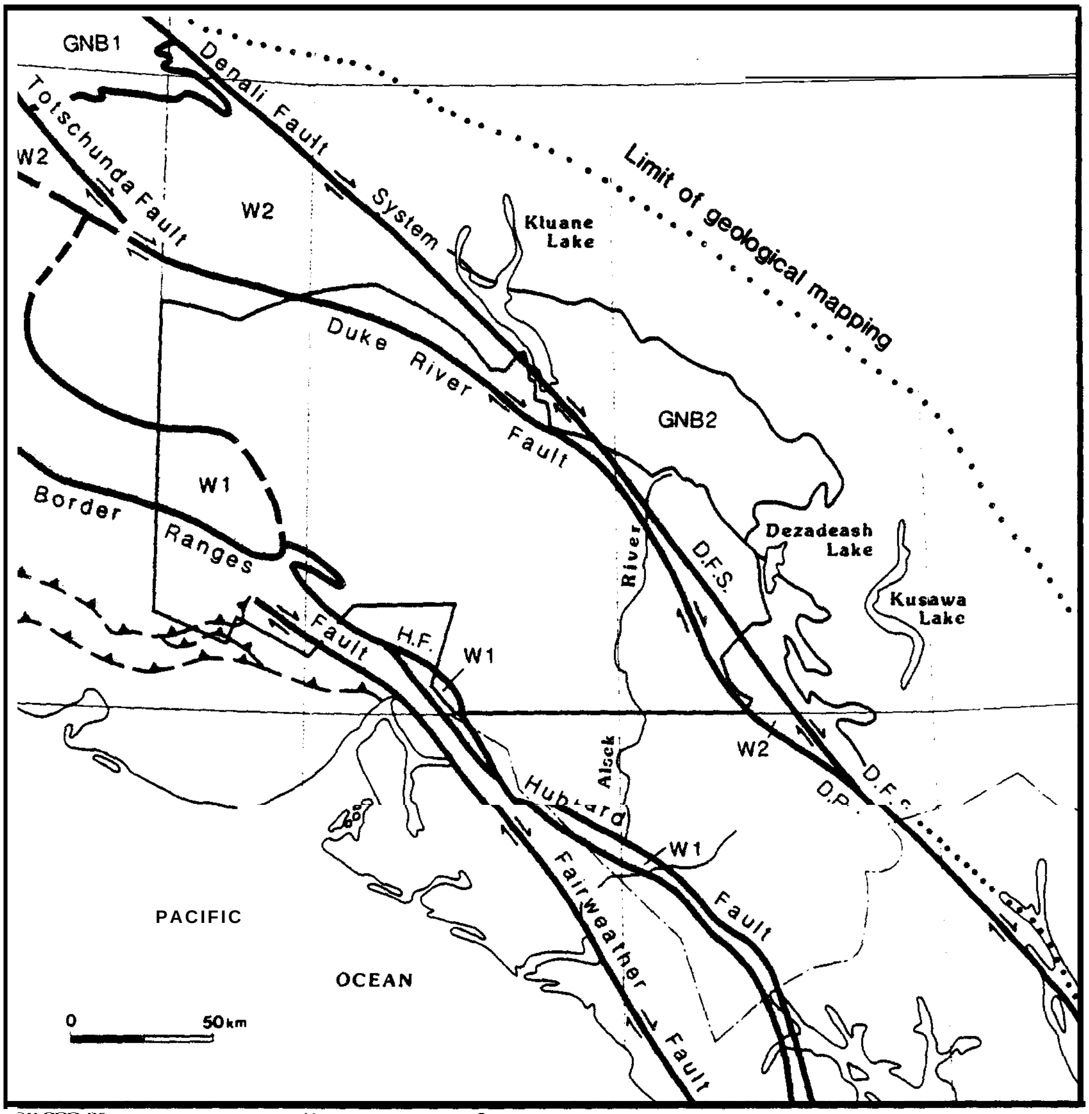
The actual mechanism of terrane accretion is poorly understood. It is clear however that the process is distinctly different from subduction accretion, which relates to the scraping up of soft unconsolidated sediments as a dense oceanic plate is forced beneath a lighter continental plate. Most Cordilleran terranes were accreted to the North American continent as coherent, strongly lithified masses (Jones et al 1983). The differences in the two processes seem to be related to the crustal thickness of the material being accreted. Thick crustal blocks such as seamounts, oceanic plateaus and ridges, and continental fragments are more difficult to subduct and tend to be accreted as intact blocks which retain their initial character. The leading edge of an accreted terrane therefore does not plunge beneath the continental plate; rather, the terrane edges take the form of thrust faults with one block moving up over another along a shallowly dipping fault or as strike-slip faults with the blocks moving past one another along a steeply dipping fault (Jones et al 1982). However it appears that subduction of the oceanic plate on which the terranes were transported does occur.

Several hypotheses link the terrane accretion process to the Laramide Orogeny (40-80 million years BP) which formed the Rocky Mountains. The details are unclear and the hypotheses remain unproven at the present time. The St. Elias Mountains formed much later (10-15 million years BP) after terrane accretion by processes related to plate tectonics, but again the details are poorly understood.

There are five terranes in the Kluane area - Alexander, Chugach, Wrangellia, Coast Plutonic Complex, and the Gravina-Nutzotin Belt. Their relative locations are shown in Figure 5.2. The inland limit of suspect terranes lies about 500 km from the coast, representing a vast volume of material moved against the continental margin and causing the continent to grow by about 25% in the 200 million years since the margin became active (Jones et al 1982).

A detailed geological history of northwestern North America and these five terranes in particular has not yet been developed. The following should be regarded as only a preliminary account and a distillation of material from many different sources.

Wrangellia formed as a volcanic island arc assemblage in latitude 15° N or S as indicated by paleomagnetic data. Coney et al (1980) believe that during its northward drift the Wrangellia terrane



SP PRO 85 140° **Source: Geological** Survey of Canada Open file 829. **830,** 831.

- Chugach Terrane
- Alexander Terrane
- Wrangellia Terrane (W 1, W 2)
- Coast Plutonic Complex
- Gravina-Nuttotin Belt (GNB 1,GNB2)

- High angle fault - defined, approximate, assumed
- Relative strike/slip displacement
- Thrust fault (teeth upthrust)

Figure 5.2 Suspect terranes in the Kluane National Park area.

amalgamated with the Alexander terrane and the Gravina-Nutzotin terrane was superimposed on both prior to being accreted to the craton, probably in late Jurassic to early Cretaceous time. Subsequently, probably in middle Cretaceous time, this composite mass then collided with the Yukon-Tanana terrane which had previously been accreted to the continental margin. In doing so, several smaller terranes were trapped within a flysch-filled zone between them. The Chugach terrane and other systems of flysch sediments to the west were subsequently accreted in late Cretaceous to late Tertiary time. With each accretion, the subduction zone stepped outward and to the south. Intraplate deformation during and after these successive accretions caused translation and strike-slip displacements of hundreds of kilometers along major faults in Alaska and Yukon, further drawing out terranes parallel to the coast.

At some point during the accretion process, the Wrangellia terrane was fragmented and accreted in at least three pieces spread out along the coast from southern British Columbia to Alaska. Strike-slip faulting subsequent to accretion has split the Gravina-Nutzotin Belt into two parts (see Figure 5.2) which today are displaced 300 km apart along the Denali Fault System in southeast Alaska and Yukon (Eisbacher 1976).

Throughout most of the Tertiary period (60-20 million years BP), these crustal blocks were still moving and adjusting their relative positions. Most areas were above sea level but there were no mountain ranges. The landscape was gently rolling, rivers flowed through broad valleys generally toward the southwest. The climate was temperate, probably warmer than today, and organic material from lush vegetation accumulated and was subsequently transformed into coal seams. Some of these seams are visible today in exposures of the Amphitheatre Formation along Sheep Creek and near Amphitheatre Mountain (Eisbacher & Hopkins 1977).

Volcanic activity began about 20 million years ago (Eisbacher & Hopkins 1977) in early Miocene time and resulted in extensive lava flows (the Wrangell Lavas) over this mature erosion surface. The Wrangell Lavas are exposed today near Steele Glacier, along Steele Creek, in the mid- Duke River valley, and along the Dusty River (Souther & Stancui 1975).

About 15 million years ago, in mid-Miocene time, this surface began to rise rapidly and differentially throwing up the St. Elias Mountains. The higher parts of the Wrangell lavas are interstratified with ancient tillites and fluvioglacial deposits in the St. Clare Creek area (Muller 1967). Similar areas along the White River in Alaska have interlayered lavas and tillites dated at 9-10 million years BP (Denton & Armstrong 1969), indicating that glaciation began in the St. Elias Range in the mid- or late Miocene.

Normal faulting accompanied this activity and two grabens, the Tintina and Shakwak trenches, formed in the Kluane area at this time. Evidence along recent fault scarps indicates the uplift continues to the present day (Eisbacher & Hopkins 1977).

A composite stratigraphic section for the eastern St. Elias area is shown in Figure 5.3. The cause of the widespread thrusting, folding, and uplift of the St. Elias Mountains is unclear although it is undoubtedly related to continuing interaction and subduction of crustal plates with a more northward component to the movement along the Pacific margin. The St. Elias uplift occurred after the terrane accretion process had been completed, although final consolidation may still have been underway. The uplift and folding resulted in shortening and thickening of the terranes, telescoping of the accreted material, and formation of the highest mountain range in North America.

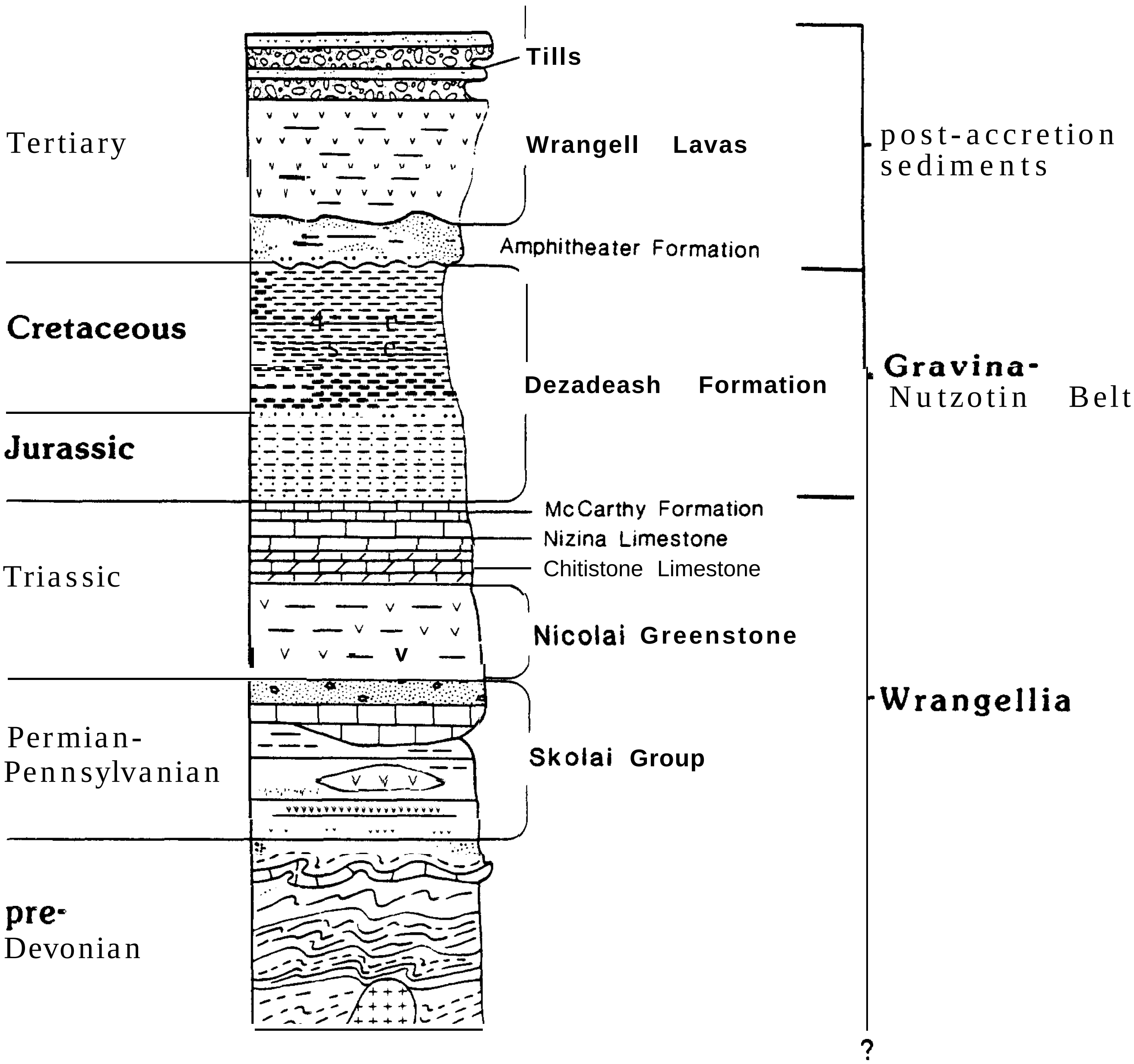
Volcanic activity has continued intermittently through Recent time. An eruption from a vent near the Klutlan Glacier about 1250 BP deposited a layer of ash eastward from the source over most of the park area (Lerbekmo & Campbell 1969, 1975). This was the second and later of two eruptions, the first occurring about 1890 BP. Bostock (1952) mapped the distribution of the ash through eastern Alaska and western Yukon (see Figure 5.4). Ash from the earlier eruption was carried northward, forming two distinct lobes. The White River Ash is an important Holocene chronological marker in the Kluane area.

5.4 General Geology

5.4.1 Description of Terranes

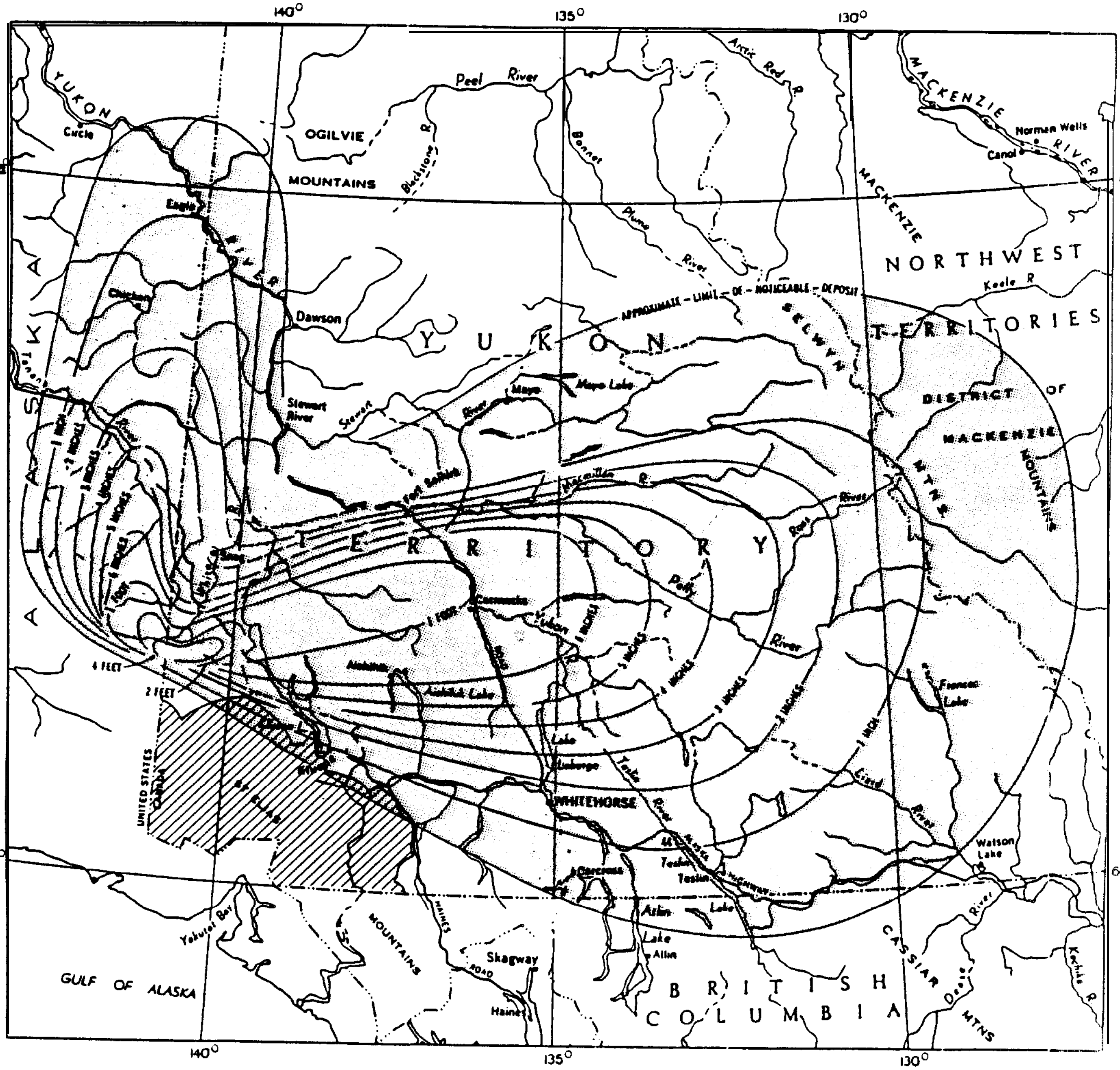
The five terranes in the Kluane area are described in Table 5.1. More complete descriptions are contained in the legend accompanying Map 5.1. Nomenclature is based on Coney et al (1980) and Campbell. & Dodds (1982 a,b,c,), and the detailed geology is from Operation St. Elias maps published as GSC Open Files (Campbell & Dodds 1982a, 1982b, 1982c). Original mapping was at 1:125,000 and has been generalized and reduced to 1:250,000 for inclusion here (See Map 5.1). Users requiring a greater level of detail are referred to the original publications.

No discussion is included here of the palaeontology of the Kluane area. Fossils have been used to date stratigraphic levels but no separate study of palaeontology has been undertaken.



(after Eisbacher 8 Hopkins 1976)

Figure 5.3 Schematic composite stratigraphic sequence - eastern St. Elias Mountains area.



(after Bostock 1952)

Figure 5.4 Distribution of the White River ash, Yukon Perritory and Alaska.

Table 5.1 Description of suspect terranes in the Kluane National Park area.

Terrane	Location and Reference	Description
Chugach	- southwest of the Border Ranges Fault (BRF) - Sharp & Rigsby (1956), Brew et al (1978), Campbell and Dodds (1978, 1979).	- early to late Cretaceous metamorphosed sedimentary and volcanic rocks, highly deformed and intruded by early Tertiary plutons. - basically a flysch sequence equivalent to the Yakutat and Valdez. - most of the area is Valdez group argillite and greywacke, minor granitoid gneiss. - Yakutat occurs only in the southwest extremity. - BRF runs across the south face of Mount Logan and makes a sharp contact between black Cretaceous Chugach sedimentaries and the granites of the Logan Massif. - fossils are generally rare but some Lower Cretaceous fossils are found on the southeast end of the Logan Massif. - thrust fault involving Tertiary and Quaternary marine rocks near Mount Saint Elias indicates that underthrusting at the continental margin continued until recently and is likely still continuing. - the current active transform boundary between the North American and Pacific crustal plates lies within the Chugach terrane along the St. Elias - Fairweather Fault system.

Table 5.1 Description of suspect terranes in the Kluane National Park area (continued).

Terrane	Location and Reference	Description
Alexander	- between Hubbard (Walsh or Art Lewis) Fault and Duke River Fault - Wheeler (1963), Campbell & Dodds (1978).	- oldest rocks in the Kluane area - volcanic island arc assemblage - Paleozoic volcanics, greywackes, carbonates of the Kaska-wulsh Group - late Cambrian to Permian age. - extensive Devonian carbonate exposed in upper Fisher, Lowell, Kaskawulsh, Donjek glacier areas, in the Centennial Range and west of Mount Wood. - low grade metamorphism - intruded by diorite and granodiorite plutons from late Paleozoic time (270-290 my) to Tertiary. The later intrusions form the Logan Massif and other high peaks in the St. Elias Range (Hubbard-Alverstone-Kennedy massif, Mt. Steele, Mt. Walsh) - complexly deformed at least 3 times, once prior to the intrusion, and the latest in late Miocene time during the St. Elias uplift. - the Hubbard Fault is apparently pre-late Cretaceous, and may represent a suture between Wrangellia and Alexander.

Table 5.1 Description of suspect terranes in the Kluane National Park area (continued).

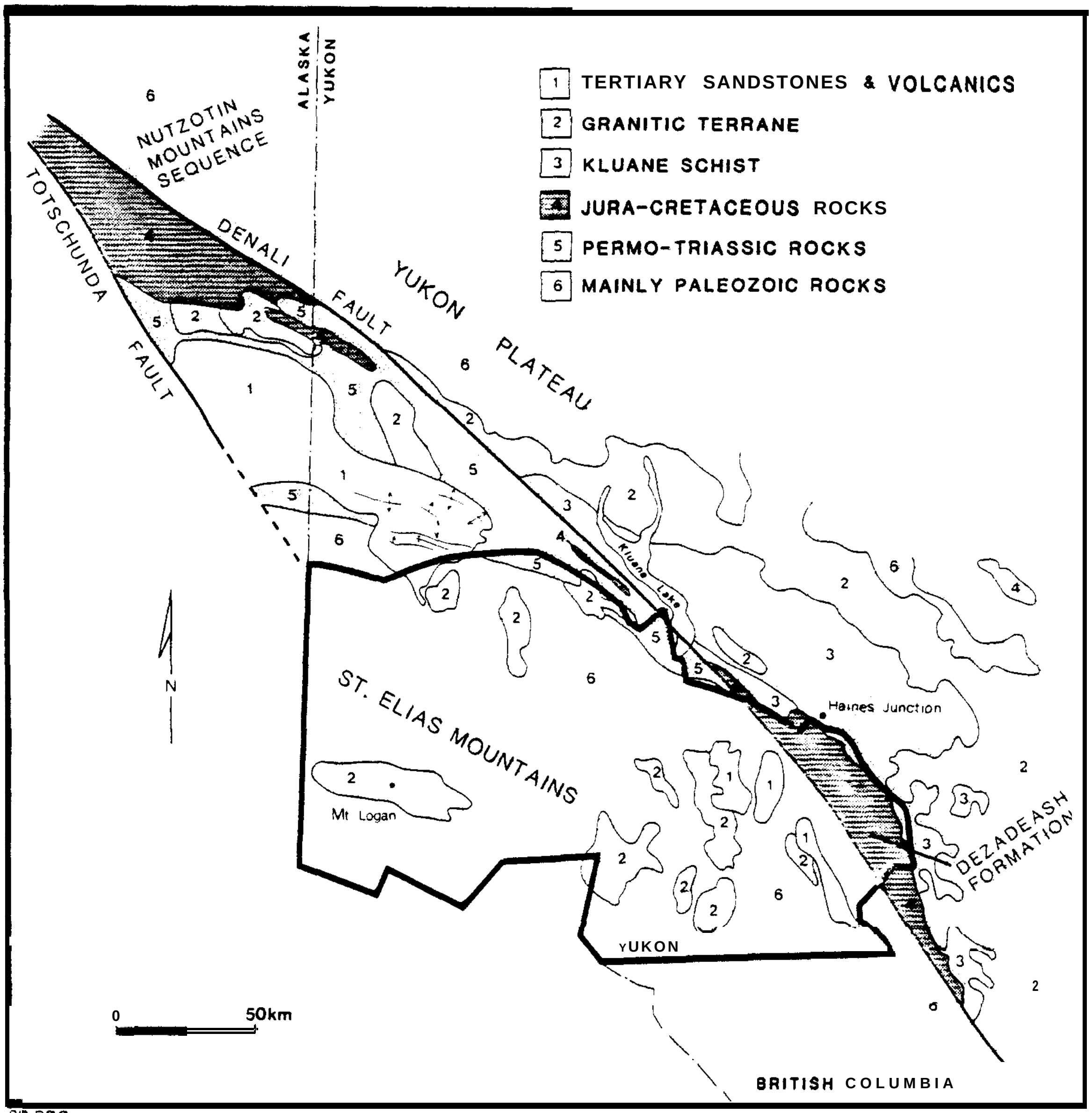
'errane	Location and Reference	Description
lrangellia	- present in Kluane as two arms, one between Ranges Fault (BFR) and Hubbard Fault, and the other between Duke River Fault (DRF) and Denali Fault System (DRF). The Alexander Terrane lies between these two arms. - Read & Monger (1975, 1976) Jones et al (1977).	- late Paleozoic, early Mesozic (Pennsylvanian, Permian, Triassic) sedimentary and volcanic rocks - volcanic island arc assemblage - includes parts of the Skolai (carbonate), Nikolai (greenstones), McCarthy (shales),and Chitistone (limestone) groups and formations - oldest rocks are thick upper Paleozoic andesitic arc sequence overlain by Lower Permian fossiliferous limestone and argillite (Skolai), overlain by Triassic Nikolai. - intruded by quartz diorite and granodiorite plutons of late, Jurassic, early Cretaceous age - these plutons form the Loga Massif. - unconformably overlain by undeformed fossiliferous late Cretaceous shallow marine sediments. - Chitistone, McCarthy and part of the Skolai rocks are unmetamorphosed. - BRF may be the trace of an early Tertiary subduction zone. DRF and DFS appear to be major transcurrent breaks which intersect and dislocate other structures. They separate terranes by major horizontal displacements rather than sutures and are therefore probably not related to the continental margin. - thick sequence of volcanic rocks between the Dalton and Duke River segments of DFS are known as the Mush Lake Group (Read & Monger 1975); dated Pennsylvanian by Campbell & Dodds (1978).

Table 5.1 Description of suspect terrannes in the Kluane National Park area (continued).

Terrane	Location and Reference	Description
Coast Plutonic Complex and Yukon Crystalline Terrane	- northeast of Denali Fault System - Templeman-Kluit (1976)	- complexly interfingered with intrusions of the Coast Plutonic Complex - quartz diorite and granodiorite multiphase plutonic rocks. - metamorphic and igneous rocks of Paleozoic age between the Tintina and Denali faults. - complex poorly understood geological history. - metasedimentary sequence derived from fine-grained clean shale and sandstone with interbedded limestone. - east of Kluane schist, large areas of biotite schist with thick marble lenses. - corresponds to the Yukon Plateau physiographic province, unglaciated during the Wisconsin glaciation.

Table 5.1 Description of suspect terranes in the Kluane National Park area (concluded).

Terrane	Location and Reference	Description
Gravina-Nutzotin Belt	- in two segments separated by DFS and offset right laterally by about 300 km. - Eisbacher (1975, 1976), Berg et al (1972).	- Jura-Cretaceous marine flysch deposits - turbidites, mass flow deposits, greywacke, argillite, and volcanic rocks of the Dezadeash Group - cut by Cretaceous and Tertiary intrusions, granodiorites dated at 111-105 my. - emplaced over Wrangellia and Alexander terranes after their amalgamation and prior to accretion. - the northeast contact between the Dezadeash Group and the Coast Plutonic Complex is unclear. - along the southeast boundary of the Park and further south the Dezadeash Formation has been metamorphosed to the Kluane Schist, a uniform sequence of hornfelsed quartz-biotite schist, - probably about 50 my ago. - the Dezadeash Group rocks were deposited by turbidity currents on a deep sea fan system fed by an uplifted volcanogenic terrane to the west. - the Group was subsequently accreted and torn by movement along the Denali Fault System (see Figure 5.5). - equivalent rocks are found in the Nutzotin Mountains Sequence and the McLaren Metamorphic Belt in Alaska on the other side of the Denali Fault System. - intrusions included ultramafic rocks in the Pyroxenite Creek area (115 my).



(after Eisbacher 1976)

Figure 5.5 Geological sketch map of the southwest Yukon showing offset of Dezadeash formation along Denali Fault System.

5.4.2 Structural Geology

The Kluane area is cut by a number of major fault systems, most are strike-slip or transcurrent faults, and they usually trend northwest-southeast. All of these faults relate in some way to the crustal plate interaction occurring along the northwest continental margin. Some represent past continental margin subduction zone sutures (e.g. Border Ranges Fault), some are sutures between amalgamated terranes (e.g. Hubbard Fault), and others are post-accretionary faults which have subsequently split and displaced terranes (e.g. Denali Fault System). Many faults are part of a system comprised of individual segments which have separate tectonic histories (e.g. Denali Fault System). Nomenclature for some segments has not been formalized - the most obvious example is the Hubbard Fault, known also as the Walsh Fault and the Art Lewis Fault. The fault systems in Kluane are shown in Figure 5.2.

Denali Fault System

The Denali Fault System can be traced 2500 km from southcentral Alaska, through southwest Yukon to northern British Columbia. Three segments occur within the Kluane. area - the Shakwak, Dalton, and Duke River faults (see Figure 5.2).

The Shakwak Fault follows the western edge of the Shakwak Trench from the Alaska border to a point near Milepost 1067 (approx.) of the Alaska Highway where it crosses the southern end of Kluane Lake. The eastern flank of the Kluane Ranges rises abruptly from the Shakwak valley along this fault; local relief exceeds 1600 m (Clague 1979). The Shakwak Valley is a graben 3-8 km wide, formed during the St. Elias uplift. Its eastern boundary is a series of normal faults (Templeman-Kluit 1980). The Dalton Fault extends from Kluane Lake through the Kluane Ranges to the British Columbia border. The Duke River Fault (DRF) branches off the Denali Fault System in British Columbia and runs subparallel north to the Duke River where it turns westward into Alaska. It marks the northeast contact between the Alexander and Wrangellia terranes. Campbell & Dodds (1978) believe the DRF is a post-accretionary transcurrent break. A horizontal displacement of at least 1000 km is suspected and may be responsible for the splitting of the Wrangellia terrane (Burles, pers. comm). The last major displacement along this fault is probably Late Cretaceous and is definitely pre-Miocene. There is only limited evidence of later activity along some of the related faults and no major dislocations are known. Microearthquake research done by Boucher & Fitch (1969) indicated however that minor activity continues along this fault today.

Lanphere (1978) concluded that large Cenozoic post-accretionary displacements of up to 350 km of dextral strike-slip offset occurred along the McKinley (Alaska), Shakwak, and Dalton segments between 55 and 38 my ago. Jones et al (1977) suggest these movements may be related to final suturing of Wrangellia.

Subsequent displacements have been less spectacular. Late Quaternary faulting has occurred along the McKinley and Totschunda segments as demonstrated by the dislocation of Pleistocene glacial features (Richter & Matson 1971). Plafker et al (1977) estimated a total late Cenozoic displacement on the Totschunda Fault of about 4 km. In the last 5 my, the Shakwak Fault appears to be the focus of dip-slip normal faulting associated with graben development (Rampton 1981). Rampton (1981) examined postglacial scarps along Shakwak Fault and believes the present dip-slip movements are related to continued graben development, to continued uplift of the St. Elias Mountains, to isostatic readjustment following deglaciation, or presumably to some combination of the above. These scarps face northeast and are of variable height, in some places exceeding 20 m (Rampton 1981). In recent times, trancurrent faulting appears to have shifted to the west and south possibly due to changes in the motion of the Pacific crustal plate. No major Quaternary displacements have been proven for the Yukon segment of this system, but Clague (1979) has described evidence of earthquake activity in Late Pleistocene sediments. Both he and Rampton (1981) have identified a number of scarps (see above) and aligned sediment mounds in the vicinity of the Shakwak Fault and the northern part of the Duke River fault that probably formed as a result of ground shaking. Little evidence of such activity was found along the Dalton Fault, but a great deal of microearthquake activity has been recorded, suggesting these segments are not completely dormant. Rampton (1981) ties these sediment mounds to faulting during deglaciation 13,000 to 10,000 B.P. This activity may have continued into early Holocene time but:

> "Neither the Neoglacial beaches and wave-cut benches of Lake Alsek and Kluane Lake, nor surface of modern floodplains and alluvial fans are offset where crossed by the Shakwak and Dalton faults. It is thus concluded that there has been no significant faulting along this part of the Denali Fault System during the last several hundred years."
>
> (Clague 1979:177).

Hubbard Fault

The Hubbard Fault System is represented within Kluane National Park by an ill-defined fault line that apparently passes under the Walsh Glacier, through part of the Centennial Range and continues southward to the east of Mount Logan where it is cut by the Border Ranges Fault. From the south, it can be traced from Tarr Inlet in southeastern Alaska north through British Columbia, under the Hubbard Glacier, and somewhere through Mt. Vancouver, where it is also cut by the Border Ranges Fault. It is generally subparallel to and about 100 km west of the Denali Fault System. The Hubbard Fault (Walsh Fault, Art Lewis Fault) marks the southwesterly contact between the Wrangellia and Alexander terranes.

Border Ranges Fault

The Border Ranges Fault (BRF) runs subparallel and very close to the Hubbard Fault in southeastern Alaska and northwestern British Columbia, cuts the Hubbard Fault, and then diverges westward from it within Kluane National Park and crosses the south face of Mount Logan (Campbell & Dodds 1978). It can then be traced discontinuously through the Chugach Mountains and down through the Kenai Penninsula and Kodiak Island for a total known length of over 1000 km. The exact location of parts of the Fault are still being modified as more study is done. The BRF separates the Chugach terrane from Wrangellia and marks the location of a late Cretaceous-early Tertiary subduction suture.

St. Elias - Fairweather Fault

The coastal region of the Gulf of Alaska is the site of an active transform boundary between the Pacific and North American plates, and as such is a very complexly faulted and folded area. The present location of this subduction zone is believed to be marked by the St. Elias - Fairweather fault system.

The Fairweather fault can be traced from Cross Sound north through Alaska subparallel to the Border Ranges Fault; it is believed to be a continuation of the Queen Charlotte transform fault occurring further to the south. The Fairweather Fault apparently intersects the St. Elias and Coal Glacier faults and Pamplona fault zone in the Mount Cook area. The St. Elias Fault is the longest segment in Yukon and follows a winding course through the Mount Cook - Mount Augusta - Mount St. Elias massif continuing as the Chugach Fault in central Alaska. This fault system is different from those systems described previously in that it cuts rocks of similar age and origin. Faults in this area are compressional in nature indicating that Tertiary and Quaternary marine sediments are being thrust under Cretaceous material to the north (Campbell and Dodds 1978).

A broad zone of onshore and offshore folds and thrust faults extends southwestward from Mount St. Elias, and is called the Pamplona zone. This is believed to be the present zone of active underthrusting. The buoyant crust lying between the Fairweather Fault, Pamplona zone, and a submarine Transition fault zone is referred to as the Yakutat block, and is currently in line to be either subducted beneath, or accreted to, the North American plate (Plafker et al 1978).

Recent earthquake activity accompanied by horizontal displacement has been recorded along this fault system, suggesting that it is currently active. A series of great earthquakes in 1899 in the Yakutat Bay area caused major vertical displacements, presumably along the northern part of the Fairweather Fault. An earthquake in in 1958 was centered in the Cross Sound area and caused horizontal displacement of up to 6.5 m and vertical displacement of about 1 m along much of the Fairweather Fault (Plafker et al 7978).

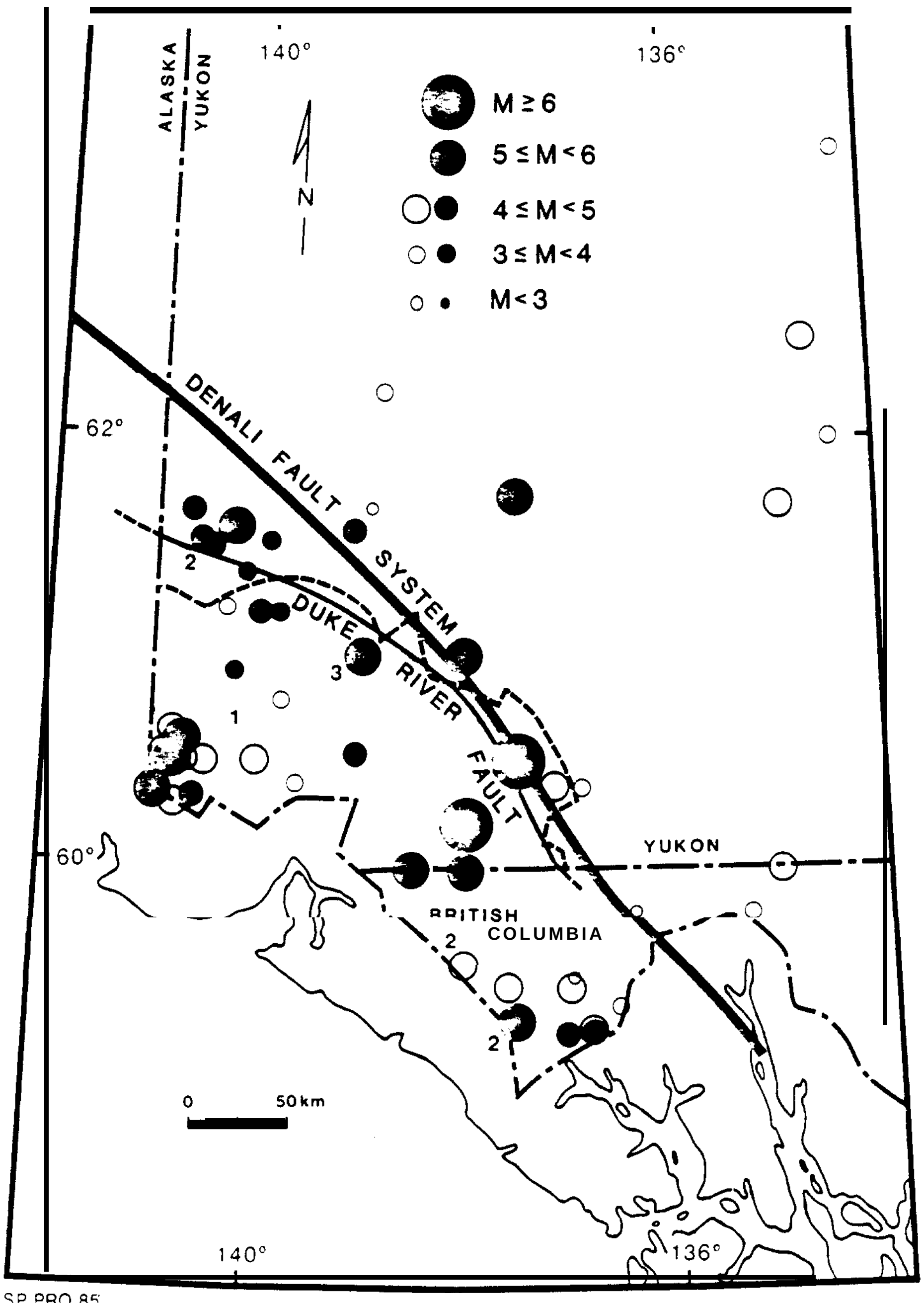
5.4.3 Seismicity

Earthquakes along the Pacific rim are usually caused by the sudden release of inertial stress and deep-seated slippage along the contact between the two crustal plates. This movement sends a shock in all directions through the ground which is felt most strongly at the point on the surface (the epicentre) directly above the point at which the slippage occurred.

There is considerable seismic activity in the Kluane area due primarily to Kluane's proximity to the active transform boundary between the Pacific and North American plates, thought to lie along the Fairweather Fault about 100 km to the southwest. Annual displacements along this fault are in the range of 4.8 to 5.8 cm and in 1958 a 7.9 magnitude earthquake produced dextral slip of 6.5 m (Plafker et al 1978). Figure 5.6 indicates earthquake epicentres and magnitudes in the southwest Yukon for the period 1899-1975. Events of magnitude-5 are considered moderate with damage concentrated only near the epicentre. Magnitude-6 events are large and potentially destructive, causing damage within SO-100 km of the epicentre. At least two magnitude-6 quakes have occurred in the area since 1899. The limitations associated with the data portrayed in Figure 5.6 are substantial. Since 1971 all earthquakes in the area greater than magnitude-4 have been detected; consistent detection of earthquakes less than 6 was not possible prior to 1964, biassing the data set toward higher magnitude events. Epicentre locations are probably accurate to about 20 km and, prior to 1971, are less accurate.

A seismograph was recently installed on Paint Mountain near Haines Junction. The recording apparatus for this station is located in the Park Headquarters building at Haines Junction. A magnitude-5.3 earthquake was experienced at the ?ark in March 1983. The epicentre was about 65 km northwest of Burwash Landing in the Park; no damage was caused. Modern seismographs also detect micro-earthquakes, minor tremors usually not felt at the surface. The Kluane area is extremely active in this regard, experiencing on average 3 events per day. The role of these minor events in local stress release is poorly understood.

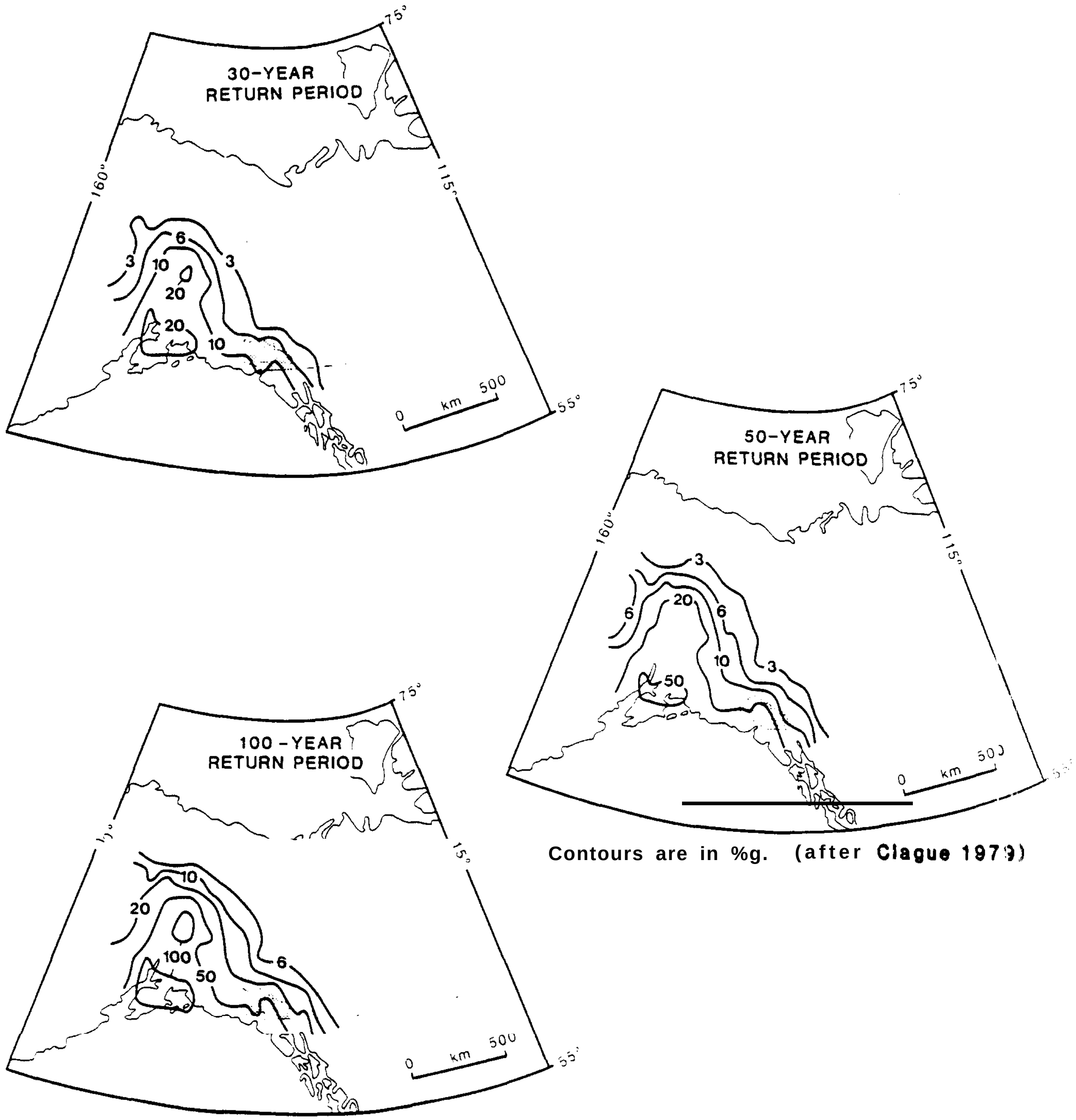
When earthquake tremors pass through an area they cause ground accelerations which are usually the source of any damage which results. Stevens & Milne (1974) analysed data from 1899 to 1970 and predicted ground accelerations for return periods of 30, 50, and 100 years. These values may vary by a factor of 2 or more due to the short length of record in the area and the inherent data bias toward larger events until recent years. Accelerations are expressed as a percentage of the acceleration due to gravity (g) - 10%g is considered the threshold of structural damage. As shown in Figure 5.7, potentially damaging accelerations can be expected to



(after Clague 1979)

‘Small number indicates the number of coincident epicentres.
The black circles represent more reliable epicentre locations.

Figure 5.6 Earthquake epicentres and magnitudes in southeast Yukon 1899-1975.



Contours are in %g. (after Clague 1979)

Figure 5.7 Predicted acceleration amplitudes for the southwest Yukon **Territory.**

occur in the eastern St. Elias area over relatively short return periods. Past strain release in this area is equivalent to one or more magnitude-6 earthquakes or 5 or more magnitude-S earthquakes per 10,000 km per 100 years (Stevens & Milne 1974).

5.4.4 Economic Geology

Since 1972, the status of Kluane as a National Park Reserve has precluded mining activity of any kind. Early in the century however the mineral resources of the area were the major impetus to exploration and development. Muller (1967) believed the geological conditions in the St. Elias Mountains (volcanic and sedimentary rocks intruded by granitic bodies) were promising for economic mineral deposits. He lists the known mineral deposits in the Kluane area as: placer gold in recent stream gravels; native copper in Mesozoic volcanic rocks; copper, nickel, and platinum sulphides associated with ultrabasic intrusions; scheelite (tungsten ore) and molybdenite (molybdenum ore) in granitic rocks; gypsum in Triassic sediments: and coal in Tertiary sediments.

Placer gold mining began on a small scale in 1896 (see Chapter 12 section 12.5), expanded dramatically in 1905 with the Bullion-Sheep creek discoveries, and has continued to the present day on a limited scale outside the Park boundaries. No lode or source has ever been discovered for the Kluane placer gold deposits. The basins of placer-bearing streams do not contain the intrusive or metamorphic rocks that would provide sources of gold. Most deposits are found in Recent stream gravels and occur in relatively narrow canyons cut in bedrock underlying thick glacial deposits (Muller 1967). Muller (1967) believes the canyons acted as natural sluice boxes washing out sands and gravels and concentrating the placer deposits. No placer deposits have been found in canyons cut below valleys occupied in the St. Elias advance in late Wisconsin time.

> "The apparent barrenness of streams incised below the younger glacial deposits may be due to shorter time available to concentrate placers from the overlying drift and partly to the smaller localized bedrock source for the St. Elias drift against the larger area including the Yukon Crystalline Complex and the Coast Mountains available as source rocks for the older drift deposits." (Muller 1967:108).

The Wisconsin glaciation was relatively minimal compared to previous episodes and preservation of some placer gravel beds was probably due to local physical features which protected the beds from glacial scouring by directing the ice around the feature.

Most placer mining activities in the park area were located along the Kluane Ranges on streams flowing toward Kluane Lake. Mining continues today along Burwash Creek, Quill Creek, Wade and Maple creeks and to some extent east of Haines Junction in the Dezadeash Range.

Native copper has been used by native people in the Kluane area to make axe heads, arrowheads, knives, and cooking utensils for perhaps 1000 years. Copper nuggets are found in the White River area north of the Park where they are derived from amygdaloidal volcanics, and in Burwash Creek placer deposits. Claims were staked in the White River area, on Tatamagouche Creek and Quill Creek about 1908 but no economic development has followed. Muller (1967) believes the native copper was initially a minor component of the local volcanic rock and was ultimately concentrated by secondary enrichment following downward percolation of water carrying copper in solution. Bornite (copper sulphide ore) was discovered north of the Park in 1952 and created a significant staking rush. Two properties were developed commercially by tie Hudson Bay Mining and Smelting Co. and by Canalaska Mines. Both mines have since closed. The Hudson's Bay property, the Wellgreen Mine, produced 189,2 11 tons of copper and nickel: the Johobo Mine south of Haines Junction produced 3647 tons of copper and silver (Scace & Assoc. 1975). These deposits all occur close to fault zones adjacent to intrusions. Malachite and azurite show throughout the Kluane area in Triassic volcanics.

Scheelite and molybdenite are present in the Kluane area in non-economic quantities.

Lignite coal was discovered by early placer miners in Tertiary sediments on upper Sheep Creek and near Amphitheatre Mountain. The coal was of excellent quality and could be burned directly in a box stove. Seams up to 2 m thick have also been noted on Granite, Ptarmigan, Burwash, Telluride, and Kimberly creeks. These were described in detail by Cairnes (19 15). The coal deposits are not suitable for commercial development because of complex folding in the host rocks.

Gypsum and anhydrite are exposed east of Bullion Creek, and also near Bock's Creek and Burwash Creek in Kaskawulsh group upper Triassic sediments.

None of the mineral deposits inside the Park can be developed as mining is not allowed within the Park Reserve. Resources outside the Park have almost all proved uneconomical usually because of the high transportation and development costs involved.

5.5 Evaluation

5.5.1 Interpretation

Kluane's mountains, glaciers, and spectacular scenery are some of its finest resources and interpretation of the origin and formation of the mountains can provide visitors with interesting insights into the scenes before them. This is particularly true of the plate tectonics-suspect terrane-mountain building aspects of the geological history of the area, which lend themselves particularly well to graphics and display techniques.

The more detailed geology of the area is too complex to be of interest to the casual visitor. However the following specific items could be developed as additional interpretation points:

Tertiary lava flows - the Wrangell Lavas (see Map 5.1 for distribution)
White River *Ash* (see Figure 5.4)
Seismic activity and fault movements (past and present) particularly in conjunction with the seismic recorder in the Visitor Reception Centre at Haines Junction.

The era of the gold rush and continuing gold mining activity is an important part of the history of the Park area since 1900 and is a valuable interpretive resource. Artifacts have been recovered from many areas of the Park and some buildings are still intact. Chapter 12 - Cultural Resources discusses development of this historic resource for interpretation.

5.5.2 Scientific Research

The Geological Survey of Canada undertook Operation St. Elias in the mid and late 1970's producing geological descriptions and mapping of the rocks of the St. Elias Mountains in southwest Yukon and Northern British Columbia at 1:125,000. This has added immensely to our knowledge of the geology of a particularly inaccessible area and has provided supporting information on the plate tectonics and suspect terrane theories advanced to explain the geological development of the region. More information is required on the formation of the St. Elias Mountains and on the continuing fault and seismic activity experienced in the area. The location of the Park so near to the active margin of the Pacific and North American plates provides exciting opportunities for this type of research, particularly with improvement of the seismic recording network and more precise location of epicentres. The microearthquake activity in the area 'has not been fully investigated. The role of this type of small frequent shock in regional stress release in unknown. These events may also influence geomorphological processes in the area, such as landslides, mudflows, and perhaps glacier surges. With the detailed seismic record now available studies of these effects can be untertaken.

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Map 5.1 Geology of Kluane National Park.

APPENDIX

5.1 Glossary of Geological Terms

accretion - the process by which large blocks of lithified rocks are added to the continental margin.

argillite - compact rock formed from fine sandstone, siltstone, and shale and lacking the fissility of shale.

breccia - rock comprised of angular fragements of volcanic origin, or may be formed by grinding along a fault.

craton - a large stable continental mass usually comprised of igneous or metamorphic rock and usually of great age e.g. Canadian Shield.

dextral strike - slip fault - see strike-slip fault. Movement along a strike-slip fault such that standing on an outcrop facing the fault, the corresponding rocks appear to have moved to the right.

diorite - a coarse-grained plutonic igneous rock, usually dark in colour.

dip-slip fault -a fault along which movement is predominantly vertical.

flysch - sediments produced by the erosion of uplifting fold structures and deposited in a marine environment by turbidity currents - usually dark coloured find-grained sandstones and shales.

gneiss - a banded and coarsely foliated metamorphic rock formed by regional metamorphism of igneous rocks.

graben - a block of the earth's crust, usually longer than wide, which has dropped relative to the blocks on either side.

granodiorite - a coarse-grained plutonic igneous rock containing more quartz than diorite.

greywacke - detrital sandstone characterized by a high percentage of unstable mineral and rock fragments contained in a finer clay matrix; often called 'dirty' sandstone.

miogeocline - the area adjacent to a craton in which eroded continental sediments accumulate usually undisturbed and often to great thickness.

normal fault - a dip-slip fault on which the hanging wall in on the downthrow side.

orogeny - a period or the processes of mountain building; especially the intense deformation of rocks by folding and faulting, regional metamorphism and volcanic intrusion extending over millions of years.

pluton - a body of igneous rock intruded in the molten state into the surrounding rock and solidified in place.

pyroclastic debris - fragmented volcanic material blown into the atmosphere by explosive volcanic activity: may be almost any size fraction from ash to extremely large "bombs".

schist - coarse-grained metamorphic rocks which readily split into thin plates or slabs as a result of the alignment of prismatic minerals (usually micas). Finer-grained than gneiss and contains no feldspars.

strike-slip fault - a fault along which movement is primarily horizontal along the strike of the fault.

terrane - a relatively large area underlain by a common rock type or assemblage of types.

tillite - a sedimentary rock formed by the lithification of till, usually pre-Pleistocene till.

CHAPTER 6

Geomorphology of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

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6.1 Introduction

Active geomorphic processes are an uncompromising and ubiquitous feature of the youthful Kluane landscape. The mountains are high, rugged and precipitous; glaciers and icefields cover over half the area and most of the remainder has only been deglaciated in the last 12,000 years; soils are thin and poorly developed; mass wasting and periglacial processes are extremely active; streamflow varies by many orders of magnitude from season to season eroding and transporting great quantitites of material; continuous tree cover is confined to lower elevations while vegetation is sparse and fragile in the subalpine and alpine zones. This vigour and wildness are the essence of Kluane.

Geomorphology is the study of the action of ice, water, wind, gravity, and frost on the land surface and the landforms which are created and continuously evolving **as** a result of these processes.

This chapter will describe these processes and landforms as they act and occur in Kluane National Park. Map 6.1 (in pocket) is reproduced from Rampton (1981) and shows the landforms of Kluane at a scale of 1:250,000. Features described in the text are keyed to the symbols used on this map. Where possible, past events are dated usually in 'years before the present' (BP).

Appendix 6.8 contains a glossary of terms which may be unfamiliar to the reader.

6.1.1 Data Sources and Limitations

Modern exploration of the St. Elias-Kluane area began in the 1930's with the Wood Yukon Expeditions sponsored by the American Geographical Society. These three expeditions established ground control points mostly in the Steele Glacier area for correlations with oblique aerial photography, and provide our early data on the Steele Glacier in its non-surge state. Further reconnaissance mapping work **was** undertaken by Bradford Washburn in the Lowell Glacier area in 1937. These early expeditions were largely possible because of logistical support provided by aircraft equipped with skiis to land on snow and ice. The evolution of the use of aircraft in the mountains is an important part of the history of exploration in the St. Elias (Upton 1980).

Project *Snow* Cornice sponsored by the Arctic Institute of North America (AINA) ran from 1948 to 1951 in the Seward Glacier area. It was the first interdisciplinary program in the St. Elias Mountains studying meteorology, glaciology, and geophysics.

Mapping in the St. Elias Mts. began with RCAF aerial photographic surveys in 1951 but topographic maps of the more remote areas at 1:250,000 were not produced until 1967. Work is now underway to complete 1:50,000 map coverage of the area. This program is essential to site planning in Kluane.

In 1961, AINA and the American Geographical Society cosponsored tie Icefield Ranges **Research** Project (IRRP). A base camp and airfield were established at the south end of Kluane Lake and research parties worked over the next 18 years in a wide variety cf disciplines throughout the St. Elias range and pioneered studies into the high mountain environment. The early work of the IRRP was reported in 4 volumes of scientific results (Bushnell & Raglej. Probably no other relatively inaccessible high mountain area has such an extensive data base and many of these studies remain as landmark papers, after nearly 20 years. Research continues today from the Arctic Institute camp, now under the administration of the University of Calgary.

The University of Ottawa has maintained an ongoing research program in the Metalline - Grizzly creek area focussing on the study on mass movement processes and phenomena. G.K.C. Clarke of the university of British Columbia and his associates are doing ongoing work on surging glaciers.

Hydrological data are perhaps the least complete part of the geomorphological data base. Water survey of Canada maintains recording equipment at several locations on major rivers in and near the greenbelt areas of the Park (see Appendies 6.3-6.8). The length of record at some of these stations is now sufficient to make reasonable estimates of the 100-year flood for design purposes. Small streams are largely ungauged and inferences for design of culverts or other structures must be made from geomorphological evidence.

Following Park establishment, Thurber (1973) did an overview study of the geomorphology of the Park, followed by a detailed study by Rampton (1981) with mapping of landforms and surficial materals at 1:250,000. Harris (1981) undertook a detailed investigation of the terrain components of the east Slims Valley for the proposed Slims valley Access Road. Mapping was at 1:10,000 and mapping of specific features at 1:1000.

These overview studies and others undertaken as theses provide an excellent database but site-specific work such as that done by Harris (1981) is necessary for planning, development, and facilities location.

The dates of events in glacial history are derived from C^{14} dating of organic material associated with various deposits. The technique is reliable for events in the last 49,000 years but the dates produced do not correspond directly with real or calender dates. Dates in the text should be read as C^{14} years BP and usually have error limits associated with them or are approximate. The relationship between C^{14} dates and calender dates varies in a complex and nonlinear manner such that several real dates may correspond to one radiocarbon date (the converse is not true). This is particularly important when dating relatively recent events such as Glacial Lake Alsek but is less of a problem for events in the more distant past as the curves become more generalized. All such dates have an associated error factor which may be several hundred years for events dated 30,000 C^{14} BP.

Sophisticated dendrochronological or tree-ring dating techniques have been used to cross-check radiocarbon dating for recent events. Clague et al (1982) obtained dates for the most recent stage of Neoglacial Lake Alsek by comparing tree ring patterns in fossil driftwood from Lake Alsek beaches with patterns in old living trees in the area and with logs from historic cabins using X-ray densitometry and computer cross-correlation techniques.

Lichenometry has been used to date Neoglacial moraines in Kluane. Rampton (1981) compared the diameters of lichen colonies on various moraines and used this technique with knowledge of the growth rate of lichens in this environment to establish dates for moraine formation.

Clarke (1984) has obtained quite deep lake bottom cores from the area of Recent Lake Alsek and sedimentological analysis of the material in the cores combined with precise levelling should provide a reliable chronology of events for the area.

A wide range of investigative techniques is available to the geomorphologist. While each technique has its limitations, used in concert they can allow the puzzle of past events to be explored and in time deciphered.

6.2 Physiography

The description of physiographic provinces and areas has fallen from vogue in the current geographic literature. Emphasis is now placed on integrated studies and on process-oriented investigations of landforms and their origins. However a brief outline of the physiography of the Park provides a useful introduction to the descriptions that follow.

Kluane National Park is a complex of mountain ranges and intervening valleys and plateaus. At the broadest scale, the Park can be divided into two physiographic areas: the St. Elias Mountains; and the Shakwak Trench. The St. Elias Mountains cover most of the Park area and are comprised of several individual ranges - the Kluane, Icefield, Donjek, Bates and Alsek ranges and adjacent lowland and plateau areas (See Fig 6.1). The Kluane Ranges form the northeastern front of the St. Elias Mountains and are divided into several short segments by cross-cutting valleys carved parallel to structural trends. Their precipitous eastern margin is a fault scarp (Shakwak Fault) marking the edge of the adjacent Shakwak Trench.

Figure 6.1 Physiographic areas, Subdivisions, and Elements- Kluane National Park.

Plateau

c l Valley

Bates Ranges

Donjek Range

Alsek Ranges

Kluane Ranges

Coast Mountains

Ruby Range

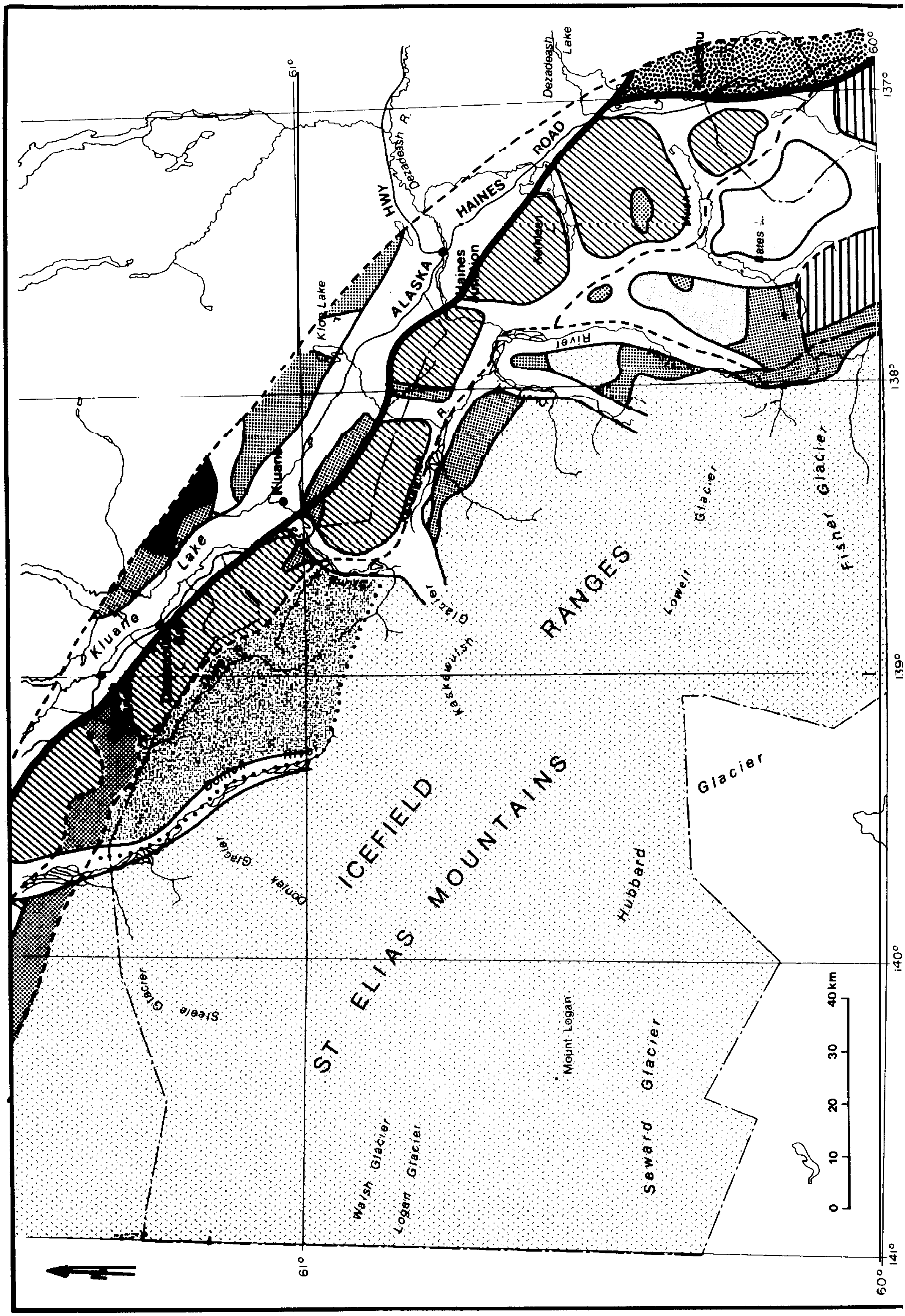
Boundary between physiographic areas

---- • physiographic subdivisions

• physiographic elements

. ...* Boundary delineating minor subdivisions

(after Rampton 1981)


Kluane Lake
ALASKA HWY
HAINES ROAD
Dezadeash R.
Dezadeash Lake
Kloo Lake
Kluane
Haines Junction
Bates L.
River
Kaskawulsh Glacier
Lowell Glacier
Fisher Glacier
ST ELIAS MOUNTAINS
ICEFIELD RANGES
Hubbard Glacier
Mount Logan
Seward Glacier
Walsh Glacier
Logan Glacier
Steele Glacier
Donjek Glacier
61°
60°
137°
138°
139°
140°
141°
0
10
20
30
40km

> "Kluane Ranges show a particular type of ruggedness that contrasts with that of other nearby ranges. Their slopes are steep and uniform, with long straight talus screes. Their ridges are serrated and narrow, and summits tend to be uniform in elevation. Many are nearly 7000 feet high, and with one or two exceptions the highest peaks of each range are about 8000 feet in elevation. Southeast of Duke River, Kluane Ranges contain alpine glaciers, some of which, between Slims River and Kathleen Lakes, are two miles long. Most of these ranges consist of two or three ridges parallel with the main front and connected by high saddles. Northwest of Slims River the first range comprises one broad rough ridge of summits. Beyond Burwash Creek two distinct ridges become apparent, and beyond Donjek River these are separated by a well-defined valley extending to White River..."
>
> (Bostock 1948 : 96)

This valley is part of a broad complex of valleys and rolling uplands which separates the Kluane Ranges from the Icefield Ranges to the east. The area was named the Duke Depression by Bostock (1948) and he extended it to include valley and plateau areas behind the full length of the Kluane Range (Fig. 6.1). Rampton (1981) excluded the areas east of the Duke River as they have a greater variety of terrain types and (with no major break in the mountains between the Duke and Donjek Rivers) are not contiguous with the area west of Duke River. Rampton's (1981) Duke Depression lies just within the extreme northern boundary of the Park.

Relief in the Bates Ranges at the southeast end of the Park is much more subdued with only one peak above 2000 m. The ranges have long continuous ridges and spurs separated by broad U-shaped valleys, long talus slopes, and a rolling plateau area at about 1520 m asl.

The Alsek Ranges are represented by two relatively small areas of precipitous slopes and sharply serrated peaks up to 2750 m in height near the British Columbia border. The two parts of the Alsek Ranges are divided by the Tatshenshini River. Valley glaciers are common (Rampton 1981).

The Icefield Ranges comprise the greater part of the 'Park. Bostock (1948) described them:

> "Icefield Ranges comprise the main body of St. Elias Mountains and embrace all the great peaks except Mount Fairweather.
>
> Along the northeast side of Icefield Ranges a border area, 15 to 20 miles wide, stands between the Duke Depression and Alsek River Valley on one side and the first line of great peaks on the other. This 'border area

rises abruptly to peaks 8,000 and 9,000 feet high, and in places to . . . . .more than 10,000 feet. The area is deeply dissected by great valleys such as those of the glaciers tributary to Kaskawulsh River. Southwest of Lowell Glacier the area is mainly one of snow and ice, even those parts bare of snow and ice in summer probably not constituting a third of this part of the border area. Along the border area northwest from Lowell Glacier, the mountains become increasingly bare of snow in summer, but perennial snow and ice remain on the more level areas at high elevations, in numerous alpine glaciers and ice-fields, and in the great valley glaciers, Klutlan, Wolf, Donjek, Kluane, Kaskawulsh, and others of lesser size. These glaciers move down valleys walled by bare slopes that receive relatively little precipitation in either summer or winter.

Southwest of this border area looms the main platform of Icefield Ranges, its valleys filled high with snow and ice and its great peaks towering above. The great peaks are the outstanding features of this platform. Chief among them are Mount Logan, 19,850 feet high [sic], and four additional peaks clustered within 8 miles on the same huge mountain block, one east and one west of the peak of Mount Logan, each more than 19,000 feet high, and two others with elevations exceeding 18,000 feet. The other great peaks of the platform are Mount St. Elias, 18,008 feet; Mount Lucania, **17,150** feet; King Peak, 17,130 feet; Mount Steele, 16,439 feet; Mount Bona (in Alaska), 16,420 feet; Mount Wood, 15,880 feet; Mount Vancouver, 15,700 feet; Mount Hubbard, 14,950 feet; Mount Bear (in Alaska), 14,850 feet; Mount Walsh, 14,780 feet; Mount Alverstone, 14,500 feet; McArthur Peak, 14,400 feet: and Mount Augusta, 14,070 feet. In addition, there are many peaks between 12,000 and 14,000 feet high. Some, such **as** Mount Craig, 13,250 feet, are named, but most of them remain unmeasured, unnamed, and unclimbed.

These great peaks rise out of the surface of *snow* and ice that forms the ice-fields between them. North of Mount Logan this surface is between 6,000 and 8,000 feet high, and appears to maintain this elevation along the main divides between the heads of Logan, Hubbard, and the other big glaciers northeast of Mount Logan. From these areas the ice-fields slope outward, gently at first and then more steeply as they separate into defined valley glaciers creeping out of the ranges."

(Bostock 1948: 98,99)

The other major physiographic area is the Shakwak Trench - a long straight valley extending northwestward from Kluane Lake to White

River. The valley is a graben formed by tectonic activity associated with the uplift of the St. Elias Mountains. The southwest edge of the trench is marked by a fault zone along which the steep wall of the Kluane Ranges rises. This wall is broken only by the deep narrow valleys cut by high gradient streams flowing to Kluane Lake. The valley floor is from 5-8 km wide, and covered by glacial, glaciofluvial, and aeolian deposits. Kluane Lake occupies the deepest parts of the Shakwak Trench and is of glaciofluvial origin. Bostock (1952) discusses the morphology of the valley in detail.

6.3 Glacial Processes and Landforms

6.3.1 Introduction

The geomorphology of the Kluane area is integrally tied to glaciation. In recent geologic time (late Tertiary to present) the area has been glaciated at least four times (Denton & Stuiver 1967) and possibly more. This repeated and continuing activity has molded the landscape by glacial and glaciofluvial erosion, altered the drainage patterns, created depositional landforms, and by concentrating placer gold has markedly influenced the exploration and economic history of the area. The seasonal runoff of glacier meltwater provides the major source of water for plant and animal communities in the semi-arid climate and ties together the biotic and abiotic systems. The harsh climate which preserves the Icefields is also a powerful geomorphic agent and an integral part of all processes.

Kluane contains the world's largest non-polar icefields, covering over half the Park area. The Icefields form a plateau-like area at 2100-2750 m asl in the centre of the park. The divide between drainage to the Pacific Ocean to the southwest and to the Yukon River and Bering Sea to the north lies within this central area. Five huge glacial arms radiate outward from the Icefields ending ultimately in the large valley glaciers of the semi-arid eastern Icefield Ranges (Kaskawulsh, Lowell, Donjek, Kluane, Steele) and the massive piedmont and coastal glaciers of the maritime Alaskan coast (Seward-Malaspina, Hubbard) and interior Alaska (Walsh-Logan).

The valley glaciers are classic examples of their type, several kilometres wide, tens of kilometres long, and up to 1000 m thick in some areas. This mass of ice, moving as a visco-plastic material, is a powerful agent of landscape modification scouring the underlying surface, and producing erosional and depositional landforms. Movement on the surface of large valley glaciers is usually on the order of several centimetres per day. The Kaskawulsh Glacier below the confluence of its north and south arms averages 40-50 cm per day (Ragle 1980).

Kluane contains over 60 surging glaciers as well, capable of rapid downvalley movements of several kilometres per year. These surges take place cyclically, often after long periods of quiesence and appear to be related to the internal dynamics of the glacier rather than to climate. The most famous is the Steele Glacier which during its most recent surge in 1965-66 moved at a rate of over 500 m per month for part of 1966. Section 6.3.3 discusses the phenomenon of surging glaciers more fully.

6.3.2 Extent of Present Glaciation in Kluane

The Icefields and the major valley glaciers of the Park area are shown in Map 6.1. Present glacial activity takes place on three scales: the Icefields, a vast body of thick ice coalescing and filling intermontane valleys in the central St. Elias Range leaving only the highest peaks standing above the ice; valley glaciers fed by and extending outward from the Icefields generally eastward toward the interior; and small cirque glaciers occupying high basins, usually with a north or east aspect in the smaller peripheral mountain ranges - Alsek, Kluane, Auriol. Ice is thickest in the Icefields and thinnest in the cirque glaciers which may be only about 100 m deep. The large valley glaciers are hundreds of metres thick, averaging about 450 m in downstream areas. Thicknesses of 1000 m occur in upstream accumulation areas on the Lowell and Kaskawulsh and are probably not uncommon (Clark 1978; Dewart 1970). Ice is generally thinner on steeper gradients.

Individual glaciers survive today because the present climate allows accumulation to approximately equal ablation over the long term. Glaciers in Kluane are thus in dynamic equilibrium with the prevailing climate conditions, advancing or retreating slowly in response to recent weather or climate changes. The response lag time in a large valley glacier is considerable and probably only trends which persist for several years ever see expression in movement at the terminus. The smaller cirque glaciers are more sensitive to short-term changes. The last period of major expansion occurred about 450 BP and, on the basis of terminal moraine formation, was the most significant advance since the end of the Pleistocene. Since that time, major valley glaciers in Kluane have been retreating slowly, forming recessional moraines between their maximum Neoglacial positions and present termini. Moraine formation is indicative of a stillstand or equilibrium situation in which the terminus remains relatively stationary for a considerable time. The size of the moraine is a reflection of the length of the stillstand. An active glacier retreating rapidly does not create recessional moraines of any significance but rather leaves a covering of moraine and outwash over the entire area previously under ice.

6.3.3 Surging Glaciers

Glaciers which experience sudden advances and spectacular increases in flow rates are said to surge. "Surges are incompletely explained cyclic flow instabilities peculiar to certain glaciers. A typical surge involves a 10-1000 fold increase in flow velocity and a l-10 km displacement as ice moves from **a** reservoir region to a receiving region." (Clarke et al 1984:232). Surges last l-6 years, commonly 2-3 years after which a period of quiescence occurs lasting usually 20-30 years but often longer (Meier and Post 1969). The length of the cycle is not clearly related to the size of the glacier.

Surging behaviour does not appear to be linked to climate: movement is believed to arise from an 'uncoupling' of the sole of the glacier from the underlying bedrock following a long period of resistance to flow and ice build up. Two thermal zones **are** thought to exist in some surging glaciers - an upstream warm zone where basal ice is at the melting point, and a downstream zone where ice is cold-based or frozen to the glacier bed. As discussed in section 6.3.5, ice movement by sliding **over** the bed is only possible where the ice is at the pressure melting point. Bottom sliding cannot take place when the basal ice is cold. Therefore relatively **rapid ice** flow occurs only in the warm-based zone and is blocked when it reaches the cold-based zone. The transition zone from warm to cold-based ice can be thought of as a "thermal dam **to** ice flow" (Clarke et al 1984:232) and is believed to be integral to the surge mechanism.

Between surges, this thermal dam or some other mechanism which produces the same effect on ice flow, restricts flow and causes the ice to thicken progressively in the reservoir or upstream warm-based zone, while in the downstream zone ice is stagnant and **downwastes. When a surge** occurs this upstream buildup of ice is released to flow rapidly into the downstream area. The event or circumstances which trigger release are not known.

During a surge, the glacier surface in the receiving zone thickens and becomes heavily crevassed and covered by a chaotic jumble of ice blocks, spires, and debris towering several metres above the general surface. Surface medial moraines are distorted by the rapid flow and form loops which are preserved after the surge. The surging history of many glaciers can be inferred from the pattern of looping medial moraines - some showing 10 or more loops (Meier & Post 1969). The surge front is identifiable as a steep wall of ice usually several metres high. The rapidly moving ice will truncate lateral features such as tributary glaciers, alluvial fans, etc. and may dam tributary creeks to form proglacial lakes. The surging ice front moves downglacier incorporating dead ice, supraqlacial debris and new material from the valley sides, but does not usually advance significantly beyond the terminus of the dead ice.

Surging glaciers seem to be concentrated in distinct geographic areas. The St. Elias Mountains in Yukon and Alaska contain over 200, nearly all that have been identified in western North America (Post 1969). Over 60 of these occur in Kluane National Park, including the Lowell, Kluane, Steele and many smaller glaciers.

Table 6.1 provides data on 6 surging glaciers in and near Kluane National Park. The classes refer to categories developed by Meier and Post (1969) based on size, velocity, surface lowering in the reservoir and other factors. Class I glaciers are very large, very fast moving and experience large displacements and a lowering of 50 m or more in the reservoir area. These characteristics decline through Classes II and III.

Steele Glacier is perhaps the best known surging glacier in Canada. Its most recent surge was anticipated and predicted by Austin Post in 1960 and 1965 (Wood 1972) on the basis of air photo interpretation and, when it did occur in late 1965, it was the object of considerable study by Government and IRRP scientists. By August 1966 an ice wall more than 30 m high had travelled 12 km down the glacier. By August 1967 nearly all identifiable features photographed between 1951 and 1965 had been displaced by at least 8 km. Velocities at the height of the surge were 12-15 m per day; by September 1967 they had declined to 2 m per day (Wood 1972).

Figure 6.2 shows five transverse profiles taken across the glacier surface from the terminus area (V-V') upstream to the reservoir area (Z-Z') showing the dramatic changes in level between pre-and post-surge conditions. Movement in the terminus area has essentially ceased now and the lower 8 km remains a stagnant debris-covered jumbled surface.

Clarke et al (1984) are monitoring the much smaller Trapridge Glacier just west of Steele Glacier. A large wave-like bulge was photographed in the lower part of the glacier from 1935-1941. The last surge began in 1941 and ended before 1949. Since 1969 a similar bulge in the glacier long profile has formed and is currently moving downglacier at 24 m per year. In 1969 the surface velocity in this area was only 5.7 m per year. Figure 6.3 illustrates the form of the bulge. Figure 6.3b shows the location of the 0^0C isotherm under the glacier documenting the existence of two thermal regimes with cold-based ice under the terminus providing the downstream resistance to flow thought to be so important to the surge mechanism.

Clarke et al (1984) believe that the subglacial drainage system plays an important role in surging behaviour. Previous authors have suggested that during a surge the ice moves on a cushion of water between the ice and the bed. Clarke and his associates postulate that a well-developed subglacial drainage system becomes established during the quiescent phase with water flowing through an unfrozen,deformable, impermeable substrate rather than along the ice/bed interface. As ice thickness and shear forces related to the resistance to movement increase, the substrate begins to deform destroying the drainage paths faster than they can regenerate and reducing permeability. This triggers the surge by allowing water pressure to build up on the bed, causing it to deform, reducing the

Table 6.1 Measurements on 6 surging glaciers in or near Kluane National Park.

Glacier	class	Approx. Max. Velocity	Approx. Displace-ment	Approx. Duration	cycling Period (years)
Walsh	I	15m/day	(11 km)	6 yrs.+	50±10
Steele	I	17m/day	(8 km)	3 yrs.+	100±10
Tweedsmuir	I	5m/day	(0.8 km)	7 mos.	(?)
Kluane	II	(?)	(2 km)	(?)	19±1
Backe	III	1m/day	(0.3 km)	6 yrs.±	(?)
"Upton"	III	(?)	(0.6 km) (?)	2 yrs.+	(?)

(after Ragle 1980).

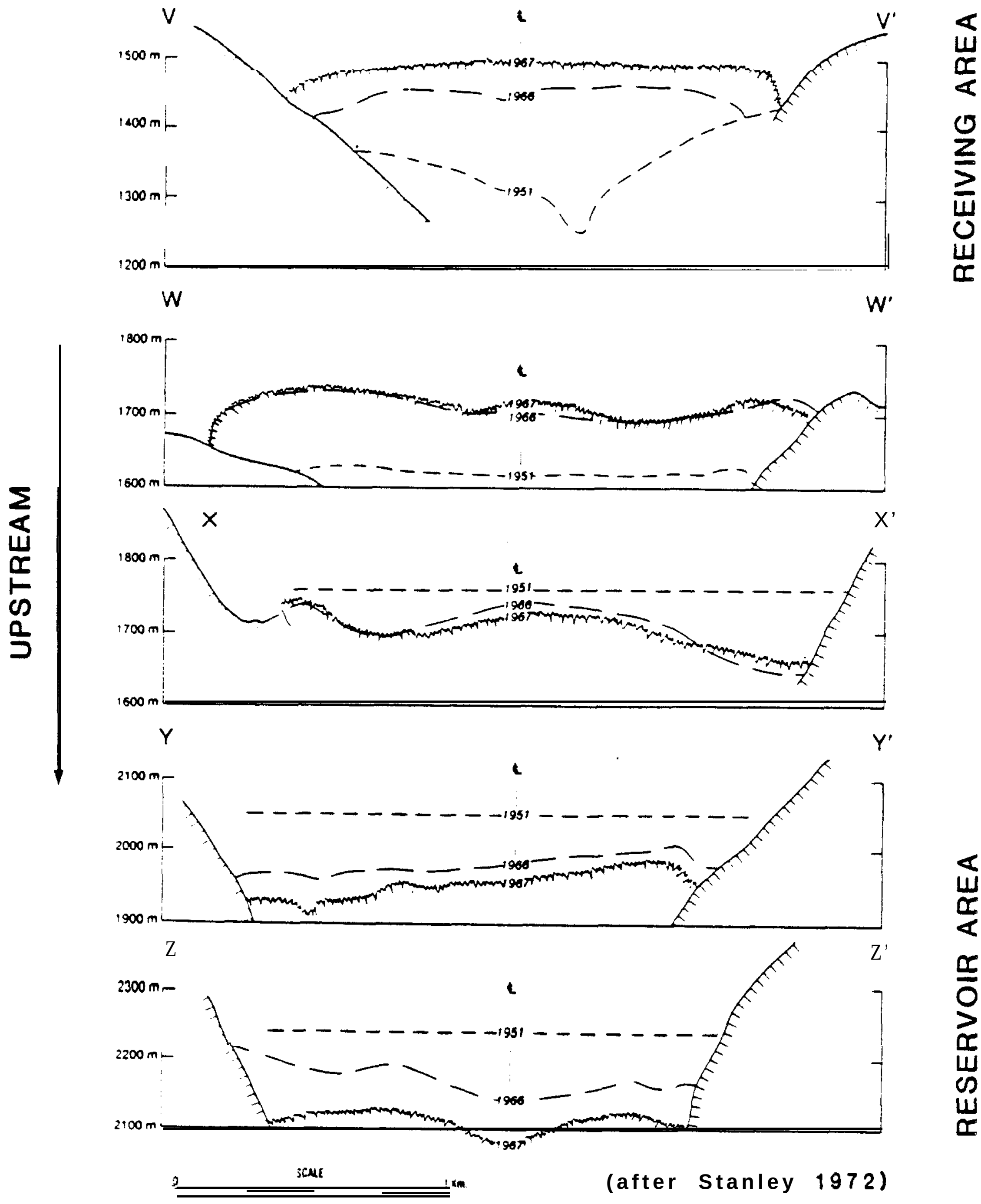


Figure 6.2 Transverse profiles of the Steele Glacier showing changes in surface elevation before and after the surge.

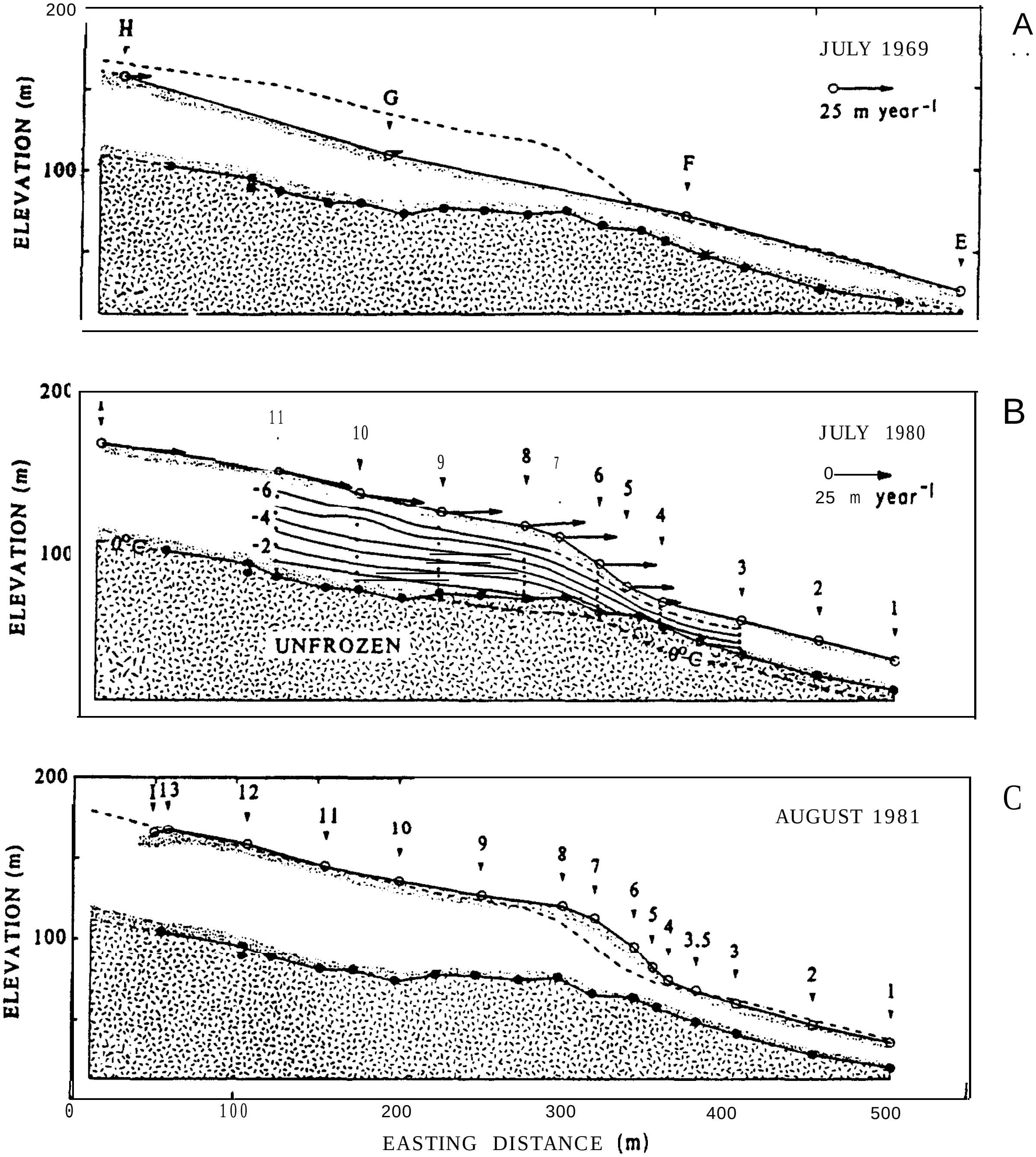


Figure 6.3

Flow evolution and thermal structure of Trapridge Glacier in the region of the wavelike bulge, 1969– 1981. The solid circles indicate the subglacial topography measured from ice drilling in 1980 and 198 I. Open circles give the location of surface markers; arrows indicate the easterly and vertical components of surface flow velocity. (A) The growth of the wavelike bulge, 1969– 1980. The 1969 surface profile and survey marker positions E. F, G. and H arc indicated as well as ice flow vectors; the 1969 flow velocity at site G was 5.7 m year-'. The 1980 surface profile is plotted as a dashed line. Note that in 1969 the flow at sites G and H was emergent (outward from the ice surface) and that at sites E and F the flow velocity was too low to be plotted (less than 1 m year-'). Thus, even though there was little surface expression of the bulge, the flow conditions that eventually caused its growth were already established. (B) The 1980 glacier surface profile. ice flow vectors, and thermal structure. Upstream from site 9. basal ice is at the melting tcmpcraturc and the gtacicr is able to slide. At site 9 and downstream from it basal ice is frozen to the bed and sliding is inhibited. The wavelike bulge has dcveloped since 1969 and its growth is presumed to be controlled by the thermal structure. Upstream from the bulge (sites 9. 10, 11, and I) the flow rate has increased roughly five-fold since 1969; downstream (sites 1. 2. and 3) the flow rate is too low to be plotted (less than I m year-'). The approximate location of the 0°C isotherm has been sketched; a zone of subglacial permafrost underlies stations at the bulge and downstream from it. In 1980 holes at sites 3. 4, 6, 8, 9, 10, and 11 were instrumented with thermistors to measure ice temperature and examine the thermal structure. (C) Comparison of 1980 (dashed line) and 198 1 (solid line) surface profiles shows that the bulge is migrating downstream at 24 m year-'. This is the 1980– 198 1 vclociry of site 6; thus the ice velocity in the bulge and the velocity of propagation of the bulge profile arc identical.

Source: Clarke et al 1984.

effective stress and increasing the sliding velocity. The surge ends when the slope and sliding rate are reduced and the subglacial drainage system begins to regenerate. Clarke (1984) has begun investigations of the hydraulic and mechanical properties of the thick glacial deposits in front of the Trapridge bulge to better, understand the role these may play in the surge process. This explanation is still theoretical but continued monitoring of the Trapridge through its next expected surge will provide the opportunity to clarify the mechanism at work.

6.3.4 Features of Active Glaciation

Some of the features described in following sections are shown on Map 6.2 This photomosiac shows the terminus of the Kaskawulsh Glacier, and features associated with the active ice margin including supraglacial and proglacial ponds, crevasses, and medial and lateral moraines. Recently formed features near the terminus such as dead ice topography and ice cored moraines are visible as well as the beginning of braided channels in the Slims and Kaskawulsh valleys. Neoglacial terminal and recessional moraines, trim lines, and alpine cirques associated with previous glacial episodes can also be seen.

6.3.5 Glacial Erosional Processes and Landforms

MOst large valley glaciers in climates similar to Kluane are 'temperate' or 'warm-based'. This means that the weight of the overlying ice, friction, and other factors cause the temperature of the ice at the base of the glacier to rise to the pressure melting point so that water exists at the interface between ice and the ground surface. In these situations the glacier can move by sliding over its bed on a cushion of water, a process which increases velocity by 40% or more (Sugden & John 1976). Ice above the base moves continuously by internal deformation. These two processes act to pick up or entrain material from the glacier bed and to grind or crush it as movement continues.

In cold-based ice, the temperature at the base is below pressure melting point and the glacier is frozen directly to its bed. The bond which forms between the ice and underlying surface is stronger than internal bonds within the ice and movement near the base takes place by deformation, shearing within the ice itself, or by 'enhanced basal creep' a process in which pressure differences allow ice to move around an obstruction on the bed rather than eroding and entraining it. Cold-based ice most often occurs where the ice is thin, for example in small cirque glaciers, or in thin ice areas of larger glaciers.

During ice movement, glacial erosion takes place primarily by two processes - abrasion, and plucking or quarrying. Abrasion occurs when the underlying rock surface is scored by debris carried in the sole of the glacier. This produces striations and glacially polished surfaces on the rock, and entrains extremely fine 'rock flour' into the glacier system. Discharge of this material into meltwater streams and lakes produces the characteristic blue-green colour of mountain tarns and some ice surfaces. Material can also be quarried in large blocks by the fracture of bedrock under the sheer weight of ice and the exploitation of structural joints and weaknesses in the rock. The ice applies a tractional force loosening material which is then frozen onto the sole of the glacier, and moved along the bed or moved upward into the ice along shear zones. When finally deposited these large blocks may have been carried by the glacier a great distance from their source area and are termed erratics. The presence of erratics at hiqh levels is one piece of evidence of the extent of past glacial episodes.

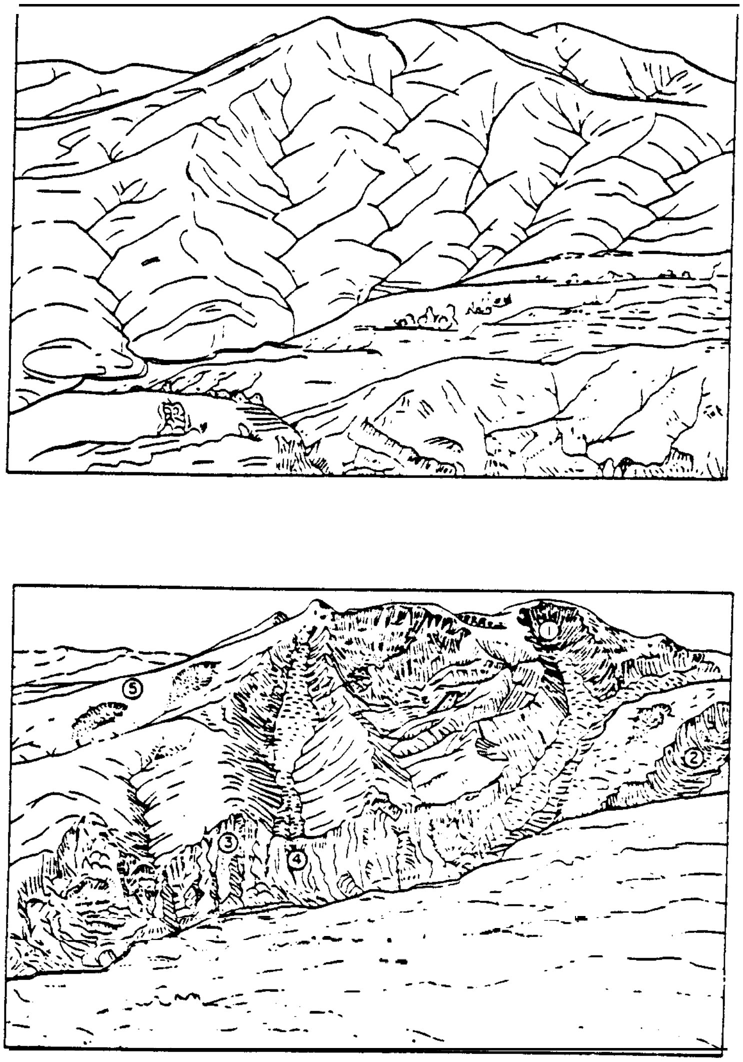
Erosion is most effective under warm-based ice where water is present, where the sole is debris-charged, and where pressure melting provides an effective method of entrainment. Great volumes of material are removed, transported and ultimately deposited under these conditions. The valley glaciers of Kluane fall into this category of "good" or effective agents of erosion. Small cirque glaciers are much less effective as they are likely cold-based, with only thin ice, low rates of accumulation, and low velocities.

In mountainous areas, glacial erosion changes the form of the terrain by smoothing the surface beneath the ice and by sharpening ridges and peaks which protrude **above**, either by direct erosion of supporting slopes or by frost action. Most major valleys in Kluane have acquired the classic U-shaped or parabolic cross-sectional profile caused by deposition in the valley bottom and by the variation in intensity of erosion between valley walls and floor. Trim **lines** marking the maximum height of ice are visible in many, often marked today by changes in the degree of weathering. In areas near active glaciers trim lines formed during the Neoglacial advances 400 years ago are plainly visible. In the Kluane Ranges and other ranges to the east of the Icefields classic alpine glacial features such as tarns, horns, cirques, cols, hanging valleys, truncated spurs are readily visible from the Alaska and Haines highways. Figure 6.4 illustrates some of these features.

Many valleys in Kluane are floored by glacially scoured bedrock which may be fluted where ice movement paralleled structural trends. Some are covered by a veneer of unconsolidated material but in others the bedrock is exposed at the surface. Examples include the valleys occupied by Alder Creek, Field Creek, Sockeye Lake, and valleys adjacent to Slims River and the Kaskawulsh Glacier. The basins now occupied by Mush, Bates, Kathleen, and Louise lakes were also deepened by glacial action. Glacial erosion also produces steep bedrock cliffs along valley walls and at the head of cirques. This often causes oversteepening of valley walls which, when the supporting ice is removed, fail causing rock slides and landslides. Landslide activity was probably at a maximum immediately following the Kluane Glaciation (Rampton 1981).

A

B



(after Thornbury 1969)

1. ciraue
2. glacial trough
3. truncated spur
4. hanging valley
5. nivation cirque

Figure 6.4 Effects of glacial erosion on a mountain landscape.

A before glaciation.

B after glaciation.

Glacially scoured rock and valley walls are shown on Map 6.1 by the symbols R and R>.

The meltwater produced by glaciers is also an effective agent of erosion. Glaciofluvial activity was at a maximum during the retreat phases of the major glacial episodes. Most features in the park date from the end of the Kluane Glaciation about 12,500 BP (although some higher level features may have been formed by older episodes). The large volumes of water produced at that time cut deep channels in many passes and along valley walls, and cut down through and probably removed valley train sediments left by small glaciers in steep valleys tributary to the larger glaciers. Identification of these now dry meltwater channels is an important clue to the patterns of deglaciation. Map 6.1 shows examples of such channels south of Alder Creek, east of Jarvis River, between **Wade** and Burwash creeks and along the flanks of the Shakwak Valley near Burwash Landing (Rampton 1981). Many stream-cut canyons and ravines may partly owe their form to the high water volumes carried at that time. The streams that flow in many valleys in the Park now are classed as underfit, because present volumes are too low to have been responsible for formation of the valley.

6.3.6 Glacial Depositional Processes and Landforms

Glacial depositional landforms are comprised of sorted (glaciofluvial) or non-sorted (till) material or a combination of both. Symbols in brackets refer to features identified on Map 6.1.

Ground moraine (Mg, MS, Mp) is the most widespread depositional landform in the Park. It is comprised of compact sandy or stoney lodgement till usually 3-9 m thick but ranging from 0.5 to 60 m (Rampton 1981). Its surface form reflects the underlying topography and it occurs on level or sloping areas. Ground moraine is present in most large valleys in the Park and the intervening slopes and plateau areas. In the northern parts of the Park and at high elevations throughout permafrost may be present and periglacial features such as polygons, ice wedges, and solifluction lobes may occur. In the 3urwash Uplands surface disturbance has caused degradation of permafrost and subsistence of level ground moraine.

Ground moraine is laid down by subglacial lodgement, a process in which material carried on the sole of the glacier is accreted or 'plastered-on' to the underlying surface. Lodgement can take place during both advance and retreat, usually under warm-based ice which is gradually losing its erosive capacity and releasing its detrital load during the pressure melting process. During lodgement, the till becomes compact and the flow of ice imparts an orientation to clasts in the till which is preserved following deposition. study and interpretation of this orientation is called till fabric analysis and provides an important tool for the reconstruction of patterns of glacier movement. Although useful in the Park, this technique is more important in areas where topography has not channelled or constrained ice movement.

Hummocky moraine (Mh, Mm) is formed when stagnant ice melts in situ and lets its load of englacial and supraglacial material down onto the surface. The surface is characteristically rolling and irregular and, when accompanied by glaciofluvial deposits, is called kame and kettle topography. There are few areas of hummocky moraine within the Park, implying that glaciers remained active during retreat (most likely) or that glacial meltwater has reworked these deposits. Hummocky moraine does occur to the north, west, and east of the Park on level terrain.

Drumlins and fluted moraines (Md) are streamline or flow features formed subglacially of till during active ice movement. They indicate the direction of ice movement and are thought by many theorists to form part of a continuum of features whose form changes as conditions within the ice and on the underlying surface change (Sugden & John 1976). Drumlins occur in the Donjek Valley below the mouth of Steele Creek and fluted moraine and streamlined bedrock hills occur along the Shakwak Valley from Jarvis River to Donjek River (both areas are outside but immediately adjacent to the Park).

Terminal and recessional moraines (Mr) are accumulations of till marking former ice frontal positions. They form only at the margins of active glaciers during still stand periods. Glaciers which are advancing rapidly override their morainal deposits and those which are retreating rapidly do not have time to accumulate any significant amount of material. The size of the feature is therefore a reflection of the length of the still stand (as well as the debris load of the glacier). Terminal moraines mark the furthest extent of ice during a particular advance: recessional moraines mark successive positions during retreat. Material can accumulate by falling off the toe of the glacier, by release of englacial debris from the glacier sole or from shear zones in the ice, by the pushing up of saturated material immediately in front of the toe by ice shove, and by the delivery of material to the terminus by subglacial streams.

Most valley glaciers in the Park are fringed by terminal and recessional moraines which date from the Neoglacial. These features are extremely variable in size and form, and some are ice-cored and are preserved by their thick insulating cover of debris. The terminal moraine on Donjek Glacier is 18-30 m in height and extends around the entire terminus area about 1.5 km from the active ice front. Several smaller moraines 2.5 m high, lo m wide and 120 m long are superimposed on this feature (Denton & Stuiver 1966). An inner set of end moraine and glaciofluvial features are post-Neoglacial. The Neoglacial moraines of the Kaskawulsh Glacier are also spectacular. Three distinct end moraines have been identified in the Slims Valley while only one is distinguishable on the Kaskawulsh lobe. The outer and assumed terminal moraine is now 1.5 km from the active Slims lobe and less than 1 km from the active Kaskawulsh lobe. It rises 4.5 to 7.5 m above the current outwash surface. These features can be seen on Map 6.2.

An ice-cored **moraine** landscape adjacent to a large valley glacier is characterized by "chaotic topography, unstable slopes, ice thaw lakes, and ice cliffs all of which result from varying thickness of material overlying glacier ice, slope aspect and meltwater activity" (Rampton 1981:23). The east side of the terminus of the Kaskawulsh Glacier provides an excellent example of this type of landscape. Many ice-cored moraines are vegetated and studies of the composition and maturity of the vegetation have been used to date the time of moraine construction (Borns & Goldthwaite 1966; Denton & Stuiver 1966; Rampton 1981).

Lateral moraines form along the sides of valley glaciers as distinct elongate accumulations of material partly on the ice and partly on the valley wall supported by the ice. The material is derived from actual erosion of the valley wall by the ice and from mass wasting of the slopes above the glacier surface by colluvial and periglacial processes. Lateral moraines may be preserved following deglaciation but their form is altered significantly by removal of the supporting ice. Ice marginal meltwater channels often flow between the valley wall and the ice and this may either remove the deposit or sort and wash it forming a kame terrace. Lateral moraines are found only in areas of alpine glaciation where higher areas protrude above the ice. When two valley glaciers flow together their lateral moraines merge forming a medial moraine. This is strictly a surface feature which continues downstream from its source area. As glaciers merge and tributary glaciers join, the surface of the main trunk glacier becomes complexly patterned by folds and flow lines in debris streams on the ice. The Kaskawulsh Glacier is particularly spectacular in this regard.

Debris-covered glaciers (M/I) are another feature unusual in other areas but common in the Park particularly south and southwest of Haines Junction in the Auriol and Kluane Ranges. These features form when supraglacial debris completely covers the surface of small glaciers, with ice exposed only at the headwall and in thaw lakes on the surface. Rampton (1981) states that ice-cored moraines and debris-covered glaciers in Kluane are of Neoglacial age.

Glaciofluvial landforms are comprised of stratified gravel, bouldery gravel, and sand which has, by definition, been washed and sorted by the action of glacial meltwater. Most of these landforms are formed in ice-marginal positions either in front of the glacier or along its sides in contact with valley walls. Only eskers are formed subglacially.

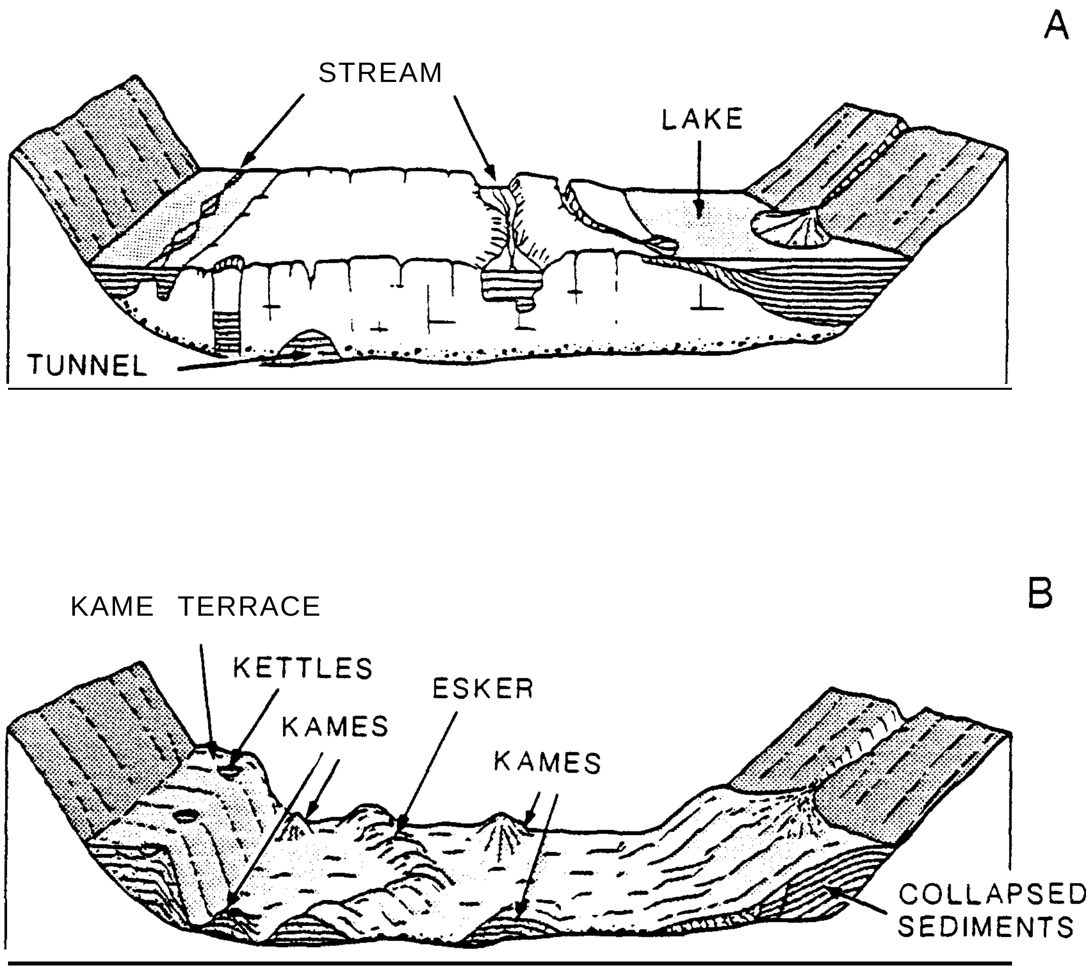
Outwash is glacially-eroded material which is subsequently sorted, transported, and deposited by water away from the ice mass. Outwash deposits 3-60 m deep completely fill many valley bottoms in Kluane forming extensive level **valley trains** (Gp, Gh). These deposits are particularly common in the southeast part of the Park and in the Shakwak Valley from Dezadeash Lake to Bear Creek. On level topography where ice wastage has been rapid, dead ice may become buried by outwash material and when melting does occur, the surface acquires an irregular appearance and is termed **pitted outwash.**

In contrast, **kame deposits** (Gk) though formed of the same material and by the same processes are laid down in contact with the ice. Kame terraces form when material carried by ice marginal streams is deposited between the ice mass and the valley wall. When the supporting ice melts, the deposits usually slump to their angle of repose but retain a recognizable form. Kame deltas were formed where ice marginal streams discharged into proglacial lakes. A good example occurs east of Wade Creek where meltwater flowing north away from ice in Burwash Creek formed a kame delta against ice moving east of out of Donjek valley (Rampton 1981). Small localized kame deposits now present as irregular mounds also formed in valley bottoms as meltwater was ponded against isolated ice masses or channelled into ephemeral ice-dammed lakes. During the Kluane glaciation, kames formed at many different levels as the glaciers downwasted. Most deposits mapped as outwash or kames were formed during and immediately following the Kluane glaciation. Although no different morphologically, deposits related to the Neoglacial period have been mapped as modern fluvial landforms.

Eskers (Gr) are long sinuous ridges of glaciofluvial material. They are formed by meltwater streams flowing subglacially in cavities between the ice and the underlying surface. They meander and deposit material in their beds just as subaerial streams do and may occur singly or as a complex produced by shifting channels, Figure 6.5 illustrates their formation and final form following retreat of the ice and side slumping. In the Kluane area, well-defined eskers are found in the Alder Creek Valley and on the Burwash Uplands. Bostock (1952) identified a long fragmented esker near Donjek River along the southern edge of the Shakwak Valley. The fracturing and minor dislocations of the feature are thought to arise from local fracturing in the ice and subsequent postglacial fault activity.

6.3.7 Glacial History

The Kluane area has been glaciated repeatedly throughout the Quaternary period (3 million years BP to present). These large scale glacial advances and retreats were not local events but occurred world-wide in response to global climatic change. The complex causes and the nature of the climatic changes which initiated the ice ages are the subject of much speculation and



Source: Flint 197 1.

Figure 6.5 Formation of ice-contact stratified drift features

A Ice affords temporary retarning walls for bodies of sediment built by streams and in lakes.

B As ice melts, bodies of sediment are let down and in the process are deformed.

theory. Certainly world mean annual temperatures declined, but the variation in other parameters such as precipitation, cloudiness, and circulation patterns is unknown.

Our understanding and reconstruction of the glacial history of the Kluane area is based on the stratigraphy of deep sections exposed along stream cuts and in later years along the Alaska Highway, and on the surface evidence of ice flow patterns presented by erosional and depositional glacial features. Radiocarbon dating of organic material found in these deposits provides chronological control but is only useful for events since 49,000 BP. Evidence of the oldest events is sparse and poorly preserved as these deposits were usually reworked by later glacial advances.

Based on evidence from areas adjacent to the Park, the earliest glaciations were probably pre-quaternary. Denton & Armstrong (1969) describe tillites in the upper White River Valley (Alaska) which indicate repeated pre-Quaternary glacial activity between 2.; and 10 million years BP. Souther and Stanciu (1975) describe drift of possibly Tertiary or very early Pleistocene age in the St. Clare creek area 10 km north of the Park. Muller (1967) describe? interbedded tillites and lavas in the same area, indicating mid to late Miocene glaciation. Exact locations of these deposits are shown on Map 5.1. Although no direct indication of pre-Pleistocene glaciation has been found in the Park proper, events in these adjacent areas undoubtedly affected the Park as well.

Muller (1967) described the glacial history of the Kluane Lake map area, an area which includes the northeast corner of the Park. He recognized three Pleistocene advances - the Nisling, Ruby, and St. Elias - as well as the Neoglacial advances in recent time. Muller's interpretation of the glacial geomorphic evidence is based on the assumption that, since mid-Pleistocene time, there have been three progressively less extensive ice sheets in the Kluane area each terminating in large valley glaciers with the upper limit of each ice sheet lying 300-450 m lower than the preceding event. This general rationale can be applied to detailed studies in other areas of the Park as well.

Denton & Stuiver (1967) undertook extensive and detailed studies in the northeastern St. Elias Mts. and developed a chronology of Quaternary glacial and nonglacial events which can be applied to Kluane (see Figure 6.6). Four glacial and three nonglacial episodes are proposed from mid-Pleistocene time to the present. Figure 6.7 shows the correlation of these events with Muller (1967) for the Kluane Lake area.

The terminology in the following discussion is that of Denton & Stuiver (1967); the names derive from type localities in the Kluane Lake area.

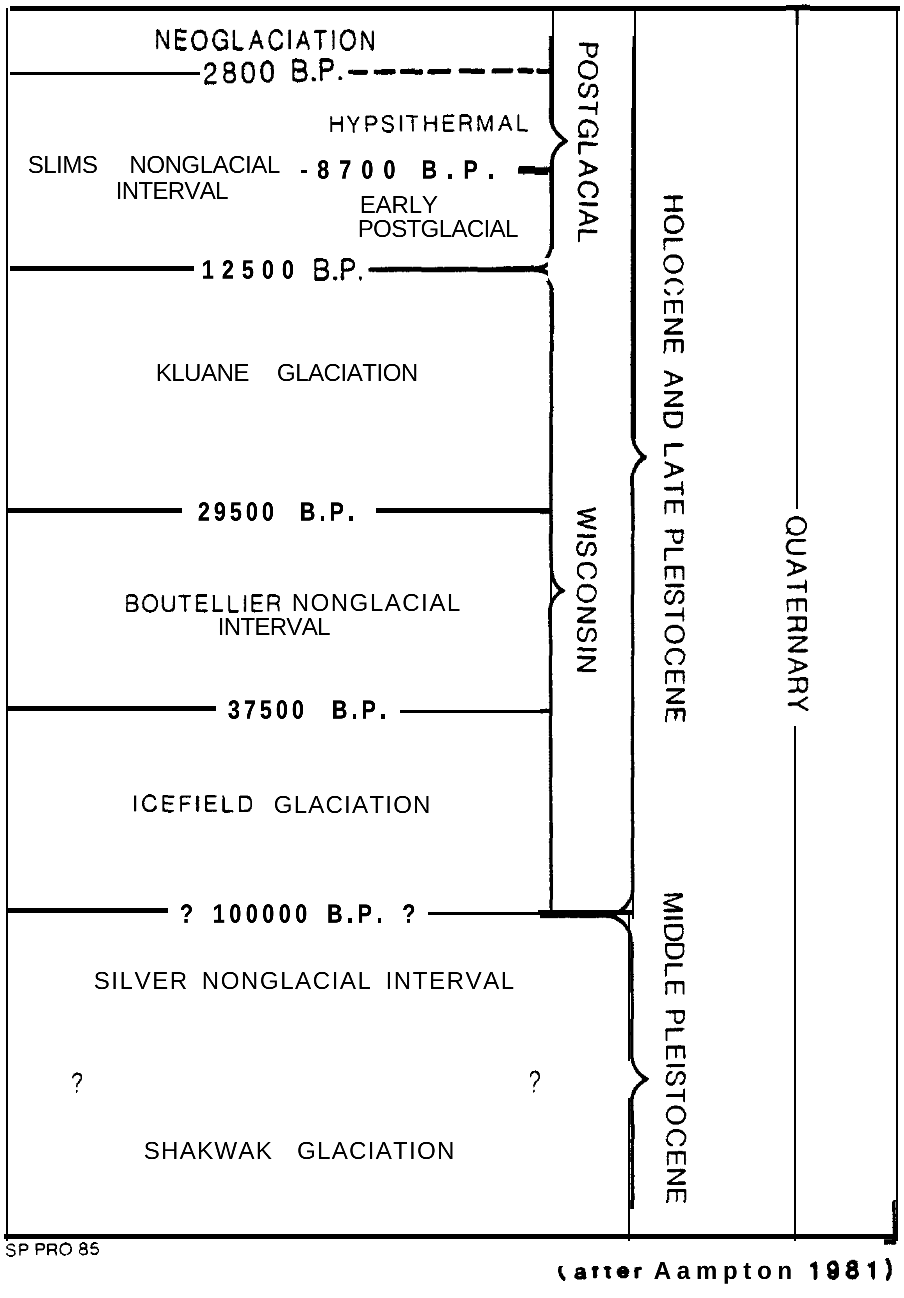
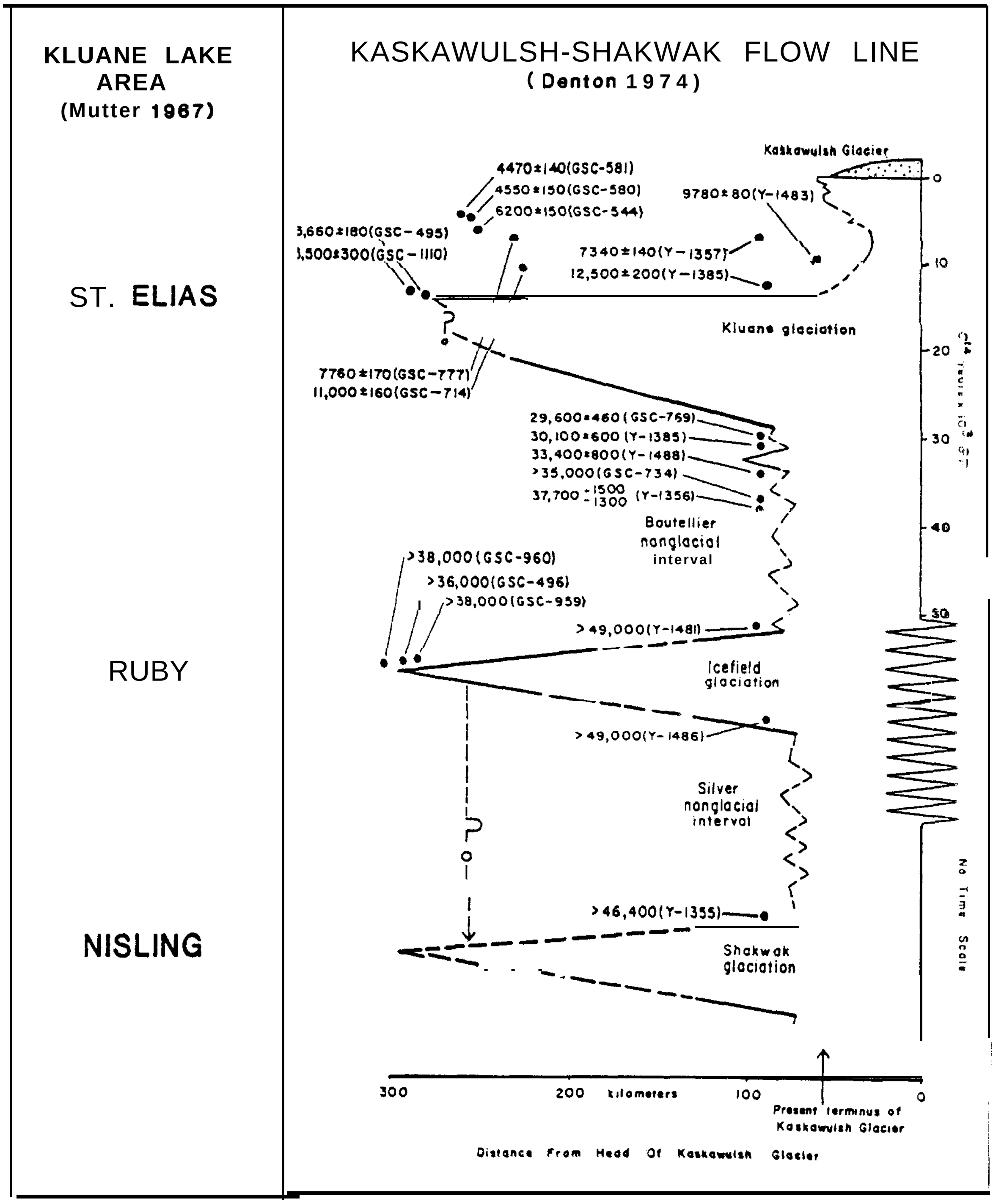


Figure 6.6 Quaternary chronology of glacial and nonglacial events in Kluane National Park.



(after Perchanok 1980)

(dates refer to C^{14} samples near the flow lines in question)

Figure 6.7 Time-distance diagram and comparison of glacial chronologies for the northeastern St. Elias Mountains

6.3.7.1 Shakwak Glaciation (Pre 100,000 BP)

The Shakwak Glaciation is the oldest event of which evidence is found in the Park. Shakwak Drift is stratigraphically the lowest till recognized in the area and is always covered by younger deposits. It is visible only in deep stream cuts - the type localities are along Silver and Outpost Creeks. Sediments believed to be contemporaneous are also found in the mid-Donjek Valley and in the White River Valley (Denton 1974). The Shakwak sediments are comprised of interfingered units of compact, non-sorted, non-stratified angular qrey till and well-sorted gravel, sand and silt outwash (Denton 1974). Till fabric analyses indicate that ice flowed from St. Elias Mountains down the Slims Valley and extended at least 35 km northeast of the present terminus of the Kaskawulsh Glacier (the area of the exposures on Silver & Outpost Creeks) (Denton & Stuiver 1967). Such an extensive advance in the slims was probably repeated in other major valleys in the Park area.

Muller's (1967) work northeast of Kluane Lake indicates a contemporaneous widespread advance of an ice sheet extending from the St. Elias Mountains across the Shakwak Trench and either covering the Nislinq and Ruby ranges to a level of 1500-2100 m (5000-7000 feet) or coalescing with ice already there as local ice caps (this distinction in unclear in the literature). This was the last event to cover the Nislinq Range. Evidence is mainly in the form of high level qranitic erratics left on plateau surfaces unqlaciated in later times. Some high level erratics in the Kaskawulsh area are also attributed to this event (Wheeler 1963). Dating of the Shakwak Glaciation is uncertain as it is beyond (i.e. older than) the range of radiocarbon techniques (49,000 BP). The glacial episode which follows the Shakwak also dates more than 49,000 BP, implying that the Shakwak is considerably older. Rampton (1981) places it in mid-Pleistocene time, more than 100,000 BP.

6.3.7.2 Silver Nonglacial Interval (Pre 49,000 BP)

Following the Shakwak Glaciation, an ice-free interval and period of climatic amelioration of unknown length occurred. This interval is represented in stratigraphic section by deep weathering of the Shakwak Drift. The top of the Shakwak Drift is separated from overlying sediments by an erosion surface on which relief varies from minor irregularities to incised channels 10-12 m deep and 30-60 m wide (Denton & Stuiver 1967). In downstream cuts alonq silver Creek, this surface forms an angular unconformity with overlying Icefield sediments, indicating a break in deposition of unknown length and potential removal of an unknown volume of sediment by erosion.

Rampton (1981) describes a deep section exposed just north of the Park boundary on Telluride Creek near its junction with Bryson Creek. The section contains very thick deposits of gravel and sand overlain by two till units which he correlates tentatively with the Icefield and Kluane glaciations. Rampton (1981) dates these deeper glaciofluvial deposits as early or mid-Pleistocene, possibly Silver Nonglacial. Part of the sequence contains ice wedge casts indicating the presence of permafrost at the time and also its subsequent melting. Wood and peaty organic layers are also present; thin layers of volcanic ash occur discontinuously about 75-80 m from the top of the section. Apparently neither the ash nor the wood have been dated. Rampton (1981) ascribes the formation of these nonglacial deposits to a high energy floodplain environment.

There are no estimates of the duration of the Silver Nonglacial apart from the time represented by development of the weathering profile on Shakwak Drift. The extent of glacier withdrawal, the climate, and vegetation patterns at the time are also unknown.

6.3.7.3 Icefield Glaciation (Pre 49,000 - 37,700 BP)

Following the Silver Nonglacial, climatic conditions deteriorated and glaciers readvanced, depositing non-weathered basal till over the weathered surface of the Shakwak Drift. This advance has been named the Icefield Glacial Episode and, again, Silver Creek provides the type exposure. Here, Icefield Drift is comprised of two outwash units, one till unit, lacustrine sediments and ice contact stratified drift - all interfingering without apparent breaks in deposition.

Radiocarbon dating of peat presumably picked up during advance and now exposed in basal Icefield till yields dates of more than 49,000 BP. Similar dates are obtained from ice contact deposits in the Shakwak Valley, indicating ice had advanced into the trench and stagnated there before 49,000 BP. Datable material from the youngest outwash yields dates of 37,700 ± 1500 BP, from which Denton & Stuiver (1967) infer that the Icefield Glaciation was well underway before 49,000 BP and lasted until about 37,700 BP.

Icefield glaciers extended at least 35 km beyond the present terminus of the Kaskawulsh Glacier and were a minimum of 450 m thick (Denton & Stuiver 1967). Again it is likely that contemporaneous advances occurred throughout the Kluane area. Valley glaciers extended from a small ice cap centred above 1980m in the Ruby Range and local alpine glaciers in the Nisling Range carved U-shaped valleys in the plateau surface previously glaciated by the Nisling (Shakwak) Advance (Muller 1967). Remnants of lateral moraines and trim lines on upper valley walls indicated that the upper limit of the Ruby Ice Sheet was probably 150-300 m lower that the Nisling Ice Sheet (correlated with the Icefield and Shakwak glaciations respectively). Most of the sediments deposited during the Icefield Glaciation have been reworked by later activity and it is only along the outer margins of the advance that evidence is preserved. Rampton (1981) defines late Pleistocene in the

Kluane area as that period form the beginning of the Icefield Glaciation to the end of the Kluane Glaciation.

6.3.7.4 Boutellier Nonglacial Interval (37,000 - 30,100 BP)

The Boutellier Nonglacial is the name given to the period of climatic amelioration following the Icefield Glaciation. It is represented by subaerial erosion, oxidation, and weathering of the Icefield Drift. The interval is radiocarbon dated from 37,000 BP to about 30,100 ± 600 BP and correlates generally with the last half of the mid-Wisconsin interstade complex (Dreimanis & Raukas 1975). Contact between the weathered Icefield Drift and overlying sediments is sharp and distinct and represents a period of subaerial erosion. Weathering of Icefield Drift is much less intense than that which affected the Shakwak Drift (Rampton 1981). Schweger & Janssens (1980) studied fossil pollen and bryophytes from Denton & Stuiver's (1967) stratigraphic sections in the Kluane Lake area. On the basis of these studies, they postulated that the climate during the Boutellier Nonglacial was colder and drier than at present. Arboreal pollen **was** very rare in the samples indicating that vegetation was predominantly tundra-grassland with moist floodplain and tundra-meadow vegetation present in areas of more abundant moisture (Schweger & Janssens 1980).

6.3.7.5 Kluane Glaciation (29,600 - 12,500 BP)

The Kluane Glacial episode has been correlated with the 'classical late Wisconsin' period - the last glacial advance which covered North America to south of the Great Lakes (Denton & Stuiver 1967). Ice in the southwest Yukon at this time was part of the Cordilleran glacial complex and was distinct and in fact completely separated from the continental (Laurentide) ice sheet by an area of unglaciated terrain. Most sections in the Park show only one unbroken sequence of till and glaciofluvial sediments, presumably of Kluane age. Apart from overlying loess, Kluane Drift is the surficial material over most of the presently ice-free areas of the Park and most landforms acquired their present form and characteristics during the Kluane Glaciation.

Kluane Drift consists of several interbedded till, glaciofluvial, and glaciolacustrine units. The ice flow pattern in the Park was complex and glaciers in small tributary valleys were often out of phase with the large valley glaciers creating complex interbedding of deposits. Rampton (1981) cites an example from lower Bullion Creek where "glaciofluvial gravel, glaciolacustrine silt and sand and landslide debris were deposited while the mouth of the creek was blocked by ice in the Slims Valley but before glaciation of Bullion Creek Valley itself" (Rampton 1981:30).

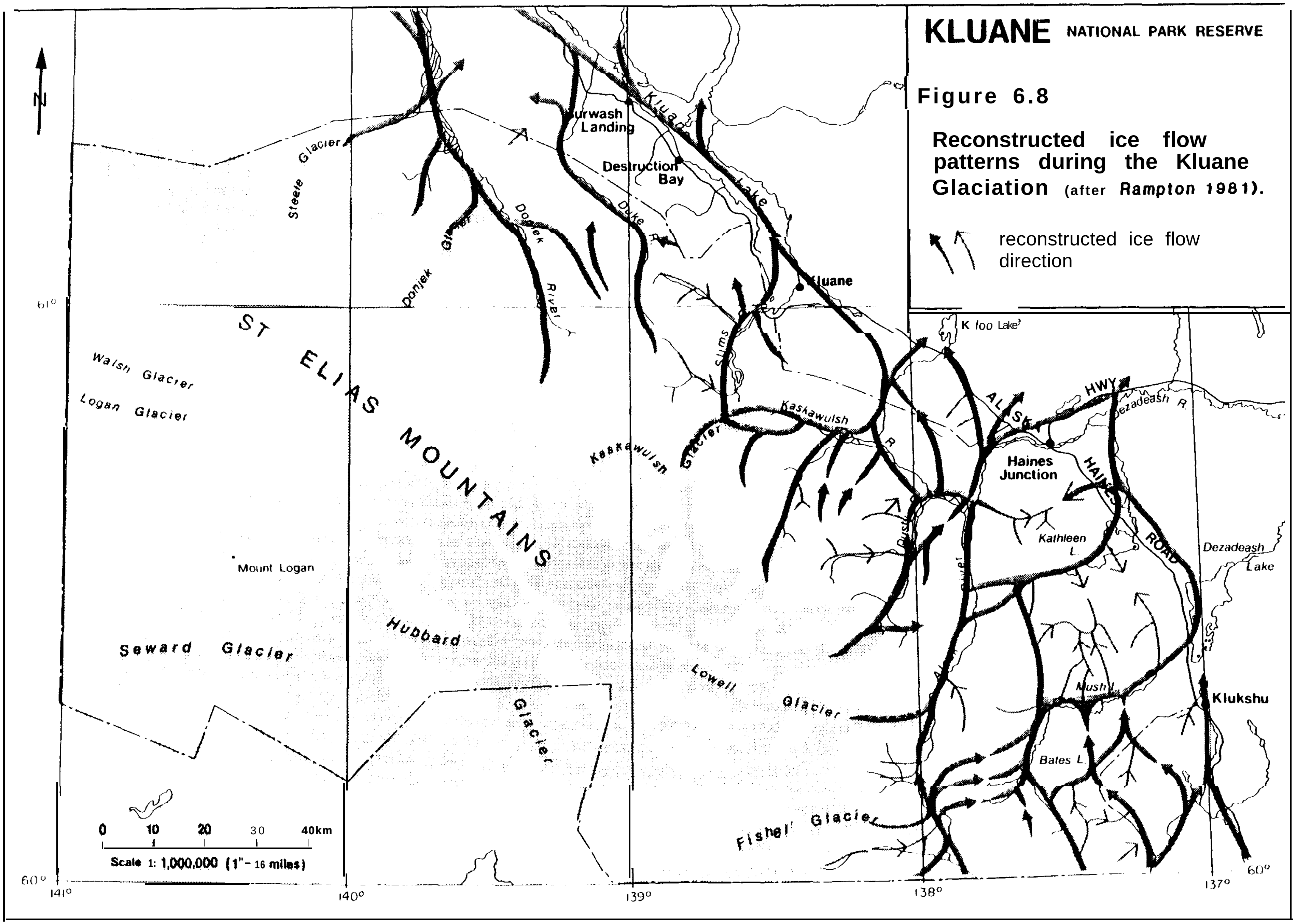
During the Kluane Glaciation ice filled all the major valleys in the Park area but did not overtop the mountains which stood as nunataks above the ice. The only exception was the lower mountains north and south of Onion Lake.

Figure 6.8 shows a reconstruction of the probable ice flow patterns in the Park during the Kluane Glaciation. In the southeast, ice flowed north through the Alsek Valley with tributary flow branching off through the Mush-Bates and Kathleen Lowlands to the east. From the Dezadeash River north, ice followed the major valleys before joining the dominant northwesterly flow along the Shakwak Trench. The glacier surface stood at about 1800 m near Fisher Glacier, 1680 m near Dalton Post, 1520 m at Haines Junction, and 1520 m near the junction of the Donjek and Shakwak valleys (Rampton 1981). Denton & Stuiver (1967) place the upper limit of Kluane erosion at 1830 m near the Slims River mouth. Erratics found at elevations higher than these probably relate to older glaciations (Rampton 1981). Local alpine cirque glaciers also formed in the Kluane, Alsek, and Bates ranges at this time and coalesced with the major valley glaciers. Ice continued to flow along the Shakwak Trench northwestward until it was no longer confined by the Ruby Range on the northeast. Here the ice coalesced with ice flowing east through the White River Valley spread out as a Piedmont-type lobe that terminated a few kilometres north of Snag.

The beginning of the Kluane Glaciation is dated about 29,600 ± 460 BP (Denton & Stuiver 1967). The glacial maximum occurred about 14,000 BP and was followed by rapid deglaciation. Ice had retreated from the Shakwak Valley to the mouth of the Slims River by 12,500 BP, near the present Kaskawulsh terminus by 9780 BP (Denton & Stuiver 1967) and in the upper White River valley by 9360 BP (Denton 1974). Some ice stagnation occurred on relatively level topography east of Kluane Lake forming ice contact deposits, but the period was characterized largely by rapid retreat of valley glaciers (Denton 1974). Denton (1974) believes the rate of retreat to be of great importance reflecting an abrupt climatic event about 14,000 BP which initiated the end of the Wisconsin Glaciation. valley glaciers are more sensitive to climatic changes that are the massive ice sheets which covered central Canada, and, once begun, recession in the Kluane area was a continuous process with no evidence of stillstands or readvances (Denton & Stuiver 1967).

Numerous glacial lakes formed throughout the area at this time as meltwater from the receding glaciers was dammed by ice or topographic obstructions. Some lakes were local and short-lived forming in small tributary basins which became ice-free before the main valleys. Others covered large areas for extended periods of time. Glacial Lake Champagne (Kindle 1953) formed about the time glaciers had retreated to the eastern edge of the Kluane Ranges, covering a large area in the Shakwak and Takhini valleys and extending along the Dezadeash River to Dezadeash Lake and along the Kathleen River valley.

The action of glacial meltwater and the physical retreat of the ice exposed vast areas of valley train and outwash and lead to the widespread deposition of loess. This began with the earliest recession of the ice in areas near the outer limit of the Kluane



KLUANE NATIONAL PARK RESERVE

Figure 6.8

Reconstructed ice flow patterns during the Kluane Glaciation (after **Rampton 1981**).

Glaciation. Loess thickness varies unsystematically over the area from **30-150 cm.** The greatest thicknesses are in the Slims and Donjek valleys (Nickling 1972). Over time, the area of active loess deposition retreated with the ice front; loess deposition in the outer areas ceased and the surface stabilized as the glacier fronts retreated. Active deposition did not begin in the areas near the present glacier termini until about 9800 BP (Denton & Stuiver 1967).

Retreat of the ice also exposed glacially scoured and oversteepened slopes to weathering and probably resulted in frequent landslide activity. It has been suggested that deposits of landslide debris without obvious source areas were formed when the landslide fell onto glacier ice still in the valley and **was** subsequently moved downvalley on top of the ice.

6.3.7.6 Slims Nonglacial Interval (12,500 - 2,800 BP)

The period of climatic warming which brought about the end of the Kluane Glaciation has been named the Slims Nonglacial. Rampton (1981) divided the period into two parts: the Early Postglacial (12,500 - 8,700 BP) and the Hypsithermal (8,700 - 2,800 BP). The latter is recognized worldwide as a period of optimum climatic condition. In the Kluane area, the climate was as warm or warmer than present by about 8,700 BP. During the Hypsithermal, the warmer climate caused glaciers to retreat far upvalley of their present positions. The Kaskawulsh receded to a point 21.9 km from the present terminus (Denton & Stuiver 1967) and, with this large retreat, the valley train in the **lower** Slims Valley became inactive. A smaller volume of meltwater changed the river pattern from braided to single channel and large areas of the floodplain and adjacent terrain previously covered repeatedly by fresh loess, stabilized and became vegetated. The vegetation inhibited renewed wind erosion and the result was the development of a brunisolic soil profile on the upper 30 an of Kluane loess - the Slims Soil. The Slims Soil is present throughout the Park below elevations of 1,370 m (4500 feet). A similar situation occurred in the Donjek valley when Donjek Glacier withdrew sufficiently far upvalley to allow deactivation of the valley train and formation of the Slims soil in the area of the present terminus (Denton & Stuiver 1966). Pollen studies and vertebrate and invertebrate fossil remains indicate that the climate during the Slims Nonglacial was warmer and perhaps drier than at present creating a grassland type environment.

6.3.7.7 Neoglaciation (2,800 BP to Present)

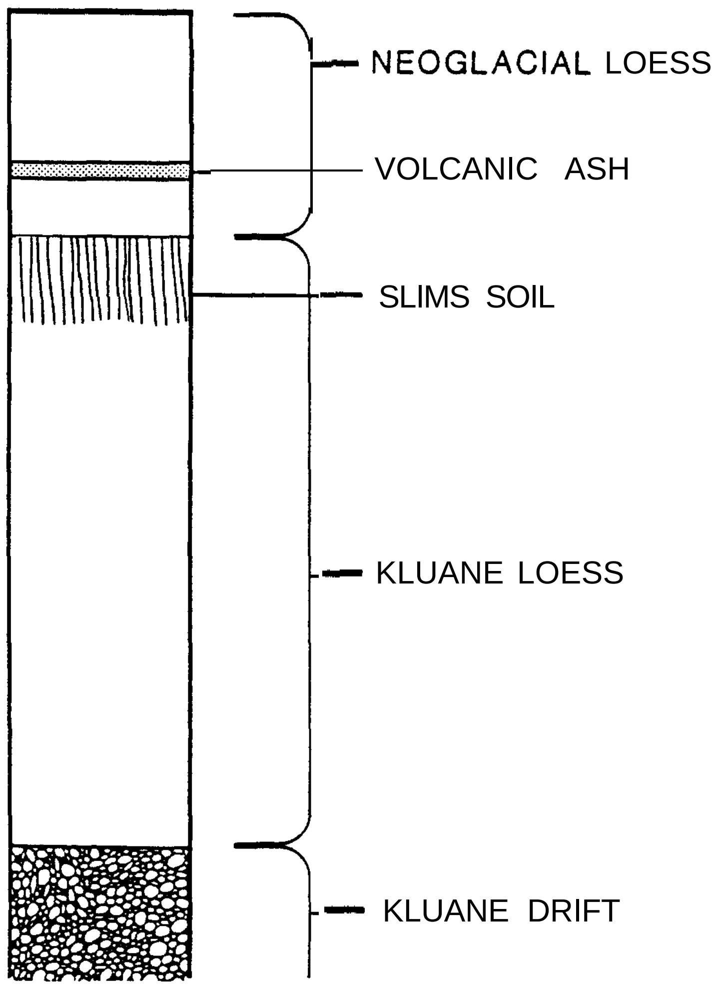
Through the latter part of the Hypsithermal, the climate again began to deteriorate and by 2,800 BP glaciers were readvancing. The term Neoglaciation is applied to the period of glacier advance following maximum retreat in the Hypsithermal. The period has also been called the Little Ice Age. Cooler and wetter conditions preceded the onset of Neoglaciation and the extensive grasslands gave way to expanding boreal forest.

Glacier readvance initiated another cycle of loess deposition which continues to the present time and which has buried the Slims Soil in areas near and just downvalley of the present glacier termini. The buried soil or paleosol is readily recognized in sections throughout the area and provides an important chronological marker in the Park. Neoglacial loess is thickest near the present glacier termini (maximum 1 m) and decreases rapidly downvalley and into the Shakwak Trench (Borns & Goldthwaite 1966). Beyond the area of active deposition of Neoglacial loess the Slims Soil is exposed at the surface presumably in equilibrium with prevailing climatic conditions (Denton & Stuiver 1967).

Neoglacial sediments include end moraine, outwash, lacustrine, sediments and loess. Neoglacial end moraines fringe the terminal areas of most of the large valley glaciers and are particularly distinct in the Slims, Kaskawulsh, and Donjek valleys. The outermost moraines mark the maximum Neoglacial advance and generally lie 1-3 km beyond the present ice margin. Inner moraines mark successive still stand positions in retreat from the Neoglacial maximum. These features are being actively eroded by modern glaciofluvial rivers and are being buried by outwash. The end moraines contain inclusions of volcanic ash, local Slims Soil and early Neoglacial loess, indicating that the formation of the moraine postdates these events. The maximum extent of the advance is confirmed by the presence of the Slims Soil overlain only by Neoglacial loess beyond the outer moraines. Advances beyond these moraines would have reworked the Slims Soil or deposited till over top (Denton & Stuiver 1966).

The Neoglacial terminal moraines are massive landforms. In Donjek Valley, the end moraine rises 18-30 m above the surrounding valley train. The recessional moraines are smaller, averaging only 2.5 m high and about 10 m wide. In the Slims valley the outermost Neoglacial moraine lies 1.6 km beyond the present terminus of the Slims lobe of the Kaskawulsh Glacier. In the Kaskawulsh Valley, the moraine is only 0.8 km from the active ice front. It varies from 4.5 to 7.5 m in height above the recent outwash surface but the actual height of the feature when formed is unknown. The terminal and recessional moraines are ice-cored. Figure 6.9 presents a generalized stratigraphic section for post-Kluane sediments in the Park. The presence within the profile of two datum levels - the Slims Soil and the White River Ash - gives excellent chronological control.

The Neoglacial period continues to the present day and has been marked by several glacier fluctuations. Advances occurred initially around 2,800 BP and subsequently between 1,250 and 1,050 BP and finally about 450 BP (Rampton 1981). Maximum Neoglacial positions were reached on most large valley glaciers between 300



(after Rampton 198 1)

Figure 6.9 Generalized stratigraphic profile for the post-Kluane glaciation period - Kluane National Park.

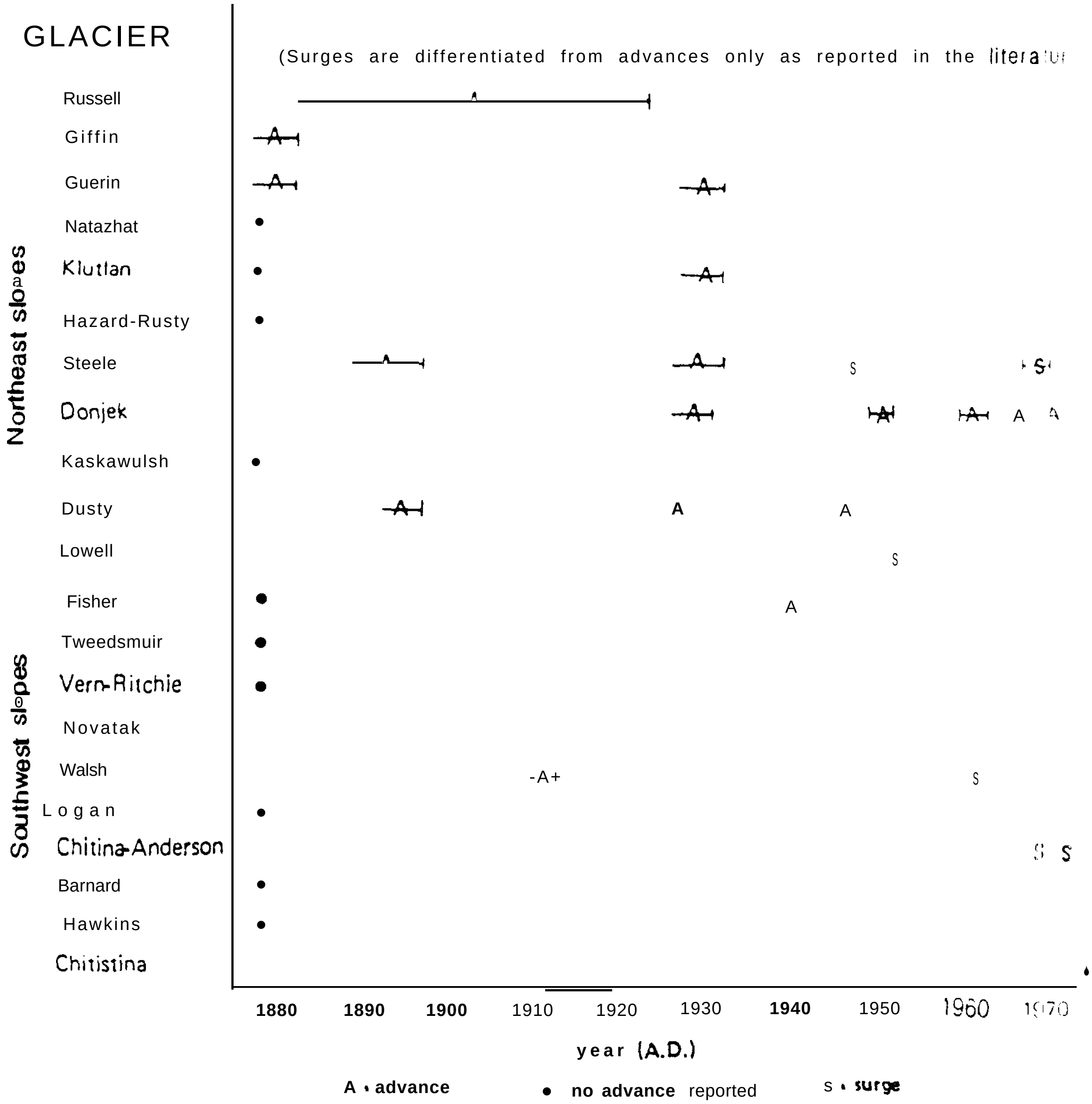
and 420 BP. Since that time, most glaciers have constructed a series of recessional moraines during still stand periods, dated by lichen diameters at 200-250 BP, 120-150 BP, 40-70 BP, and 25 BP to the present (Rampton 1981).

Figure 6.10 represents activity in the period 1880-1980 on glaciers in and near Kluane National Park.

Neoglacial Lakes

In the perimeter areas of the Icefield Ranges, large valley glaciers extend into the Greenbelt to intersect with major unglaciated valleys. This pattern can result in the formation of glacier-dammed lakes if the glacier terminus advances across the unglaciated **valley** floor completely blocking stream flow in the valley and causing water to pond upstream of the ice. Repeated advance of valley glaciers during the Neoglacial period caused large lakes to form several times in the Donjek and Alsek valleys and changed drainage completely in the Slims River - Kluane Lake area. Glacier-dammed lakes also formed in many smaller valleys throughout the Park. The mechanism is most effective when surging glaciers advance rapidly against the opposite valley wall and seal off water flow before a subglacial or proglacial channel can be cut.

The largest lake in the Park to form this way was Neoglacial Lake Alsek created by the advance of the Lowell Glacier into the Alsek valley. The lake formed and drained at least five times in the last 2,900 years - most recently between AD 1848 and 1891, between 1736 and 1832, twice between 250 and 500 BP and at least once between 800 and 2,900 BP (Clague & Rampton 1982). The White River Ash is present in glaciolacustrine silts near Bear Creek indicating expansion of the Lowell Glacier and formation of the lake around 1220 BP. Dating of these events has been possible through historical records, through dendrochronological and radiocarbon dating of driftwood in beach deposits, and by radiocarbon dating of organic material in buried soils ~~formed on these~~ lacustrine deposits. The geomorphological evidence of the extent of the lake phases is spectacular. Sequences of raised beaches and wave-cut benches are present along the valley sides of the Alsek and Dezadeash valleys, and giant current ripples and wave cut terraces formed during the drainage of the lakes was found on the floor of the Alsek Valley. As implied by the formation of huge ripples, the drainage of Neoglacial Lake Alsek was a catastrophic event initiated by breaching of the ice dam and rapid emptying of the lake by an outburst flood or "jokulhlaup". Clark (1978) studied the ripple marks and concluded that the lake probably drained in 1-2 days with peak discharges exceeding 50,000 m^3/s. Clarke (1984) has obtained four high quality lake bottom cores up to 5.5 m in length from small lakes in the former Lake Alsek reservoir. Initial analysis of these cores indicates three distinct environments: 1. Lake Alsek phase (varved silts and clays); 2.



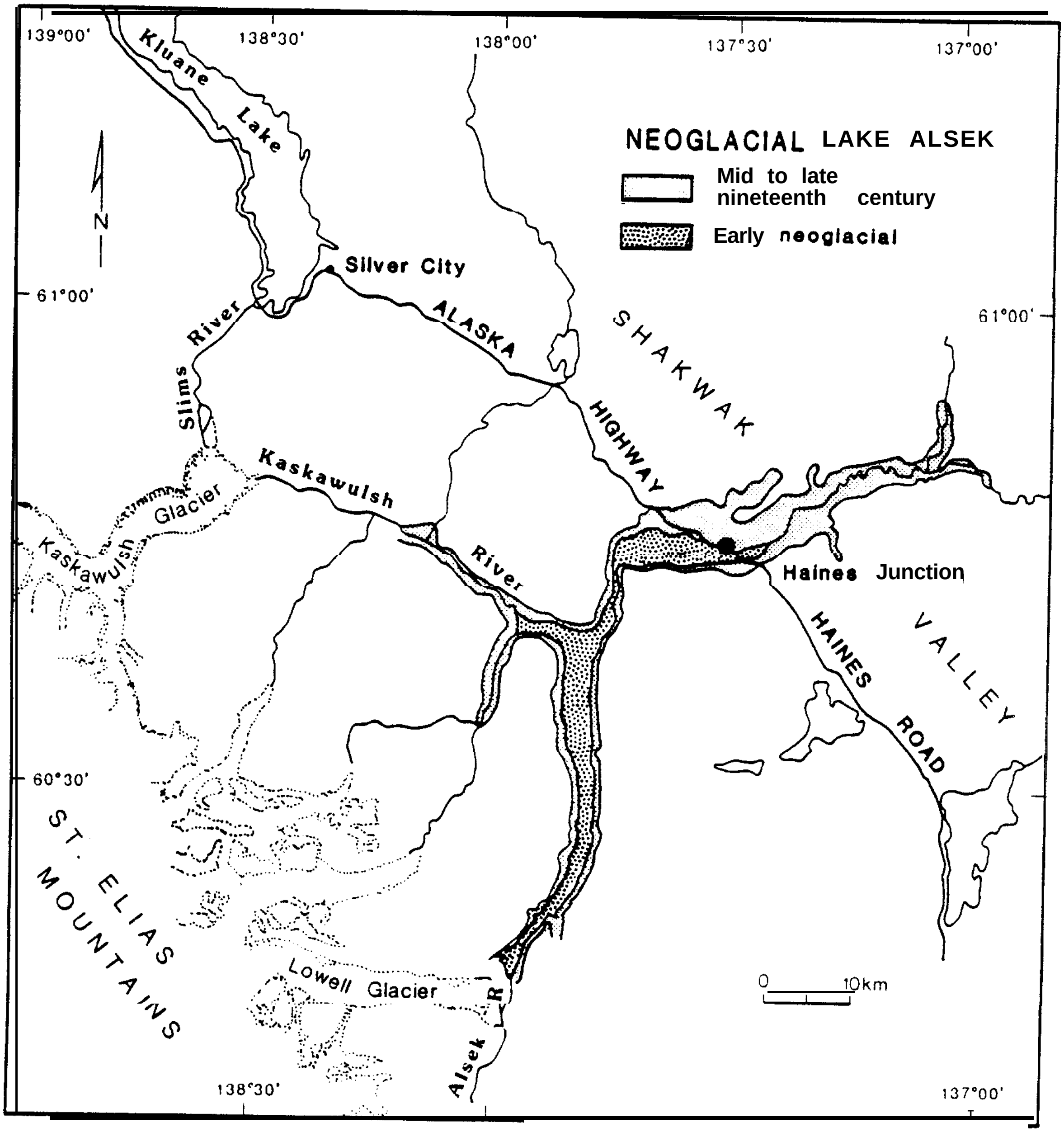
Source : Perchar o

Figure 6.10 Modern glacial advances, St. Elias Mountains 1830- .

Lake Alsek flood deposits (sand and gravel); 3. normal or inter-episode deposits (organic material). These sequences are repeated many times in each core and it hoped that further analysis will yield a detailed history of past episodes of Lake Alsek. These data are augmented by precise elevations of terraces and other features obtained from a 100-km long level survey from a bench mark on the Alaska Highway to Lowell Glacier which should allow a precise chronology to be assembled.

At its maximum, Neoglacial Lake Alsek may have been the largest Neoglacial lake in North America, over 200 m deep at the ice dam and over 100 km long, flooding parts of the Alsek, Kaskawulsh, Dusty and Dezadeash valleys (Clague & Rampton 1982). The maximum phase in early Neoglacial times and the most recent, less extensive phase in the late 19th century are shown in Figure 6.11. A much smaller lake may have existed in the Alsek Valley as late as AD 1917 (Clague & Rampton 1982). The area now occupied by the Haines Junction townsite was flooded repeatedly by the various lake phases. At present, the terminus of the Lowell Glacier is about 1.5 km from the east wall of the Alsek Valley and another advance of sufficient magnitude could block the valley again causing Lake Alsek to refill. However, the Lowell Glacier has thinned and receded in the last century and it is unlikely that the ice dam formed by another advance would be large enough to allow the lake to fill to a level higher than it was circa 1850. Clague and Rampton (1982) estimate it would take a full year after blocking of the Alsek River for water to backup and reach Haines Junction.

Lake Donjek forms by a similar process when Donjek Glacier advances across the Donjek Valley. There is evidence in the form of raised shorelines and beaches, relic channels, and lacustrine deposits of at least four fill and drain episodes in the last 700 years. The earliest episode began between AD 1270 and AD 1430 and may have lasted for 200 years draining and filling repeatedly. This was accompanied by the maximum downvalley Neoglacial expansion of Donjek Glacier. Two more separate phases of unknown age and duration then occurred, prior to the most recent formation of the lake sometime after AD 1622 and drainage between AD 1810 and AD 1840 (Perchanok 1980). The most recent phase was the highest and drainage was by glacier outburst. Shorelines were at 1127 m (3700 feet) and the reservoir volume has been calculated to be 234 x $10^6 m^3$. Estimated peak discharge was in the range of 3968 - 5968m^3 per second (Clarke & Mathews 1981). Perchanok (1980) described and mapped the features of Recent Lake Donjek (see Figure 6.12). Lake depths ranged from 5 m near the upstream end to 35-40 m at the widest point, to 60 m at the ice dam (Clarke & Mathews 1981). At present the terminus of the Donjek is very close to the valley wall. Its location varies through the year, advancing to within 10 m in the early summer and retreating slightly as streamflow in the Donjek River increases with snowmelt and erodes the terminus (Perchanok, pers. comm.).



(after Clague & Rampton 1982)

Figure 6.1 1 Extent of Neoglacial Lake Alsek in early Neoglacial time and in the mid to late 19th century.

Special sites
- a sand dune
- b slumped sediments
- c shoreline profile
- d shoreline profile
- e location of dead trees
- f location of loess overlying relic allu
- g alluvial fan remnant
- h location of flood deposits
- i location of flood deposits
- j location of stratigraphic exposure

Surficial materials
- moraine
- active alluvium
- relic alluvium
- clay
- silt

Landf orms
- shoreline terrace or terracetts
- overflow channel (a.b.c.)
- paleochannel
- striation
- flood deposit

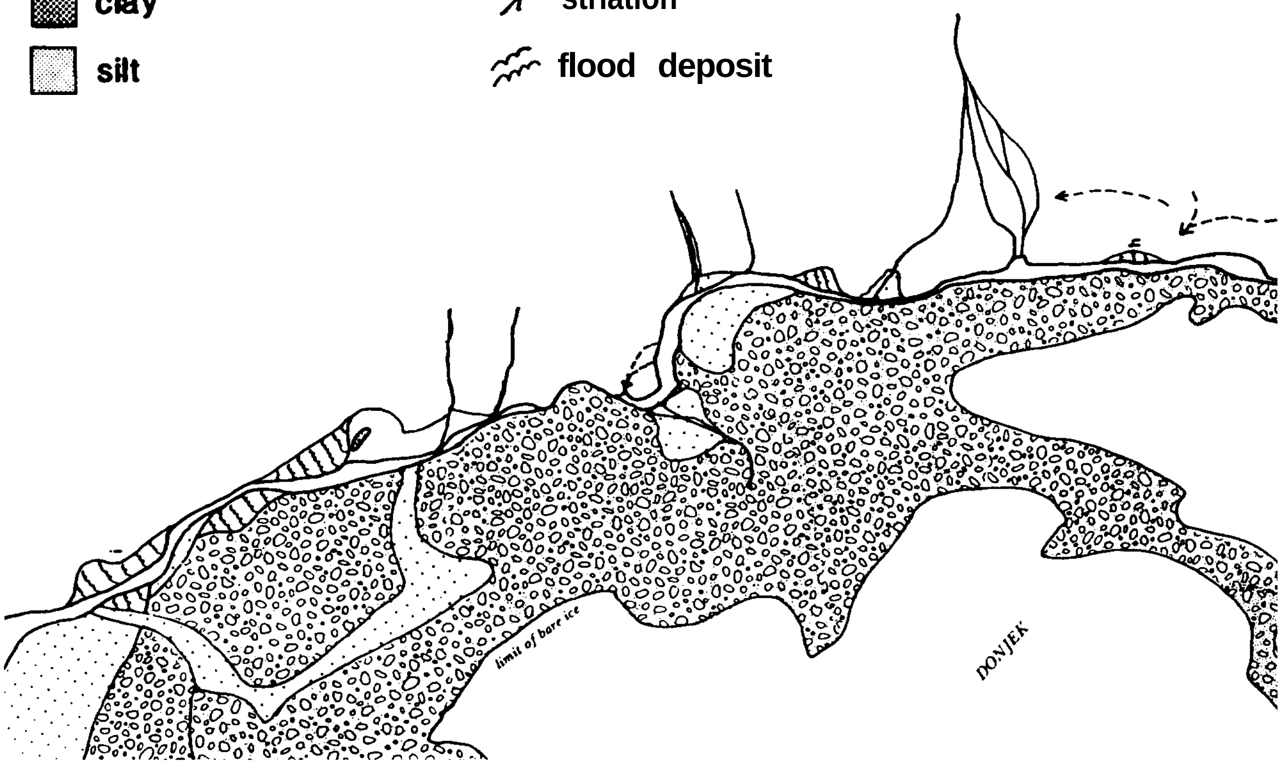


Figure 6.12 **Landforms** of **glacial** Lake **Donjek.**

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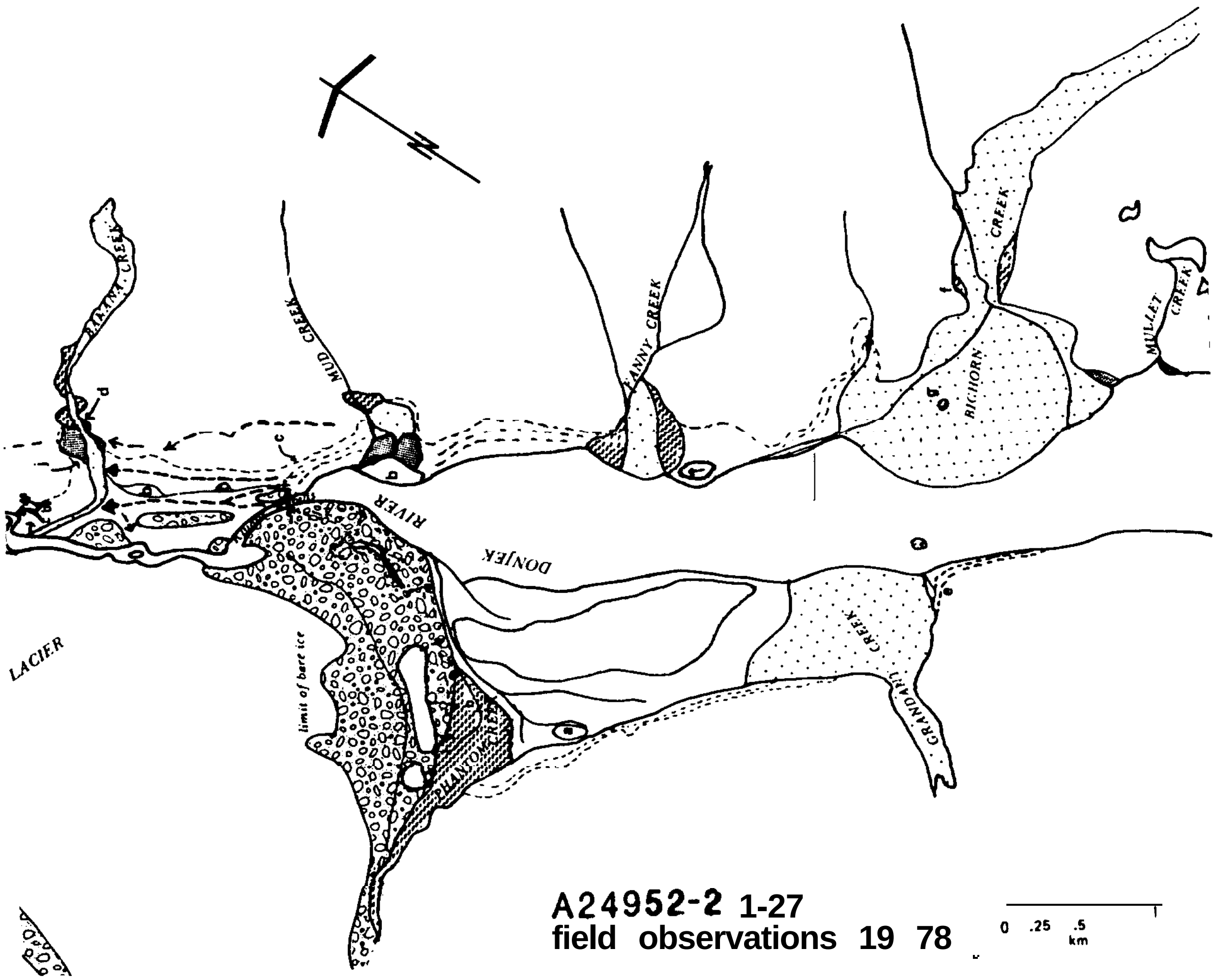

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field observations 19 78

(after Perchanok 1980)

The Donjek Glacier has a record of strong surges in this century (Canada 1977) and it is likely that Lake Donjek will fill again in the future. Formation of Lake Donjek presents no danger to life or property but the catastrophic drainage of the lake could threaten the Alaska Highway bridge and other structures (pipelines, power lines etc.) downstream.

More than 150 basins in the White, Donjek and Slims-Kaskawulsh drainages are or have been glacier-dammed (Canada 1977). Many of the lakes formed in these basins are quite small and many, such as Hazard Lake, fill and drain annually. The 1965-66 surge of the Lowell Glacier dammed the mouth of Hazard *Creek* forming a proglacial lake which began filling in June 1966. The lake remained until July 1975 when it drained through a subglacial channel. The lake filled again in July 1977 and drained between August 2-5 1977 and has filled and drained annually since that time (Clarke 1982). The August 1978 release was estimated at 19.62 million m^3 at a peak flow of 640 m^3/sec (Clarke 1982). The lake covers an area of 1.2 km^2 with a maximum depth of 95-100 m. The basin has been studied closely to provide calibration and testing for empirical and theoretical models of glacier lake drainage.

Lacustrine deposits of clayey silt and well-sorted gravel and sand now cover the former lake bottoms and mark the shorelines of Kluane age and Neoglacial glacier-dammed lakes. The lake bottom silts cover extensive flat areas and vary from 1.5 - 60 m in thickness; they are commonly varved and include fine sand interbeds (Rampton 1981). The gravel deposits are found as strandlines, narrow beaches and benches and range from 1.5 to 5 m thick. Permafrost is often present in the silt material which tends to be poorly drained. Thermokarst may result from surface disturbance in these areas.

Kluane Lake Drainage

Today, the Slims River flows northward to Kluane Lake which drains through the Kluane and Yukon rivers to the Bering Sea, a distance of over 2400 km. The Kaskawulsh River flows east to the Alsek system and the Gulf of Alaska over a distance of only 240 km. Geomorphological features near Kluane Lake provide considerable evidence of late Pleistocene fluctuations of up to 12 m in lake levels and a possible reversal of this drainage pattern. This evidence includes raised beaches, wave-cut terraces, and a drowned forest in the northern shallow parts of the lake, indicating that levels have been both higher and lower than at present. Bostock (1969) has studied these features and the regional topography and believes that during the Slims Nonglacial Kluane Lake drained southward through the Slims Valley to the Kaskawulsh and Alsek rivers.

Kluane Lake is of glaciofluvial origin, formed as glacial meltwater filled the deepest parts of the Shakwak Trench following the Kluane

Glaciation. Bostock (1969) postulates that as ice retreated up the Slims Valley an arm of Kluane Lake filled the lower reaches of the valley. With an outlet to the north blocked by drift or ice, this body of water drained southward into the Kaskawulsh Valley passing through an outwash-filled channel 500 m wide between Kaskawulsh Knob and Vulcan Ridge at the fork between the two valleys. During this time lake levels were 12 m lower than at present and areas now underwater near Sandspit Point and in Christmas Bay were forested (Bostock 1969). Bostock believes this pattern continued until late Neoglacial time probably about 450 BP when the Kaskawulsh Glacier advanced against the Knob and down both valleys blocking the southward drainage. This caused water to back up and lake levels to rise drowning the nearshore forested areas and forming beaches and storm terraces up to 10 m above present lake levels (Bostock 1969). Standing tree stumps are visible underwater in some areas. Radiocarbon dating of these tree stumps yielded a date of 340 ± 130 BP, indicating how recently this event occurred. With lake levels 10 m above present an outlet at the north end of the lake through what is now the Kluane River became available and the lake drained quickly cutting down through drift and into bedrock. This bedrock outlet now controls the lake level and in years when the Duke River contributes a heavy bedload the level of the outlet can rise resulting in lake level fluctuations of 3-4 m (Bostock 1969). Figure 6.13 illustrates this sequence of events.

6.4 Fluvial Processes and Landforms

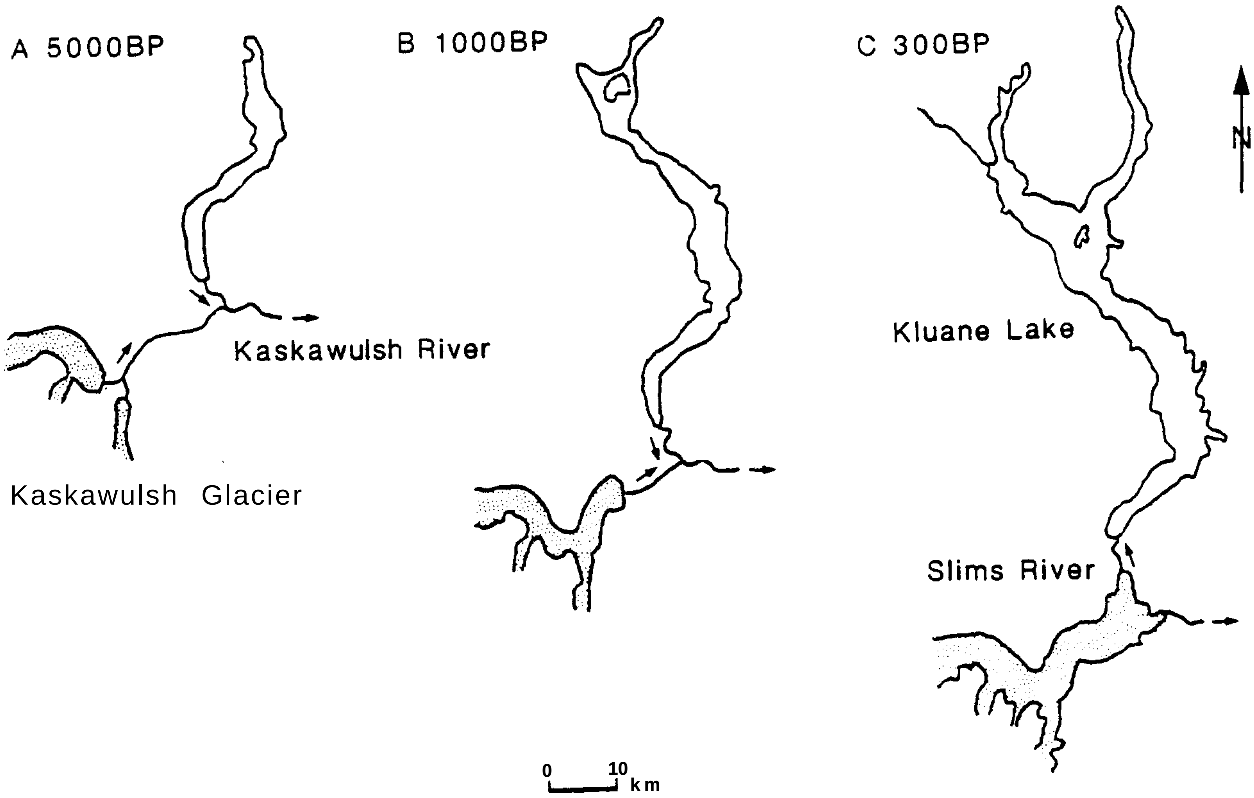
6.4.1 Drainage Patterns in Kluane

Most rivers within Kluane are fed by glacial meltwater from the large outlet glaciers of the Icefield Ranges. These rivers form parts of two major drainage systems, the Yukon and the Alsek with the divide lying in the Kluane Ranges just south of Kluane Lake. The divide is dramatically evident at the terminus of the Kaskawulsh Glacier which supplies two rivers - the Slims flowing north to the Yukon system and the Kaskawulsh flowing east to the Alsek. Figure 6.14 shows the drainage systems in the Park.
Other drainage divides occur subglacially in the Icefields with flow westwards to interior Alaska and southwards to the Alaska panhandle.

6.4.1.1 Yukon Drainage System

Northward drainage originates at the Kaskawulsh Glacier terminus where meltwater feeds the Slims River. Part of this flow issues from outwash gravels in front of the terminus as two fountains, described in 1965 by Fahnestock (1969) as l-l.6 m in height, 6 m across, and discharging 120-140 m^3/sec.

The divide between flow to the Slims and Kaskawulsh lies beneath the terminus and the relative proportions of the flow carried by the two rivers are controlled by the opening and closing of



(after Clague 1981)

Figure 6.13 Evolution of the current drainage pattern in the Kluane Lake area.

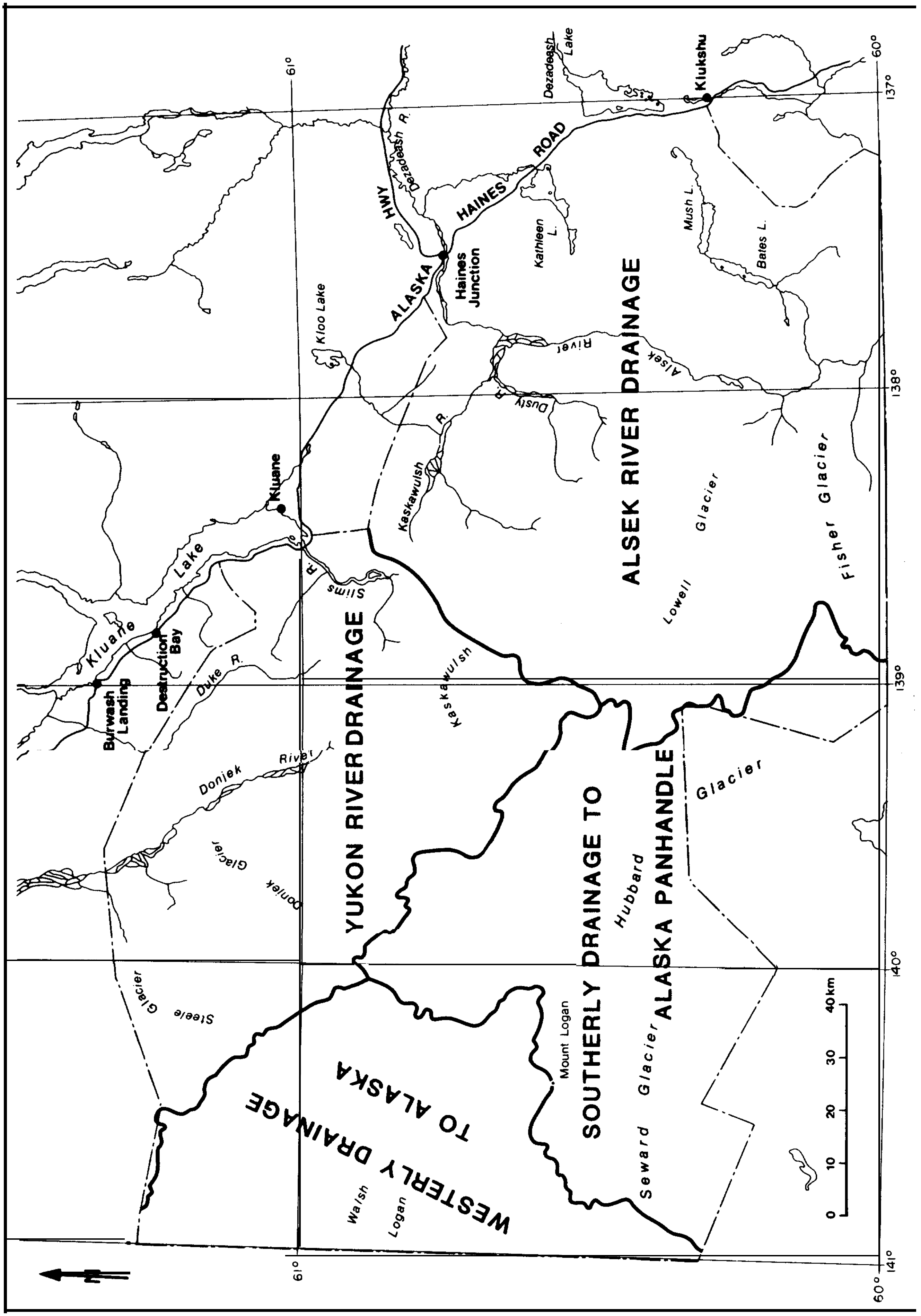

ALSEK RIVER DRAINAGE
YUKON RIVER DRAINAGE
SOUTHERLY DRAINAGE TO ALASKA PANHANDLE
WESTERLY DRAINAGE TO ALASKA
ALASKA HWY
HAINES ROAD
Haines Junction
Klukshu
Kluane
Destruction Bay
Burwash Landing
Kluane Lake
Kloo Lake
Dezadeash Lake
Dezadeash R.
Kathleen L.
Mush L.
Bates L.
Alsek River
Dusty R.
Kaskawulsh R.
Kaskawulsh Glacier
Slims R.
Duke R.
Donjek River
Donjek Glacier
Lowell Glacier
Fisher Glacier
Hubbard Glacier
Seward Glacier
Steele Glacier
Walsh
Logan
Mount Logan
61°
60°
137°
138°
139°
140°
141°
0 10 20 30 40 km

Figure 6.14 Drainage systems in Kluane National Park.

Note: The divide between drainage to the Slims and Kaskawulsh rivers lies beneath the terminus of the Kaskawulsh Glacier and the exact location of the line extending under the glacier is therefore uncertain.

subglacial meltwater channels as ice shifts in the terminus area (Fahnestock 1969). From 1965-70, the flow seemed to switch back and forth between the two valleys with one and then the other receiving the greater proportion of the discharge (Scace 1975). A decrease in flow in the Slims from 112 m^3/s on July 30 to $18.5 m^3/s$ on August 4, 1970 is attributed to such a shift (Bryan 1972).

The Slims River flows northward 22 km to Kluane Lake where it has built a large delta. Several high gradient - high energy streams descend from the adjacent hills of the Kluane Range and join the slims along its course, building large alluvial fans onto the Slims floodplain, (e.g. Canada Creek, Bullion Creek, Vulcan Creek). Two tributaries, Bullion and Sheep creeks, have eroded spectacular steep-walled gorges, in some places 600-900 m deep.

These streams contribute only a small proportion of the total Slims discharge. The Slims is the major source of water for Kluane Lake, although some tributaries contribute flow along the western side of the lake and streams such as Christmas, Cultus, and Gladstone creeks drain the Kluane Hills and the Ruby Range on the east side of the lake outside the Park.

Kluane Lake is the largest lake near, but now within the Park, formed by collection of glacial meltwater in the lowest areas of the Shakwak Trench following the Kluane Glaciation. Geomorphological evidence indicates that lake levels and drainage patterns in the area have varied significantly since that time. Its current mean level is 781.2 m (2,563 feet) asl. Section 6.3.7.7 discusses the area's history in more detail.

Kluane Lake is drained by Kluane River through an outlet cut in bedrock at the northeast end of the lake. In the last few decades mean annual lake levels have varied by more than 3 m in addition to an annual range of 2 m (Scace 1975). These variations are due to changes in the discharge of Slims River, changes in the level of the outlet caused by sedimentation in Kluane River at its confluence with the Duke River, and changes in the course of the Duke River.

The Kluane River is a marshy meandering stream. Its main tributary is the Duke River which drains the interior of the Donjek Range, and joins the Kluane just north of the Kluane Lake outlet. The Duke is a turbid, swift-flowing river fed by small glaciers.

The Donjek River is one of the great glacial rivers of Kluane National Park. It is fed by the Kluane, Donjek, Spring and Steele glaciers and flows 110 km through a wide braided floodplain to join the Kluane River north of the Park boundary. The Donjek continues north to meet the White River and then east to ultimately join the Yukon. Water originating at the Kaskawulsh Glacier flows over 2400 km through the Yukon system before discharging into the Bering Sea.

6.4.1.2 **Alsek Drainage** System

The Alsek drainage originates at the Kaskawulsh terminus where the Kaskawulsh River flows southeastward. Along its course it is joined by the Dusty River (fed by the Dusty Glacier) and Dezadeash River which drains Dezadeash Lake and a large area in the Dezadeash Range and Coast Mountains. The Dezadeash is the only major river in the Park which is not glacier fed. At the confluence of the Dezadeash and the Kaskawulsh the river turns south and becomes the Alsek. Meltwater from the Lowell and Fisher glaciers contribute to the flow. The Alsek is a fast-flowing powerful river and has cut steep canyon walls 300 m high in some areas (e.g. south of the junction with Bates River) . The Alsek is subject to glacier-damming by the Lowell Glacier within the Park, and by the Tweedsmuir south of the Park. This has occurred in the past and could recur either glacier were to surge (see Section 6.3.7.7).

The other major lakes in Kluane are part of the Alsek system. Kathleen and Louise lakes were once one body of water filling a glacially carved basin. Victoria Creek has deposited a large alluvial fan across the basin forming two lakes and raising the level of Louise (732.43 m) above that of Kathleen (730.61 m). The alluvial fan has also acted as a dam and filter for sediment and as a result, Louise is the aquamarine colour of waters with a heavy, fine rock flour load while Kathleen is clear.

Both lakes drain north via the Kathleen River to the Dezadeash. Mush and Bates Lakes (at 685.8 m and 679.7 m respectively) also occupy glacially scoured basins. They drain southward via the Bates River to the Alsek.

The total distance from the Kaskawulsh Glacier to the Gulf of Alaska southward by the Alsek is about 240 km - only a tenth of the distance along the Yukon system.

Bostock (1969) believes that the northward drainage of the Slims River is only a recently established pattern. Prior to the late Neoglacial advances (ca. 400 BP), the Slims drained Kluane Lake southward to the Alsek System. The advance of ice blocked this drainage and caused levels in Kluane Lake to rise until a northward outlet through the Kluane River became viable.

Presently the gradient in the upper reaches of the Kaskawulsh River is considerably steeper than that of the Slims River, the floodplain surface in the Slims is higher than the Kaskawulsh and the rate of headward erosion with continued glacier retreat is greater on the Kaskawulsh River (Bostock 1969). Given these factors, the possibility exists that the Kaskawulsh will capture the headwaters of the Slims at some time in the future and once again reverse the flow in the Slims Valley.

6.4.2 Fluvial Processes in Kluane

6.4.2.1 Seasonal and Diurnal Discharge Patterns

Most major rivers in Kluane are glacier fed and their flow varies markedly annually and diurnally in response to changes in the input of glacier meltwater. Discharge maxima are usually recorded in early August with minima prevailing from February to May. The Kluane and Alsek rivers show this annual pattern. These stages may differ by several orders of magnitude. Appendices 6.1-6.7 summarize data on river discharge in Kluane.

Diurnal variations are also pronounced with maxima occurring between 2200-2300h and minima between 1100-1500h (Nickling 1973). Data collected by Barnett (1971) indicate increases in discharge of 35-40% in 6-10 hours (e.g. July 5, 1400 hrs. - $112m^3/s$, July 6, 0000 hrs. - $157m^3/s$.). This pattern represents a lag time of about 8-10 hours between glacier melt maxima and peak discharge. Lag time will vary from one river to another with such factors as distance of the gauge from the glacier, size of the ablation area of the glacier (i.e. distance of meltwater travel over the ice itself), and aspect, etc.

Smaller tributary creeks similarly follow a seasonal and diurnal flow pattern but this pattern is more closely tied to the snowmelt cycle rather than glacier melt. Thus, discharge maxima are usually recorded earlier in the summer in June and July when snowmelt is at a maximum, and flow declines rapidly toward the end of the summer. Response lag time is much reduced on these smaller basins and daily maxima are usually recorded late in the afternoon. Aspect has a considerable effect on runoff in small basins as well. Vulcan and sheep creeks in the slims Valley are examples of snowmelt-fed streams. Both have their source areas in high névé fields.

Other small streams are fed by cirque glaciers. The hydrologic regime of these basins is more like that of the larger streams but with substantially reduced lag times due to basin size. Canada and Bullion creeks are examples of this type of basin.

6.4.2.2 Channel and Floodplain Morphology and Landforms

Channel morphology (size, shape, gradient, pattern) and bedform are dynamic parameters which change with the volume of water and the load carried by the river. Glacially-fed rivers experience wide variations in discharge and a generally high sediment load, and a braided river pattern characteristically develops to accommodate these changes. A braided stream flows in several anastomosing (dividing and reuniting) channels across a broad floodplain usually comprised of easily erodible coarse material. The channels are commonly wide and shallow and in plan resemble the strands of a braid. Channels may be at different elevations across the floodplain, with the higher level channels being occupied to accommodate higher stages of the river. The braided pattern develops when suspended and bed load is very high and coarse-grained sediment is constantly being deposited as interchannel islands and bars with active channels interlaced around these obstructions. The pattern of bars changes constantly as old channels fill and new ones are cut and as a result, the most active parts of the floodplain are usually bare of vegetation.

Rampton (1981) recognized two types of braided river floodplain. The first (FpA) is active across its total width and largely unvegetated because of constant erosion and deposition. Relief on the floodplain is in the range of 15 cm to 1.2 m. These floodplains are Neoglacial and modern valley trains. The second type (Fp) is the result of postglacial downcutting through Kluane-age valley train deposits forming low terraces which are flooded infrequently and then only by overbank flow. These terrace surfaces are vegetated because there is little erosion or deposition. Old channels on these levels are indiscernible because of infilling by overbank silt deposits.

The Slims, Kaskawulsh, and Donjek rivers are examples of classic **dalsandurs** - glacially carved valleys filled with outwash and occupied by a glacial meltwater braided stream. The Slims floodplain is about 2 km wide except where narrowed by alluvial fans built onto the valley floor by high gradient tributary streams such as Bullion Creek, Canada Creek and Vulcan Creek.

The Kaskawulsh Glacier has retreated from its Neoglacial terminal moraines and the river is now actively regrading the outwash material deposited along the length of the valley at that time. unlike many glacial stream floodplains which are usually comprised of very coarse sediments, the greater part of the Slims floodplain is fine gravel, sand, and silt. The sediments exhibit almost perfect proximal to distal sorting (exponential decrease in geometric mean size from the glacier terminus to the Slims delta) due to selective transport (Fahnestock 1969).

Three zones can be identified along the length of the river. The 'proximal' zone extends from the glacial terminus past the Neoglacial moraines to the point where the river assumes a braided pattern. In the proximal zone, flow is confined to two or three main channels, separated by large islands. This pattern is due in part to the presence of the Neoglacial moraines through which the river can flow only at a limited number of points where the moraines have been breached. The moraines also serve to create a form of settling basin between themselves and the glacier margin in which the coarsest fraction of the river load is deposited. Once past the moraines, the river, lightened of its bedload, expends energy once used to transport heavy bed material to deepen its channels. As a result, the channels in the proximal zone are more deeply incised than elsewhere along the valley. Coarse gravel is the dominant bed and bank material and because of a relatively steep gradient, this zone is seldom flooded.

The intermediate zone comprises the braided reaches of the Slims River. Fahnestock (1969) observed up to 30 active channels across the valley floor in this section at a flow of **280 m^3/sec.** Interchannel bars were only about 30 cm above the water. The braided pattern is the response of a river with easily erodible banks to fluctuating flows and a heavy debris load. The predominant bed and bank material is fine gravel and sand. Further downstream, the channels become wider until the flow is almost a continuous sheet of water with few gravel bars visible.

The third or 'downstream' zone begins where the Bullion Creek fan advances across the valley floor from the west and confines the flow of the relatively fewer channels against the east valley wall. This pattern is maintained for the remainder of the valley length and is perpetuated by the training of the river under the Alaska Highway bridge. In these reaches the river is actively building its delta into Kluane Lake. Bostock (1952) estimated the delta was building at a rate of **48-73** m per year. Highway related river training may have affected this rate to some extent.

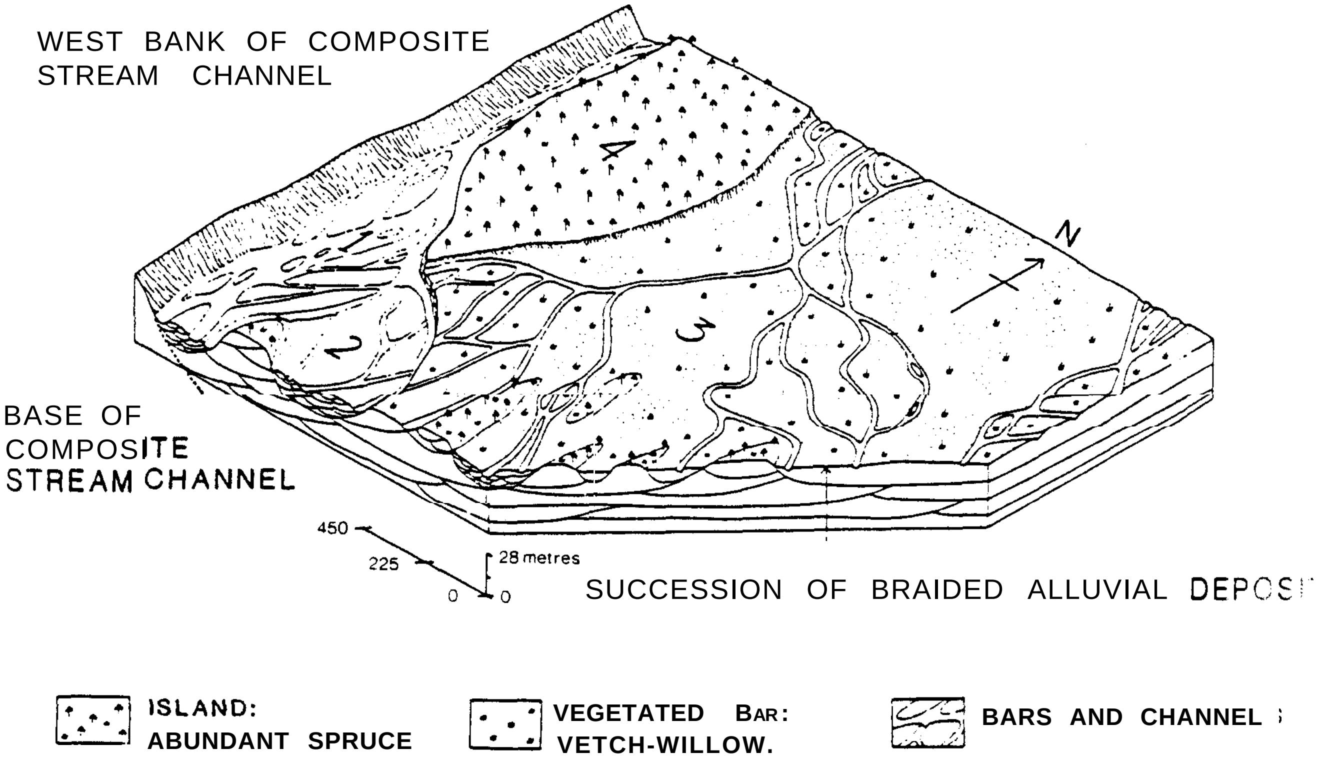
Zone boundaries are dynamic and migrate up and downstream with changing flow conditions. The base level control for the Slims River is the extension of the Slims Delta into Kluane Lake and variation in lake levels.

Williams and Rust (1969) and Rust (1972) studied reaches of the Donjek River - a 24 km stretch downstream from the terminus of Donjek Glacier, a 6 km stretch near the Alaska Highway crossing of the river, and a 9.6 km section below the confluence of the Donjek and Kluane rivers. Only the first segment is in the Park.

In this area the river is braided but has a distinct main channel which zig-zags between alluvial fans built onto the floodplain by tributary streams. The area between Kluane and Donjek glaciers is also braided. The floodplain in the downstream segment near the Alaska Highway is extremely wide and part of it has become inactive. Four topographic levels have been identified on the floodplain. The oldest and highest level is represented by islands vegetated with 200-year old spruce (Williams & Rust 1969). Figure 6.15 is a three-dimensional model of the floodplain in this area.

The formation of alluvial fans is another process characteristic of the Kluane environment. Alluvial fans are common throughout the Park in areas where high gradient - high energy streams descend from sparsely vegetated alpine and subalpine slopes to a level floodplain. These conditions provide for maximum erosion and transport of material by these streams; a rapid reduction in velocity when they reach the floodplain causes the stream load to be dropped quickly building a fan-type structure.

Fans are commonly composed of gravels with grain size decreasing away from the apex of the fan. The steeper fans may be extremely



(after Williams 8 Rust 1969)

Numbers refer to topographic levels on the floodplain.
Vertical scale is exaggerated.

Figure 6.15 Three-dimensional model of the Donjek River floodplain near the Alaska Highway bridge.

bouldery. The active stream channel swings back and forth across the surface of the fan, depositing new material and reworking previous deposits. Large fans tend to have lower gradients and a number of distributary channels across their surface (e.g. Bullion Creek). The smaller fans are generally steeper and have only one active channel which changes course quickly and frequently across the fan.

Groundwater seepage and subsurface flow through alluvial fans are also common and may result in massive icings on the fan surface in winter. Ice lenses and permafrost features such as frost mounds may also form in fine-grained floodplain material around the edges of alluvial fans with a constant supply of subsurface water. These features occur on the east side of the Slims Valley where flood levels have built levees which restrict the drainage of groundwater to the river.

The Slims River Delta is another remarkable fluvial feature in the Kluane area. The Delta above normal water levels covers an area of 11 km^2 and water depths of less than 3 m extend more than 16 km into the lake from the highway bridge (Scace 1975). It has been built in the last 500 years if Bostock's (1969) calculation of transport rates and interpretation of the drainage history of the area are accepted. Bostock (1952) estimated that since 1899, the Delta has built outward at SO-70 m per year. Bryan (1972a) noted that the rate between 1944 and 1970 was only 17.7 m/year and suggested the decrease may be due to: 1) increased width of the river and the lake requiring greater volume of sediment to build outward; 2) decreased gradient of the valley profile as the delta extends causing coarser material to be deposited further upstream, and 3) possible erosion of the delta front by wind and waves. The rate of formation has no doubt been variable, changing with the levels of Kluane Lake. A great quantity of coarse material was contributed by erosion of older parts of Bullion and Vulcan fans, evident today as terraces on these surfaces.

The turbid plume of Slims River water entering the lake is visible throughout the summer, extending 3 km or more into the lake (Bryan 1974b).

The present Alaska Highway bridge over the Slims River is built on a causeway which is protected from erosion by groins. This structure has trained the river into two channels under the 122 m span of the bridge and has stabilized much of the delta on the upstream side.

6.5 Colluvial Processes and Landforms

Colluviation is the process of gravity-induced mass movement. Movement may be very slow (creep or solifluction) or rapid (landslides, rockslides) and involves material of all particle sizes. Other processes such as seasonal frost, permafrost, water movement, and climate influence the rate of mass movement. The products of mass wastage are collectively termed colluvium. colluvium is poorly sorted and contains a large angular pebble to boulder size fraction in a variable matrix. On lower slopes, morainal and fluvial deposits may contribute rounded clasts to the body of material subject to mass wasting. Most colluvial deposits are well-drained because of their coarse texture and high slope angle. On gentle slopes at high elevations drainage may be impeded by underlying permafrost and solifluction, and periglacial phenomena such as stone stripes and polygons and ice wedge polygons may occur.

6.5.1 Creep

Creep is the very slow downslope movement by gravity of the surface layers of unconsolidated material. It is the least obvious of the processes, may take place on slopes of any angle from very gentle to steep, and is accelerated by freeze-thaw cycles and by water saturation.

Creep is the dominant process on colluvium-covered slopes (CS) where material has accumulated by insitu disintegration of the underlying bedrock. This is particularly the case on slopes above the level of the Kluane Glaciation. These slopes may be bare or sparsely vegetated and the process proceeds so slowly that it is only discernible by extended precise observation or by changes in vegetation patterns.

6.5.2 Solifluction

Solifluction is the shallow-based slow downslope movement of soil or colluvium under the influence of gravity in periglacial areas where freeze-thaw cycles are numerous. Characteristic lobate or terrace-like forms with bulging 'risers' develop in the upper metre and appear from above as viscous waves. Solifluction occurs on slopes of extremely low angle which, under conventional analysis, are very stable. The freeze-thaw process is essential to solifluction-type movement in several ways. On the scale of a single particle on a slope, freezing and subsequent heave lift the soil particle upward perpendicular to the slope. Thawing lowers the particle but gravity causes it to be displaced downslope of its original position. Freeze-thaw also loosens the structure of the surface material so that its strength on thawing is essentially nil. The most important process in solifluction is thought to be loss of strength on thawing due to supersaturation of the upper layers because drainage is impeded by underlying permafrost. Williams (1982) points out that we do not fully understand the process, nor are we even sure of the season in which movement takes place. He indicates that current research is investigating the importance of plastic movement of the soil/ice material in the frozen state.

Solifluction lobes and other periglacial features are found on colluvial slopes in the upper alpine zone in the southern areas of the Park, are less well-developed in the drier central areas, and are increasingly common northward in the Duke and Donjek Valleys. Rampton's (1981) CS category includes these areas (e.g. Observation Mountain, Hoge Creek area - see Map 6.1). Johnson (1975) describes variations in the form and nature of periglacial phenomena with aspect and altitude in the Metalline Creek Valley.

6.5.3 Talus

Talus (or scree) fans and aprons (Cf) are formed by the accumulation of colluvium at the base of steep bedrock slopes. This material is produced by frost shattering and weathering of bedrock and subsequent rock falls of the loosened material to the valley floor. Talus is usually very coarse and maintains a high angle (over 25°) at rest.

The processes inherent in talus accumulation are complex, involving first weathering, then rapid rock falls which, as well as adding material to the fan, dislodge and redistribute material already there. Snow avalanches and finally talus creep, act to redistribution of talus on the fan and modify the apron surface.

Talus accumulations are common in Kluane especially beneath glacially oversteepened valley walls. Striking examples occur near Kathleen Lake. Rampton (1981) believes talus formation was at a maximun during the early post-glacial but the process continues today.

6.5.4 Rock Glaciers (MR)

Rock glaciers occupy a curious middle ground between landforms developed by processes of creep and rockfall and are puzzling, poorly understood features of variable form, internal composition, and movement processes.

Rock glaciers are accumulations of unsorted colluvial debris which move downslope assuming surface configurations suggesting viscous flow. Active features are fed from steep cliffs above which provide a continuous source of talus material.

Some are apparently formed by the cementing of talus by interstitial ice; others appear to be debris-covered glaciers; some are comprised of avalanche debris and others may contain large ice lenses and have complex hydrologic regimes which influence their movement. The exact nature of their formation and movement are unknown due largely to the difficulty of obtaining information on their internal structure.

Rock glaciers are a relatively common feature in Kluane, occurring for example in the Slims Valley, on Sheep Mountain, in the Grizzly Creek Valley and in many other areas. P.G. Johnson and students from the University of Ottawa have done considerable research on rock glaciers and related mass movement landfonns in the Grizzly Creek area. In **1969**, instrumentation **was** installed in the Sheep Mountain rock glacier by J.P. Johnson of Carleton University. Internal temperature measurements were made in **1969-1972**, **1976** documenting a warming trend; most of the rock glacier is now above 0°C. A **1976** resurvey indicated that the borehole had move 6 m downslope and that internal deformation caused by differential movement had occurred. It is now believed that the rock glacier has ceased to be active (Johnson & Nickling 1979).

Currently, a student at the University of Calgary is working on the Vulcan Creek rock **glacier** in the Slims Valley. This study (Blumstengel 1984) **was** prompted by the proposed **Slims** Valley access road and is investigating the thermal and hydrologic regimes, internal composition, and movement patterns and rates of the feature.

6.5.5 Landslides (CL)

Landslides **are** virtually ubiquitous in Kluane. The **area** is comprised of complexly faulted and fractured bedrock and is subject to frequent earthquakes and minor shocks which may trigger large scale mass movement events.

Included in this category are a wide range of processes and features such as rotational slumps and skin flows in fine-grained material (e.g. slumps in loess on Vulcan Ridge), large volume rockslides, and debris and mudflows. Again these processes were probably most active immediately following the Kluane Glaciation when glacially-oversteepened slopes failed. Most deep seated bedrock failures date from this time (Clague 1981).

Landslides are most common in "poorly indurated Tertiary sediments **and** in areas of structurally weak layers of volcanic pyroclastics in Tertiary volcanic sequences" (Rampton 1981:11). A major relatively recent landslide occurred in this type of material on sheep Mountain at the south end of Kluane Lake as two separate events about 500 and 1950 (C14) years BP (Clague 1981). These landslides involved 5-10 million m^3 of material from the east flank of Sheep Mountain. Much of the west shoreline of Kluane Lake north of the Slims River is covered by blocky landslide debris from these and similar earlier events. Some large blocks **are 500** m^3 in volume (about 1500 tonnes) and slide debris from the most recent event is 7-14 m thick at the Alaska Highway cut. In pre-Neoglacial time landslide material up to 40 m **thick was** deposited on the lower slopes of Sheep Mountain and in the Kluane Lake basin when its levels were lower. Rising lake levels have drowned the toe of these deposits leaving some separated from the main body of debris on an island. Dating of the most recent events is based on dendrochronology, and inclusion of layers of the White River Ash and Slims Soil.

6.5.6 Debris Flows and Mudflows (CL)

Debris flows are another ubiquitous mass movement process in Kluane. These events involve extremely rapid downslope movement of mixtures of weathered rock, unconsolidated material of all particle sizes, and water together in the form of a slurry. They involve large volumes of material, occur in conjunction with many other landforms - alluvial fans, talus fans, landslides - and recur at indeterminate intervals. In connection with preliminary work on the proposed Slims River Valley access road, a student from the University of Calgary is studying active debris flow fans in the slims (Gustafson 1984). Following extremely heavy summer rainfall, flows involving 4000-8000 m^3 of material have occurred in two consecutive years on these fans. The events are potentially destructive to life and property and a hazard to economic operation of the access road. The frequency of occurrence is a function of several factors: 1) rate of accumulation of material; 2) presence of sufficient water from snowmelt; 3) occurrence of extreme precipitation events; and 4) potential triggering by external events such as microearthquakes (probably minor). These factors in combination provide a complex picture of the debris flow problem and assessment of the probability and frequency-magnitude of events is extremely difficult if not impossible. Gustafson is, however, investigating the processes associated with accumulation and collecting climate data to provide a basis for correlation of flows to high temperature - high precipitation conditions.

The accumulation problem is particularly interesting as it appears that the presence of permafrost and ground ice in the high, steeply sloping source areas is an important factor. Normal gully erosion removes the surface active layer and exposes frozen ground to air temperatures. This surface thaws and slumps releasing material (in this instance till) and water into the source area. If further lubricated by heavy summer precipitation, the conditions have been set for flow of accumulated material. Gustafson's study promises to document important elements of an interesting problem. Previously flows were thought to recur in intervals of several years - the occurrence of several flows in two consecutive years is undoubtedly tied to unusual climatic events. Presumably assessment of the return period of these events will provide some measure of the potential frequency of mudflows. The problem lies in collecting a sufficient length of weather data to make this determination. As these flows recur in the same channels, subsurface investigations combined with dendrochronoloqy could provide further information.

Broscoe and Thomson (1972) actually observed a mudflow on Steele creek, again following a heavy summer rainfall. In this case, material containing boulders up to 3.5 m in diameter was deposited in several pulses accumulating to a depth of 2.4-3.6 m in 2 hours.

Clague (1982) states that debris flows have occurred repeatedly on Sheep Mountain probably throughout postglacial time. Intense rainfall in the summer of 1976 caused a debris flow which blocked the Alaska Highway at the south end of the lake.

6.6 Aeolian Processes and Landforms

Aeolian processes involve the entrainment, transport, and deposition of fine-grained material (fine sand and silt) by wind.

In Kluane the combination of strong glacier winds and wide expanses of valley train sediments have made aeolian deposits quite common. sand deposits range from 0.5 to ii m in thickness and are usually well drained. Aeolian sand in the Donjek Valley contains permafrost. Many deposits are too small to be mapped at 1:250,000. Mappable areas of parabolic and linear sand dunes (Ed) occur along the Alsek and Slims Valleys in association with blowouts on modern floodplains. Clifftop dunes also occur in the Donjek Valley.

Deposits of loess occur near the large valley glaciers throughout the Park in depths ranging from 50 - 100 cm. Loess blankets the underlying topography leaving its form generally unmodified and accordingly Rampton (1981) did not map it separately. Loess is common below elevations of 1370 m and is thickest in the Donjek Valley (Rampton 1981). Deposition continues today near active valley trains. Deposits below the modern surface and outside the area of influence of present day glacier winds were formed during the Kluane Glaciation. The Slims Soil formed on this older surface during the Hypsothermal.

Loess is well sorted silt and because of its fine texture and physical properties tends to impede drainage, resulting in the accumulation of organic material and the formation of permafrost on flat terrain. In the subalpine and alpine zones on sloping terrain the loess blanket is susceptible to slumping if saturated or to blowouts if the vegetation mat is disturbed.

Nickling (1978) investigated loessial transport in the Slims Valley. He found that the worst storms occurred shortly after heavy or extended precipitation. Initially this seems unlikely but heavy rain leaches away the surface salt crust which is an important binding agent. Initial evaporation of surface moisture then allows the larger grains to begin to move by creep and saltation (bouncing along the surface) and further evaporation allows entrainment of the finer material in suspension. The conditions most conducive to sediment transport are - low surface moisture content (less than 34% dry weight), low salt concentration, and high wind shear (change of velocity with height). Dust storms are more common in the afternoon when glacier winds are strongest and when the surface moisture content has decreased following overnight condensation. In 15 storms, Nickling concluded that creep accounted for movement of 2.3% of the total material transported, saltation 51.33, and suspension 46.4%.

6.7 Evaluation

6.7.1 scientific Research

The geomorphologically active landscape of Kluane provides many opportunities for research into mass movement processes, permafrost-related features, fluvial processes and of course the features of past and present glaciation. Access is relatively good along the Alaska and Haines highways and logistical support is feasible through the Arctic Institute base camp at Kluane Lake. Both the University of Calgary and the University of Ottawa maintain ongoing programmes of geomorphological research. UBC under G.K.C. Clarke is doing extensive glaciological research into the physical characteristics of glaciers in the Park and particularly the surge phenomenon.

The Environmental Impact Assessment of the Slims Valley access road project (Gray 1983) prompted two studies in the Slims Valley - one into rock glaciers and the other on debris flows. These will hopefully provide valuable information for the final design stage of the development if the decision to proceed is taken.

In general, opportunities are virtually unlimited and many potential studies have practical application to future Park activities and development.

6.7.2 Interpretation

Interpretation of the geomorphology, of Kluane plays an important part in the presentation of the Parks wilderness theme. Much of the area's wildness is due to the rugged, fresh appearance of the landscape and the immensity of the features - hugh glaciers, wide river valleys, and fast-flowing mountain streams. The opportunities for interpretation are limited only by access but many areas of interest are easily reached by the public. The rock glacier self-guided trail on the Haines Road is an example. other areas which could be developed for interpretation from the Alaska Highway include:

- the Sheep Mountain landslide, perhaps best viewed from the east side of the lake. Visitors then literally drive through the landslide debris as they proceed north on the highway;

- the Slims Delta is a unique feature which could be described through a series of aerial photographs showing the growth of the delta over time and the current extension of the Slims River turbid plume into Kluane Lake. This could be tied to the whole theme of glacial erosion and deposition from mountain valley to delta: and

- the reversal of drainage in the Slims Valley is another interesting point which could be explored again by aerial photographs in a display in the Haines Junction Visitor Reception Centre.

Should development in the Slims Valley and the Mush-Bates Lake area be pursued, the realm of interpretation is expanded to include among other things features of active glaciation. Map 6.2 is an example of the type of display that could be used to illustrate these features, perhaps using two colour anaglyphs that mimic stereovision without the expense of special equipment.

Photographs of the 'bulge' on the Trapridge Glacier provide spectacular evidence of the imminent surge condition of the glacier. These could be combined with existing photographs of the Steele in **surge** in 1966 to describe the phenomenon of surging glaciers.

The features of Neoglacial Lake Alsek offer an exceptional opportunity for interpretation. The formation of the lake, its sediments, geomorphological features, resulting vegetative patterns, and wildlife all contribute to **a** special environment in the Park. All elements are interesting individually but also provide an example of how all aspects of the environment combine to produce **a** particular biophysical land unit.

In many **ways** the interests of travellers are expanding to the point that the provision of a guidebook for Park visitors travelling along the Alaska and Haines highways is becoming feasible. With kilometre post markings along the highway it is relatively simple to identify features visible from the road or which can be reached by a short hike which are of interest to the public. At some point in time it might be possible to produce theme booklets for public purchase on for example the glacial history of Kluane or other specific features. An integrated approach to these subjects would probably be best taking the visitor from the strictly physical landscape to its ultimate influence on the biotic environment.

6.7.3 Limitations to Use

Rampton (1981) identified environmental concerns associated with the various landforms in Kluane. His findings are reproduced as Table 6.2. Most relate to problems arising from disturbance of ground thermal regime in permafrost areas and surface disturbance in areas of fragile vegetation (e.g. subalpine and alpine slopes in the Slims Valley). These are problems only in the face of increasing visitor use or development of access to the Park interior. At the time of such proposals, the Parks Canada environmental assessment and review process will be used to identify site-specific environmental impacts, mitigation measures, and monitoring requirements.

Table 6.2 Summary of landform descriptions, environmental concerns regarding landforms, and landform ages!

Landform	Description	Environmental Concerns	Age
Talus fan or apron (Cf)	Moderately to steeply sloping accumulation of coarse angular bedrock fragments; commonly located below steep cliffs or at the mouths of avalanche chutes; sources are areas of rapidly disintegrating bedrock.	Rock falls and debris flows common on active fans; steep slopes generally unstable to traffic.	Range from late Kluane to Neoglacial; many more still active.
Landslide (CL)	Generally moderately sloping, but with some surface irregularities, accumulation of poorly sorted debris; debris varies from large blocks of bedrock in some slumps to finer material in debris flows; generally landslides have an elongate shape and debris flows have a fan shape; commonly associated with Tertiary rocks.	Landslides generally are recurrent in susceptible areas and may become active if disturbed.	Range from late Kluane to modem.
Colluvium covered slope (CS)	Gentle to steep slope underlain by unsorted rubble; at the surface are stone stripes, solifluction lobes, and other periglacial features.	Areas of fine textured materials and gentle slopes at high elevations where there is ground ice will be susceptible to high solifluction rates and thermokarst if disturbed.	Generally late Kluane; high slopes may be older.
Sand dunes (Ed)	Elongate parabolic dunes with blowouts. Commonly associated with active braided valley trains; also occur at the top of cliffs containing sandy unconsolidated deposits.	Unstable and subject to blowouts if disturbed.	Majority are Neoglacial, some are still active.
Alluvial Fan (Ff, F_f^A)	Gently sloping accumulation of rounded to subangular alluvium; small-scale surface irregularities due to shallow channels and boulders on surface.	F_f^A subject to shifts in channel and bar positions; Ff occasionally subject to flooding.	F_f^A is modern, Ff varies from early postglacial to Neoglacial.
Floodplain (Fp, F_p^A)	Flat to very gently sloping accumulation of alluvium; minor surface irregularities due to shallow channels on surface.	F_p^A subject to shifts in channel and bar positions; Fp occasionally subject to flooding.	F_p^A is modern. Fp is mainly Neoglacial.
stream terrace (Ft)	Flat to gently sloping accumulation of alluvium; stream side generally is marked by escarpments; escarpments may be present within the "nit.	Relatively stable except where surface is covered by silt or peat containing permafrost and ground ice; disturbance may cause thermokarst and channelling.	High terraces generally early postglacial; low terraces may he as young as Neoglacial.

Table 6.2 Summary of landform descriptions, environmental concerns regarding landforms, and landform ages" (continued).

Landform	Description	Environmental Concerns	Age
Kame delta (?) or kame terrace (Gk)	Patches of gravel and sand in the form of deltas and terraces along valley walls; generally flat topped but with steep downslope escarpments.	Steep escarpments may be subject to channellinq if disturbed.	Happed kames are Kluane; small unmapped Neoqlacial kames are present.
Outwash plain, fan and valley train (Gp)	Extensive flat area of gravel and sand well above present stream levels.	Flat areas that are covered by silt or peat may degrade through melting or ground ice if disturbed (probably a serious hazard in Donjek Valley).	Kluane; Neoglacial outwash plains generally have been mapped as Fp, F_p^A, Ft.
Kame-and-kettle complex (Gh)	Irregular mounds and hills of qravel and sand.	Depressions within unit may contain ice-rich fines that will be subject to thermokarst if disturbed.	Kluane
Esker and esker complex (Gr)	Gravel ridges.	Steep slopes may be subject to channellinq if disturbed.	Kluane
Outwash-covered slope (GS)	Gravel blanket on bedrock-controlled slopes; difficult to ascertain whether gravel is part of a kame system or a collapsed and eroded valley train.	May be subject to channellinq on steeper slopes if disturbed.	Kluane
Cirque glacier (Ic)	Glaciers confined to cirques; lower parts generally have gentle to moderate slopes; upper parts may be steep.	Crevasses are a hazard to traffic.	Modern
Mountain ice cap (Im)	Ice caps on higher portions of Icefield Ranges; includes flat ice-covered plateau and valley areas and steep ice-covered mountaininous slopes and peaks.	Avalanches, ice and rock falls, and crevasses are hazards to traffic.	Modern
Outlet valley glacier (Io)	Large valley glacier flowing from mountain ice cap.	Crevasses, incised meltwater channels and calving of ice blocks into proglacial lakes are hazards to traffic. Positions of glacier termini unstable.	Modern
Cliff glacier (Is)	Patches of glacier ice confined to cliffs..	Avalanches, ice and rock falls are hazards to traffic.	Modern

Table 6.2 Summary of landform descriptions, environmental concerns regarding landforms, and landform ages (continued).

Landform	Description	Environmental Concerns	Age
Valley Glacier (Iv)	Glacier extending downvalley from its cirques.	Crevasses and incised meltwater channels are hazards to traffic. Positions of glacier termini unstable.	Modern
Lacustrine plain (Lp)	Flat benches in lowlands, generally adjacent to lakes.	Drainage may be imperfect in these areas due to flatness and low topographic position.	Most are late Kluane or early Postglacial; small Neoglacial areas have not been mapped.
Lake beaches (Lb)	Small ridges of sand and gravel generally paralleling present-day shorelines.	Where beaches are clustered in low areas, intervening swales may be swampy.	Late Kluane to early Postglacial.
Drumlinized or fluted moraine (Md)	Elongate hills of drift; in some cases individual drumlins can be identified; in other cases elongate ridges and swales alternate and the terrain may be more appropriately classified as fluted.	Peat may be present in poorly drained swales; disturbance may cause some thermokarst.	Kluane
Ground Moraine (Mg)	Area of drift having gentle to moderate slopes, probably controlled by topography of underlying bedrock.	Some flat areas are poorly drained and susceptible to thermokarst.	Kluane
Hummocky moraine (Mh)	Hills and mounds of morainal deposits having moderate slopes.	Many depressions are poorly drained.	Kluane
Rolling moraine (Mm)	Rolling topography with most slopes being gentle to moderate; flat areas common within unit.	Flat areas may be poorly drained, covered by peat, and ice rich; may be susceptible to thermokarst.	Kluane
Morainic plain (Mp)	Area of flat to gentle sloping morainal deposits.	At high elevations may be susceptible to thermokarst.	Kluane
Moraine ridge ((Mr)	Ridges of coarse drift, generally paralleling present glacier borders.	Some ridges are ice cored and subject to degradation if ice is exposed.	Neoglacial

Table 6.2 Summary of landform descriptions, environmental concerns regarding lendforms, and landform ages. (concluded).

Landform	Description	Environmental Concerns	Age
Debris-covered glacier (ice-cored moraine) (M/I)	Accumulation of coarse drift overlying glacier ice; surface is generally hummocky or ridged with many ice cliffs present within unit.	Younger moraines are hazardous to cross because of melting ice; ice under older moraines makes them vulnerable to thermokarst if surface is disturbed; many unstable slopes.	Neoglacial
Rock glacier (MR)	Coarse bouldery drift; frontal edge generally steep; upper surface flat except for minor ridges.	Ice within rock glaciers may make them thermally susceptible to deep disturbance. Positions of termini unstable.	Neoglacial
Till-covered slope (MS)	Bedrock slopes mantled with till.	some solifluction may occur.	Kluane
Bog (Ob)	Shallow accumulation of peat having pools of water on the surface.	Poor drainage will affect trafficability; shallow depth Of ice-rich, fine grained soils underlying many togs may lead to thermokarst if bogs are disturbed.	Postglacial to modern
Forested peatland (Ofp)	Thick accumulation of peat draped over a" undulating surface of mainly morainic deposits.	Ice-rich peat is subject to thermokarst if disturbed.	Postglacial
Rock cliffs (R)	Steep cliffs commonly having a fine dendritic patter" of avalanche chutes on them.	Rock falls a common hazard.	Erosion leading to cliff development is Pleistocene to modern.
Glacially scoured rock (↑R)	Rounded hills and ridges with depressions and grooves produced by glacier scour; slopes are flat to moderately steep, in some areas a veneer of mixed deposits is present; e.g., shattered rock, patches of drift, and windblown silt (loess) and sand.		Rock scoured during Kluane Glaciation.
Glacially scoured valley walls (R→)	Glacially scoured valley walls, commonly ridged; slopes generally veneered with colluvium and drift.		Rock scoured during Kluane Glaciation.

(after Rampton 1981).

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APPENDIX

APPENDIX 6.1 MEAN DAILY DISCHARGE (Q) (m^3/sec) - KLUANE RIVER AT OUTLET OF KLUANE LAKE (SOURCE: WATER SURVEY OF CANADA - 1971-1983).

STATION MD. 09CA002 61°25'37"N 139°02'56"W **DRAINAGE AREA 4950 KM^2**

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MAXIMUM		MINIMUM	
													)AILY Q	DATE	)AILY Q	DATE
1953	a.1	5.7	10.7	15.8	24.9	74.2	146	112	80.4	45.9	24.3	7.8	162	(Jul. 7)	5.0	(Feb. 10)
1954	6.0	5.6	5.4	5.4	12.7	74.7	172	248	214	107	41.9	11.7	269	(Aug. 14)	5.2	(Mar. 29)
1955	9.8	8.8	a.4	10.8	10.3	33.9	162	228	164	70.8	29.2	11.3	242	(Aug. 13)	6.7	(Dec. 31)
1956	4.1	1.8	1.0	1.2	12.9	80.9	216	274	191	109	50.9	20.0	283	(Aug. 16)	1.0	(Mar. 21)
1957	16.7	16.3	15.1	13.4	27.7	135	244	308	23A	120	56.6	33.4	331	(Aug. 18)	12.2	(Apr. 21)
1958	19.4	13.4	12.8	14.8	22.3	104	214	132	69.1	32.6	17.7	10.8	244	(Jul. 15)	9.4	(Dec. 31)
1959	a.4	6.9	6.0	10.9	23.2	96.8	211	220	167	80.9	38.2	14.0	229	(Aug. 26)	5.7	(Mar. 13)
1960	15.4	17.1	12.0	11.7	26.5	68.8	157	238	178	84.9	35.4	22.6	275	(Aug. 21)	10.9	(Mar. 20)
1961	19.2	17.6	17.6	15.8	22.4	55.5	136	220	149	64.0	31.1	20.4	234	(Aug. 12)	14.3	(Apr. 29)
1962	11.6	5.9	5.9	5.9	la.7	102	228	306	223	96.2		17.6	314	(Aug. 16)	5.94	(Feb. 1)
1963	17.0	15.9	15.3	15.7	27.7	69.6					39.6	18.4	311	(Aug. 23)	14.4	(Apr. 1)
1964	17.3	17.8	17.8	la.7	21.1	119	206	269	188	82.4	35.7	a.0	294	(Aug. 8)	6.5	(Dec. 31)
1965	6.5	6.5	6.1	5.2	12.5	54.9	130	202	150	68.2	34.0	17.4	218	(Aug. 251	5.0	(Apr. 21)
1966	10.2	a.5	7.7	a.4	12.9	80.7	240	291	130	49.8	21.6	13.0	328	(Jul. 301	7.4	(Mar. 22)
1967	9.3	8.9	a.7	a.9	23.2	143	192	147	75.8	43.0	25.6	12.4	209	(Jun. 26)	7.8	(Dec. 31)
1968	5.8	7.1	11.4	13.6	29.4	78.4	191	165	95.7	49.2	19.8	7.2	221	(Jul. 15)	4.7	(Feb. 4)
1969	6.1	6.7	9.0	19.7	30.9	106	258	257	150	77.3	35.7	7.0	303	(Aug. 8)	5.4	(Jan. 20)
1970	9.5	17.9	18.1	16.4	20.2	55.8	122	114	62.3	33.4	12.5	5.2	150	(Jul. 30)	4.3	(Dec. 31)
1971	2.4	0.6	0.6	1.2	7.0	65.9	196	348	214	90.0	33.4	15.6	382	(Aug. 14)	0.5	(Feb. 27)
1972	10.2	10.0	10.4	12.9	35.7	108.4	244	302	207	94.5	49.2	26.8	314	(Aug. 101	9.6	(Mar. 5)
1973	16.0	12.0	13.4	14.8	23.0	48.4	171	232	160	77.4	34.2	14.5	245	(Aug. 14)	9.2	(Dec. 31)
1974	6.5	4.3	4.1	5.3	26.2	03.2	la6	265	216	110	46.7	24.5	300	(Aug. 19)	4.0	(Mar. 11)
1975	14.3	13.4	20.4	la.2	20.5	48.1	207	260	la3	102	56.0	21.8	272	(Aug. 11)	11.5	(Feb. 12)
1976																
1977																
1978	18.9	18.7	19.9	19.7	22.0	65.7	169	289	213	92.5	33.1	11.5	323	(Aug. 14)	9.0	(Dec. 28)
1979	9.4	10.8	16.1	21.5	33.4	82.5	210	308	231	99.8	46.2	18.4	319	(Aug. 18)	a.9	(Jan. 10)
1980	15.9	15.6	17.8	23.0	25.0	71.6	179	242	170	103	44.4	27.4	259	(Aug. 151	14.3	(Jan. 31)
1981	22.0	18.2	15.5	14.9	25.7	68.2	173	272	202	93.4	38.9	21.8	308	(Aug. 151	14.4	(Apr. 14)
1982	13.5	12.7	12.3	11.2	17.8	95.6	203	276	187	91.5	42.3	18.9	310	(Aug. 7)	11.0	(Apr. 9)
1983	13.0	12.2	13.5	18.4	23.4	76.2	206	276	171	76.4	41.7	25.2	294	(Aug. 141	11.5	(Feb. 10)

APPENDIX 6.2 MEAN DAILY DISCHARGE (Q) (m^3/sec) - DEZADEASH RIVER AT HAINES JUNCTION
(SOURCE: WATER SURVEY o p CANADA - 1971-1983).

STATION NO. 08AA003 60°44'54"N DRAINAGE AREA 8500 KM^2
137°30'19"W

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MAXIMUM DAILY Q	MAXIMUM DATE	MINIMUM DAILY Q	MINIMUM DATE
1953	13.2	9.71	8.9	12.5	49.5	87.5	100	71.0	66.8	50.7	35.4	21.1	133	(Jul. 16)	8.2	(Mar. 20)
1954	14.9	13.6	12.9	12.0	61.1	106	94.2	72.5	53.5	41.9	25.2	18.9	164	(Jun. 7)	11.3	(Apr. 27)
1955	17.2	15.6	15.0	15.2	40.2	102	142	87.5	59.2	41.6	21.9	14.1	184	(Jun. 26)	12.7	(Dec. 31)
1956	12.7	11.9	10.9	14.9	48.1	67.9	80.4	55.2	45.9	43.0	32.3	22.9	125	(Jun. 29)	10.5	(Mar. 24)
1957	18.2	15.4	14.3	16.2	71.0	173	124	78.1	63.4	51.8	30.3	19.6	210	(Jan. 13)	13.9	(Mar. 14)
1958	16.7	15.7	14.8	19.5	46.1	58.0	37.6	26.8	29.4	24.8	18.1	15.5	70.8	(Jun 7)	14.3	(Mar. 21)
1959	13.3	11.7	10.4	10.7	53.5	125	72.2	70.2	55.5	43.3	27.4	21.3	157	(Jun. 24)	10.2	(Mar. 30)
1960	17.8	15.2	13.4	12.5	71.3	96.5	92.8	70.8	49.5	33.9	21.0	19.2	141	(Mar. 31)	11.3	(Apr. 16)
1961	17.0	14.4	12.7	13.0	54.1	117	116	67.1	51.2	38.8	24.3	22.1	286	(Jun. 28)	11.9	(Apr. 1)
1962	17.0	12.2	9.9	9.9	35.9	170	152	95.1	64.8	51.2	38.8	26.6	275	(Jun. 21)	9.9	(Mar. 1)
1963	21.5	17.6	16.4	15.9	65.4	100	156	95.7	74.2	58.9	35.4	27.7	180	(Jul. 7)	15.9	(Apr. 1)
1964	23.5	19.8	17.5	18.5	70.2	189	109	88.0	68.8	42.5	21.9	14.6	236	(Jun. 8)	14.1	(Dec. 26)
1965	13.8	13.2	12.5	12.6	34.2	71.3	88.6	45.6	32.6	27.7	17.7	15.4	111	(Jul. 8)	12.3	(Mar. 26)
1966	11.1	9.1	10.2	15.3	26.7	111	79.2	54.6	45.6	33.1	19.4	14.9	199	(Jun. 21)	8.9	(Feb. 21)
1967	12.1	9.0	7.1	11.9	54.9	130	105	75.8	67.6	45.0	21.1	15.6	158	(Jun. 6)	6.7	(Mar. 22)
1968	14.6	14.9	14.7	19.0	72.5	77.5	101	74.4	71.6	54.1	27.7	21.3	260	(May 23)	10.2	(Feb. 1)
1969	16.4	15.8	14.4	22.7	52.6	86.0	60.3	63.4	60.5	69.3	42.2	29.4	123	(May 25)	12.7	(Mar. 17)
1970	19.3	17.0	16.3	22.7	44.7	70.5	60.2	50.7	42.5	34.8	25.5	17.2	80.9	(Jun. 17)	14.4	(Dec. 31)
1971	12.1	11.0	9.9	10.2	31.7	92.8	83.5	62.5	43.6	30.6	18.3	12.5	148	(Jun. 29)	9.2	(Mar. 31)
1972	10.5	11.7	12.3	12.8	53.8	109	84.1	76.4	49.8	35.9	20.7	15.1	190	(May 31)	9.8	(Jan. 18)
1973	13.6	12.7	11.4	13.7	33.1	66.2	77.8	66.2	52.6	36.8	17.7	14.8	119	(Jun. 21)	10.5	(Apr. 13)
1974	11.8	9.2	8.5	9.5	42.5	65.4	61.1	59.2	53.5	32.8	18.6	17.8	91.7	(Jun. 24)	7.9	(Mar. 9)
1975	15.1	11.6	8.4	10.3	50.4	-	-	99.9	116.9	77.5	23.7	22.4			7.5	(Apr. 6)
1976	19.4	19.7	20.4	18.1	41.3	116	132	67.6	41.0	38.5	30.0	26.2	182	(July 12)	15.9	(Apr. 6)
1977	22.4	21.5	22.3	28.0	31.1	102	97.6	65.7	44.4	38.2	31.4	28.2	165	(Jun. 3)	20.0	(Feb. 14)
1978	22.6	19.4	17.9	18.4	42.2	70.5	50.7	47.8	40.2	35.1	28.6	21.1	90.3	(Jun. 6)	16.4	(Apr. 11)
1979	18.7	16.1	18.4	22.3	51.1	98.4	97.4	57.6	54.9	42.3	23.3	15.3	147	(Jun. 24)	13.2	(Dec. 22)
1980	16.7	19.9	17.8	20.9	44.8	85.2	55.2	42.4	37.4	35.6	27.5	16.5	121	(Jun. 7)	12.1	(Apr. 5)
1981	15.6	15.5	15.3	17.6	55.1	61.5	54.3	44.3	46.6	45.8	30.8	22.3	86.0	(May 28)	11.4	(Feb. 16)
1982	20.2	16.6	14.9	17.9	62.1	271	62.5	57.9	40.0	34.1	21.7	17.9	700	(Jun. 8)	10.0	(Mar. 8)
1983	17.2	17.8	14.2	32.3	44.0	75.9	69.0	45.6	36.9	30.0	21.8	16.1	121	(Jun. 1)	11.6	(Mar. 29)

APPENDIX 6.3 MEAN DAILY DISCHARGE (Q) (m^3/sec) - DUKE R. NEAR THE MOUTH
SOURCE: WATER SURVEY OF CANADA - 1982-1984).

STATION NO. 09CA004 61°21'37"N
139°09'23"W DRAINAGE AREA 631 KM^2

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MAXIMUM DAILY Q	MAXIMUM DATE	MINIMUM DAILY Q	MINIMUM DATE
1981	1.0	.9	.9	1.4	13.8	8.9	16.8	14.4	5.2	3.4	2.1	1.4	34.6	(Jul. 17)	0.9	(Feb. 18)
1982	1.1	1.1	1.1	1.2	4.4	16.8	17.3	15.0	6.1	3.7	2.7	2.2	30.8	(Jun. 7)	1.0	(Feb. 25)
1983	1.6	1.4	1.3	1.2	3.2	16.1	41.1	21.0	6.5	4.0	2.6	2.0	85.2	(Jul. 19)	1.1	(Apr. 3)

APPENDIX 6.4 MEAN DAILY DISCHARGE (Q) (m^3/sec) - ALSEK RIVER ABOVE BATES RIVER
(SOURCE: WATER SURVEY OF CANADA - 1974-1983).

STATION NO. 08AB001 60°07'09"N DRAINAGE AREA 16,200 KM^2
137°58'27"W

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	MAXIMUM DAILY Q	MAXIMUM DATE	MINIMUM DAILY Q	MINIMUM DATE
1974								557	464							
1975	32.3	30.3	30.0	36.8	151	362	866	518	402	177	39.1	34.0	1129	(Jul. 13)	28.3	(Mar. 5)
1976	32.3	29.4	29.1	25.0							53.0	52.1				
1977	44.4	42.5	41.9	50.4	114	436	716	380	289	87.2	47.8	38.8	1058	(Aug. 22)	37.4	(Dec. 10
1978	32.6	28.9	26.9	41.6	118	317	543	575	251	104	54.9	45.0	784	(Aug. 3)	26.2	(Mar. 27
1979	36.9	30.6	34.5	45.5	129	375	706	585	399	171	89.7	56.7	813	(Jul. 22)	28.3	(Feb. 12
1980	38.6	30.9	27.6	37.7	130	446	637	195	205	126	61.0	38.8	702	(Jul. 23)	23.4	(Apr. -)
1981	37.1	39.3	40.3	41.3	207	361	628	529	259	191	73.5	40.1	1090	(Aug. 10)	31.0	(Dec. 31
1982	28.2	22.8	27.0	36.7	69.1	413	622	557	287	104	55.0	44.0	897	(Jul. 31)	16.9	(Feb. 12
1983	35.7	34.0	32.4	36.9	111	466			289	146	73.8	46.4			31.0	(Mar. 8)

APPENDIX 6.5 MEAN DAILY DISCHARGE (Q) (m^3/sec) -KATHLEEN RIVER NEAR HAINES JUNCTION
(SOURCE: HATER SURVEY OF CANADA - 1976).

STATION NO. 08AA004 60.35'35'N 137°13'45"W DRAINAGE AREA = 635 KM^2

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MAXIMUM AILY Q	MAXIMUM DATE	MINIMUM AILY Q	MINIMUM DATE
1959							22.0	14.3	9.45	6.8	4.8	4.3				
1960	3.5	2.8	2.5	2.1	4.8	24.4	29.2	19.7	12.1	0.1	5.6	4.5	38.5	(Jun. 30)	2.0	(Apr. 14)
1961	3.9	3.1	2.7	2.4	4.3	27.5	37.1	21.3	13.9	10.5	6.7	5.4	47.0	(Jul. 1)	2.3	(Apr. 8)
1962	4.9	3.8	3.2	2.1	3.3	28.6	37.6	19.5	10.8	11.5	0.0	6.4	54.1	(Jun. 26)	2.6	(Apr. 20)
1963	5.4	4.1	3.2	2.7	4.7	18.3	35.7	19.8	14.6	10.1	6.3	5.3	44.4	(Jul. 10)	2.5	(Apr. 24)
1964	4.5	3.8	3.3	2.8												

APPENDIX 6.6 DISCHARGE DATA - SLIMS RIVER, YUKON 1955 - 1970.

YEAR	DATE	HOUR	DISCHARGE (m^3/s)	YEAR	DATE	HOUR	DISCHARGE (m^3/s)
1955	25 Way		24.7	1970	08 July	1900	135.0
1962	27 June		181.1		08 July	2200	161.0
	09 Aug.		251.6		09 July	1400	103.3
	16 Aug.		316.9		15 July	0300	197.0
	27 Sept.		3.8		19 July	1500	107.1
1963	21 Feb.		0.2		19 July	1800	112.4
	03 July		179.1		19 July	2100	125.1
	07 Aug.		271.7		20 July	0000	131.3
1964	06 May		3.5		20 July	0300	123.5
	27 May		27.1		20 July	0900	104.3
1965	27 July	0900	96.2		30 July	1400	112.1
	27 July	1500	110.4		04 Aug.	1500	20.7
	27 July	1800	110.4		04 Aug.	1800	18.5
	28 July	0900	121.7		04 Aug.	2100	22.4
	31 July	1200	213.7		OS Aug.	0000	25.6
	08 Aug.	0000	266.0		05 Aug.	0300	24.8
	11 Aug.	0000	280.2		05 Aug.	0900	23.0
1970	30 June	1500	108.7		06 Aug.	1500	24.6
	05 July	1400	111.9		07 Aug.	1200	24.0
	05 July	1800	116.5		07 Aug.	1500	17.3
	05 July	2100	138.0		07 Aug.	2100	20.3
	06 July	0000	157.6		08 Aug.	0000	24.3
	06 July	0700	122.2		12 Aug.	1500	17.0
	06 July	1300	134.0				

Sources: Barnett 1971, Bryan 1972, Fahnestock 1963.

APPENDIX 6.7 HYDROLOGIC DATA - SLIMS RIVER, YUKON
(0700 JULY 12 - 2300 JULY 15, 1973).

DAY	TIME	DISCHARGE m^3/s	DISSOLVED CONCENTRA-TION (PPM)	SUSPENDED [I' (PPM)	MEAN GRAIN SIZE 0	PH	MEAN DEPTH (IN.)
July 12	0700	377	123	263	7.34	8.18	3.37
	1100	258	106	218	7.24	7.66	3.37
	1500	264	102	222	7.22	7.91	3.21
	1900	354	124	281	7.34	8.32	3.24
	2300	377	125	369	7.25	8.15	3.37
July 13	0300	371	117	313	6.74	8.31	3.27
	0700	329	129	208	7.88	8.26	3.35
	1100	302	117	230	6.94	8.02	3.44
	1500	314	133	198	8.61	8.12	3.24
	1900	342	132	228	7.26	8.03	3.28
	2300	364	138	245	7.37	8.20	3.40
July 14	0300	346	114	225	7.57	8.36	3.26
	0700	308	125	181	7.59	8.36	3.11
	1100	301	125	200	7.19	8.24	3.09
	1500	290	135	205	7.73	8.24	3.02
	1900	298	141	228	7.10	8.18	3.09
	2300	325	147	293	7.69	8.24	3.09
July 15	0300	313	130	268	7.86	8.21	3.05
	0700	336	139	185	7.46	8.25	2.92
	1100	262	141	191	7.34	8.29	2.86
	1500	267	118	158	8.01	8.21	2.83
	1900	269	107	189	7.20	8.15	2.84
	2300	305	119	241	7.25	8.08	2.92

[1] concentration.

Source: Nickling 1973.

Appendix 6.8 Glossary

aggrading - building up by deposition of sediments.

drift - all material moved by glaciers and by the action of meltwater streams and glacial lakes associated with them. Usage of the word originated in the early 19th century before the Glacial Theory had been developed when the Biblical Flood was invoked to explain the presence of till and erratics over extensive areas of northern Europe.

englacial - within the glacier.

erratics - glacially eroded bedrock boulders which have have been transported some distance from their source area

graben - a block of the earth's crust, usually longer than wide, bounded by faults, which has dropped relative to adjacent blocks.

glaciofluvial - pertaining to streams flowing from glaciers and the deposits and landforms made by such streams.

glaciolacustrine - deposits laid down in lakes dammed by glacier ice or formed by meltwater flowing directly from glacier ice.

interstade or interstadial - pertaining to a period of time during a glacial stage in which ice retreated temporarily.

mass wasting - the downslope movement of rock debris, either slowly or rapidly, by gravity.

nunatak - an isolated hill or peak rising above the surface of a glacier: a hill or peak surrounded by glacier ice.

paleosol - a ancient soil profile which has been buried by more recent deposits.

periglacial - in the strictest sense, refers to the area, conditions, processes, and deposits immediately surrounding a glacier or glaciated area. Yore commonly used to describe a generally cold, dry climate characterized by frequent freeze-thaw cycles which give rise to distinct surface and subsurface processes, landforms, and vegetative cover.

piedmont glaciers - glaciers occupying broad lowlands at the base of steep mountainous terrain. Each is the expanded terminus part of a valley glacier discharging from confined terrain onto an unconfined plain.

proglacial - the area immediately beyond the limits of a glacier. Refers to all landforms, deposits, and processes in front of or at the foot of a glacier.

slurry - any free-flowing fluid mixture of fine solids and water; a thin watery mud.

strandline - **a** beach raised above the present level of a waterbody, usually marking an older higher water level.

subaerial - formed, existing or taking place on the land surface exposed to the atmosphere.

subglacial - beneath the glacier.

supraglacial - on top of the glacier.

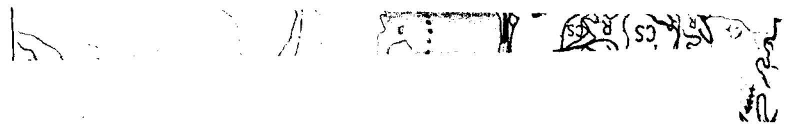
talus - coarse angular rock fragments dislodged by weathering, moved downslope by gravity, and collected at the foot of cliffs or steep slopes; also, the apron of rock or actual landform at the base of a cliff; synonymous with scree.

tillite - a sedimentary rock formed by the lithification of till.

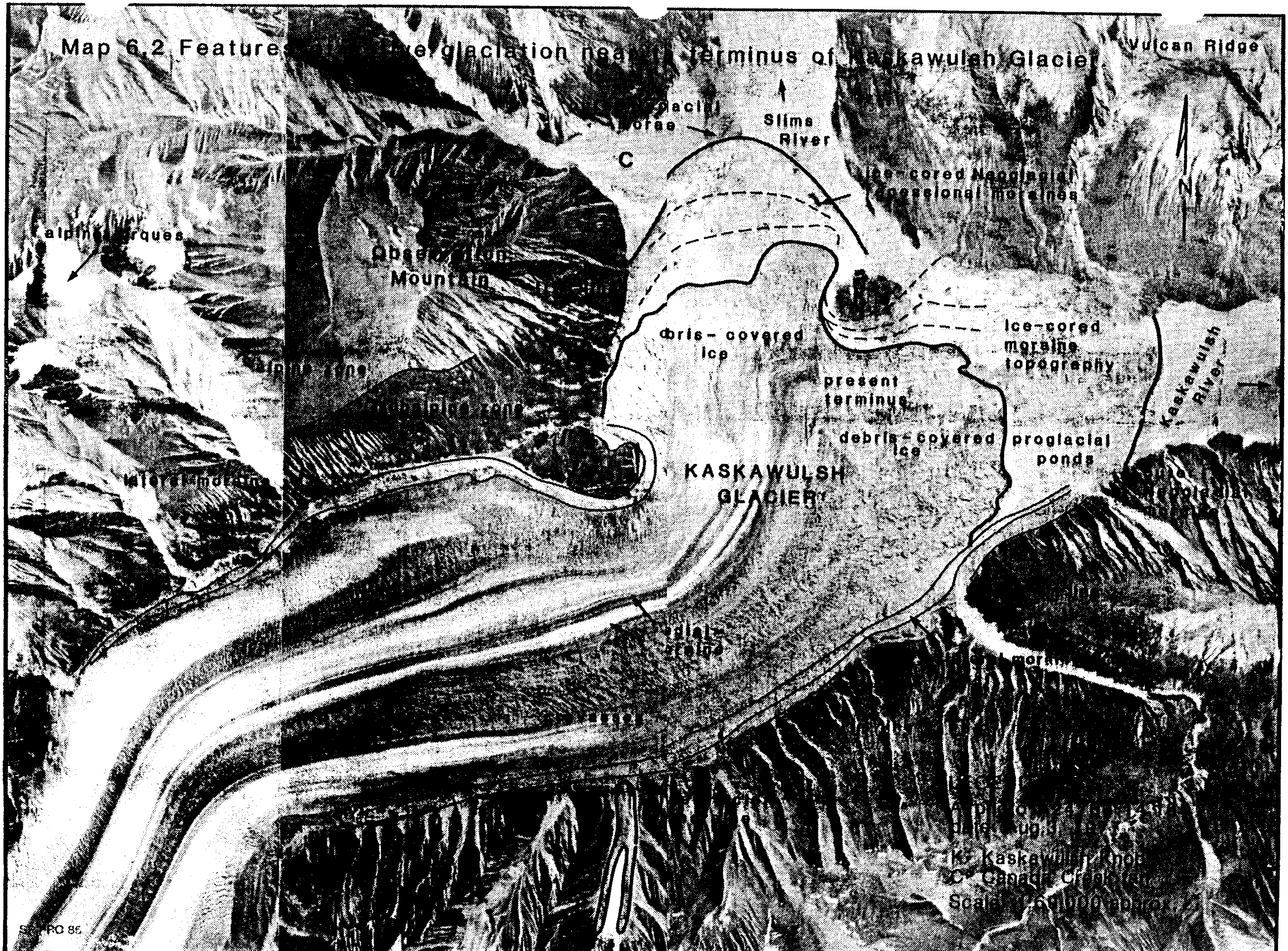
trim line - **a** line marking the maximum height of glacier ice in a valley. The valley walls below this level are denuded of vegetation and then eroded by movement of glacier ice.

unconformity - an erosional or nondepositional break in the stratigraphic sequence in which younger rocks overlie older rocks that do not immediately precede them in geological succession.

valley train - **a** long narrow body of outwash confined within and partly filling a valley, consisting mainly of stratified sand and gravel carried and deposited by meltwater streams.



Map 6.1 Landforms of Kluane National Park.


Map 6.2 Features
terminus of
Glacier
Vulcan Ridge
Slims River
C
Ice-cored Neoglacial
moraines
Observation
Mountain
debris-covered
ice
present
terminus
Ice-cored
moraine
topography
Kaskawulsh
River
debris-covered
ice
proglacial
ponds
KASKAWULSH
GLACIER
N
Scale 1:60000 approx.

KLUANE NATIONAL PARK

RESOURCE DESCRIPTION AND ANALYSIS[1]

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CHAPTER 7

Soils of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

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7.1 Introduction

The development of a soil profile and the specific characteristics of that profile result from the interaction of all elements of the local ecosystem - climate, parent material, topography and drainage, vegetation, soil organisms, and time. In Kluane, the rugged topography, youthful landscape, active geomorphic processes, and harsh climate have combined to produce a group of soils characterized by only limited profile development. Five soil orders are present - Regosols, Brunisols, Gleysols, Organic soils, and Cryosols. These have developed on a wide range of parent materials, throughout the three biogeoclimatic zones - montane, subalpine, and alpine. Regosols and Cryosols predominate in the alpine zone; Regosols in the subalpine; and Brunisols, in the montane. Gleysols are relatively uncommon because the cool temperatures limit the biological activity necessary to produce oxygen deficiency and gleying. Organic soils are frequently frozen and are classified as Organic Cryosols.

Of particular interest, is the presence within many soil profiles of a layer of volcanic ash, named the White River ash. The layer has been identified in soils from the Slims River northward and can be accurately dated. This provides temporal control for study of geomorphic and soil-forming processes since the volcanic eruption, about 1250 years ago.

A Paleosol, named the Slims Soil, is also present in some areas. It developed in a period of climatic amelioration following the end of the Wisconsin glaciation and was buried by reactivated loess deposition during the Neoglacial Period between 2600 and 3000 years ago.

7.2 Data sources and Limitations

Soil studies were first undertaken in the Kluane area during construction of the Alaska Highway (Leahey 1943), but these early initiatives ended with the end of the Second World War.

Day (1962) surveyed and mapped the soils of the Takhini and Dezadeash valleys, including unfortunately only a few square kilometres of Kluane National Park. Mapping was at a scale of 1:126,720 or 2 miles to the inch. Douglas and Knapik (1974), Knapik (in Blood 1975), and Ballard and Otchere-Boateng (in Douglas 1980) have described and mapped the soils of most of the Park area at the reconnaissance level and some areas of the Park where soils are best developed and where planning and activities requiring the information are likely to occur.

Knapik's study (Blood 1975) focussed on five corridors - the Duke, slims East and West, and Donjek valleys and the Mush-Bates lakes area, with mapping at 1:50,000. Ballard and Otchere-Boateng (in Douglas 1980) surveyed most of the Park but their field check site density was quite low; mapping again was at 1:50,000. At this scale, the smallest mappable unit is 10-20 hectares in area. Given Kluane's rugged, varied terrain, an area of 20 hectares may contain several parent material and vegetation types and, therefore, several soil types. Map units identified in the study are thus generalized to the degree that they indicate the dominant soil in an area, not the soil present at any one locality.

Ballard and Otchere-Boateng (in Douglas 1980)identified map unit boundaries from aerial photographs as specific combinations of landforms, biotic zone and vegetation type, slope, drainage class, and geological materials. Field checking and laboratory analysis of several hundred pedons resulted in confirmation and modifications of these boundaries. This material was broken down to allow description of soils by parent material type and life zone to allow an understanding of the underlying pattern of variation in soil forming processes, soil development and type. Users requiring more than this generalized level are referred to the original. studies for detailed mapping, laboratory analyses, and pedological descriptions. Site specific needs would still require further field investigation.

7.3 Soil Classification

Soil development in Kluane is extremely limited due to the relatively recent age of most of the surficial materials, the active geomorphic processes, and the harsh, arid climate which limits weathering and plant growth. Two soil orders predominate - Regosols and Brunisols.

Regosols represent the initial stages of soil development. The soil profile is very weakly expressed - just a minor accumulation of organic material in the surface A horizon over parent material. Regosols are found throughout the Park; they dominate in the subalpine and alpine zones. The order includes soils which exhibit virtually no development (e.g. Orthic Regosols on unvegetated active alluvial fans) to soils with deep Ah horizons developed under lush productive alpine meadows.

Brunisols represent the next stage in soil development with formation of a deeper soil profile and a B horizon. Brunisols develop under forest vegetation and represent the maximum stage of soil development in Kluane. They predominate in the montane zone and are particularly well developed in the Mush-Bates lakes area where the more moderate, wetter climatic conditions favour soil development. Locally, some small pockets of Podzolic soils may exist in association with well developed Brunisols but detailed surveys would be required to confirm this.

Three other soil orders are found within the Park usually in intimate association with the dominant orders. Gleysols are very poorly drained soils exhibiting a grey mottled appearance in the B and C horizons. This colour change is caused by chemical reduction of iron and other compounds and indicates saturation, oxygen deficiency, and reducing conditions in the soil for some or all of the year. Gleysols are generally found only in the montane zone, for even though poorly drained soils occur in the subalpine and alpine, the soil is generally too cold in those areas to support the biological activity necessary to cause oxygen deficiency and gleying.

Cryosols are soils containing permafrost within l-2 m of the surf ace. They occur frequently in the alpine zone, especially above 2000 m, and in the subalpine and montane zones under conditions conducive to permafrost formation (north aspects, poor drainage, fine-grained material, etc.) Chapter 4 explains these relationships in detail. Cryosols become more common in northern areas of the Park. The surface layers of Cryosols often exhibit periglacial phenomena such as solifluction, patterned ground, stone stripes, etc. These features are well developed in the upper alpine zone at the south end of the Park, and become more common at lower elevations in the Duke and Donjek Valleys. They are relatively rare in the drier central areas of the Park in the Slims and Kaskawulsh valleys. Cryosols are the dominant type in the Duke River valley on valley sides and alluvial fans. The soils are wet, with peaty surface layers and an active layer only 0.2-0.5 m thick. Organic soils occur in bogs and forested peatlands in the montane zone in Kluane. Bogs are most common in the southern areas of the Park; forested peatlands are best represented in the lower Don jek Valley. Minor organic soils occur in association with other soils throughout the Park. Most bogs and peatlands are permanently frozen, usually with an active layer of 50 cm or less. When permafrost is present, these soils are classified as Organic cryosols.

The relationships between parent material, life zone (indirectly vegetation), and soil type in Kluane are outlined in Table 7.1. Given the relatively limited variability in Kluane's soils, this approach to their description should allow general conclusions to be made about the soil types present in an area without a large scale detailed survey.

7.4 Evaluation

7.4.1 Sensitive Areas

The identification of sensitive areas and their limitations to use can be seen from two overlapping perspectives - environmental impact and engineering risk. Areas underlain by permafrost (e.g. bogs, peatlands, organic soils) and subject to thermokarst are environmentally unsuitable for any activity with the potential to

Table 7.1 General soil type distribution - Kluane National Park..

	BIOGEOCLIMATIC ZONES			
	Montane (upper limit 1100 m)	**Subalpine** (upper limit 1500 ml	**Alpine** (above 1500 m)	KEY TO SYMBOLS AND ACHRONYMS
ZONE DESCRIPTIONS	continuous Picea glauca forest, confined to lover *lop.* and valleys; marsh, fen, shrub vegetation communities • •• occur. • ctiv* • lluvi*l fans unvegetated or in early stages of succession.	- broad belt above continuous forest; dominated by tall • hrub* (4-6 m) Salix ssp.; scattered Picea glauca.	- lower alpine dominated by low (up to 1 m) Salix-Betula-heath krummholz shrub mosaic; upper • lpin. character-ized by dwarf vascular plants (alpine tundra). - solifluction and other periglacial phenomena are common on colluvial materials; fine-grained colluvium is vegetated; coarse-grained is bar.. - few plants occur above	lope Classification /P over 60% A 9-308 /S 30-60% /G 0-9% omenclature • xtr*ct* from the Canadian System of Soil Classification (CSSC) are contained in Appendix I. *Soils containing permafrost have been reclassified . . Cryosols (CSSC 1978) since the soil surveys used as sources for this table. Th. new nomenclature has been applied where possible replacing the use of the modifier Cryic.
	BIOGEOCLIMATIC ZONES			
PARENT MATERIAL	**Montane** (upper limit 1100 m)	**Subalpine** (upper limit 1500 m)	**Alpine** (above 1500 m)	SOIL PROFILE DESCRIPTIONS/COMMENTS
OLLUVIUM poorly sorted materials from boulders to clay air. derived from mass wasting processes • land slides, rock-falls, creep, soli-fluction.	**Orthic Regosols** colluvial *lop.* in th. montane are commonly /P, but many are stabilized to a greater degree than in the subalpine and therefore buried *oil horizons occur la** frequently.	**Orthic Regosols** thick Ah layers (up to 10 cm) or multiple Ah layers or Ahb layers. - Cryosols are rare. most *lop** are /P; /M slopes are rare. Gleysolic Static Cryosols* on slopewash deposits over bedrock in Duke R. area. Act iv. layer 0.2-0.5 m. whit. R. Ash present in layer 5-20 cm thick.	**Orthic Regosols** dominate with Regosolic Static Cryosols* present over 2000 m. . most occur on /S slopes some on in slopes. There are few /P collu-vial slopes as soli-fluction and mass move-ment tend to reduce *lop** angle* in the • lpin*. • some buried or truncate Ah layers due to soli-fluction e.g. Observa-tion Mt.	mappable units are gravelly to very gravelly loamy sand to sandy loon.. generally high pH. between Dezadeash R. and Sugden Ck. olivine-rich ultramafic bedrock occurs, high in available Ni and Cr. in quantities sufficient to affect plant growth. **Orthic Regosols** Ah < 10 cm B < 5 cm or absent C

Table 7.1 General soil type distribution - Kluane National Park (continued).

PARENT MATERIAL	BIOGEOCLIMATIC ZONES: Montane (upper limit 1100 m)	BIOGEOCLIMATIC ZONES: Subalpine (upper limit 1500 m)	BIOGEOCLIMATIC ZONES: Alpine (above 1500 m)	SOIL PROFILE DESCRIPTIONS/COMMENTS
ACUSTRINE deposits water-laid, usually fine-grained material Finest textures are found where water was deepest. landforms include level plains (lake bottoms), beaches, standlines, wavecut benches.	major "nits associated with Neoglacial Lake Alssk sediments in Kaskawulsh, Dusty and Alssk valleys. Lake Alsek sediments are characteristically course-textured. Most soils are very well drained Orthic Regosols Local occurrences of Rego Humic Gleysols Snd Gleyed Dystric Brunisols on finer textured material in the south areas of the Park near Alder Creek, Dezedeash Lake and Kathleen Lake. Orthic Regosols also occur on lacustrine clay, sand Snd gravel deposits in the upper Donjsk Valley where Donjek Glacier has repeatedly dammed a glacial lake.	organic soils overlying lacustrine material. Few units of mappable extent.	Orthic Regosols (peaty phases) under poorly drained conditions (Shorty Creek area). No gleying observed. Few units of mappable extent.	Rego ❑ rnlc Gleysol L,F,H, or 0 Ah $\geq$ 10 cm Cg Orthic Humic Gleysol L,F,H, or 0 Ah $\geq$ 10 cm ag $\geq$ 5 cm Cg Gleyed Dystric Brunisol L,F,H Bmgj Cg
RAINAL MATERIAL variously textured, unsorted material deposited by glaciers either while active or during melting. landforms include ground moraine, drumlins, ridges, hummocky moraine, till-covered Slopes.	Orthic Regosols are most common. Regosolic Static Cryosols* occur in the Duke & Donjek valleys, especially on north aspect.. In the southern part of the Park, Brunisols (Orthic Eutric, Sombric, Snd Dystric) occur on /G, /M, and /S slopes with some gleyed Subgroups on /G slopes. The Orthic Dystric Brunisols appear to represent maximum soil development in the Pork.	orthic Regosols are mat common. Gleyed Orthic Regosols Snd Brunisols are also found. Gleysols occur only on /G slopes snd are uncommon. Even under poor drainage conditions gleying does not occur - probably because the soil is too cold for the biological activity necessary to produce oxygen depletion Snd reducing conditions. conditions.	Orthic Regosols dominate on /G, /M, and /S slopes. Regosolic static Cryosols* are common west of the Alsek River, above 2000 m and as peaty phases at lower elevations on northfacing slopes with poor drainage. Even in non-Cryosols, melting of seasonal ice lenses may not occur until very late summer. nost Soils are shallow to bedrock and subject to solifluction. The orthic Regosols of nt. Hoge have very deep Ah layers under lush alpin meadow vegetation. organic accumulation related to low temperature and high productivity.	It is difficult to generalize About soils developed on morainal parent material as texture depends largely on the source of the glacially-scoured de tritus. Granitic source rocks usually produce gravelly to very gravelly loan Send. Fine-grained volcanics yield gravelly sandy loam, and fine-grained sedimentaries yield gravelly loams,sil ty clay loams or clay loam. Orthic Sombric Brunisols L,F,H, (pH < 5.5) Ah $\geq$ 10 cm am $\geq$ 5 cm C

Table 7.1 General soil type distribution – Kluane National Park (continued).

PARENT MATERIAL	BIOGEOCLIMATIC ZONES			SOIL PROFILE DESCRIPTIONS/COMMENTS
	Montane (upper limit 1100 m)	Subalpine (upper limit 1500 m)	Alpine (above 1500 m)	
ALLUVIUM well-sorted material deposited by river., including glacio-fluvial ordigins. landform. include fans, terraces, floodplains, eskers, kames, outwash plains in Kluane, alluvial deposit. are usually gravel, the steeper Can. are bouldery; wet notable exception is Slim. R. floodplain where sand, silt and clay predominate. vegetation is generally spars., some areas are bare. Picea associations have developed on un-disturbed areas.	Orthic Regosols most common. Brunisols on old glaciofluvial material where forest vegetation has developed – the type or parent material determines the pH of the soil end thus further classification. e.g. Esker Ck Orthic Dystric Brunisols; Dusty R. – Orthic Eutric Brunisols. On long-undisturbed forested parts of recent fans – Orthic Melanic Brunisols end Orthic Dystric Brunisols. Slopes are usually /G or /M. Slim. River flood plain end delta – Saline Orthic Regosols unique in study area. Cumulic Regosols occur on active floodplains Where deposition of alluvium is continuing. Humic Organic Cryosols* occur on some fans in Donjek Valley. Upper layer is loess and peat mixed l-5 m thick over alluvial fan deposits. Frozen below 0.5 m. Whit. R. Ash layer up to 30 cm thick, present about 60 cm below surface.	● 11uvi.1 deposits are uncommon in the sub-alpine. where they do occur, Orthic Regosols have developed, usually on /M elope.. Cumulic Regosols occur adjacent to active stream-courses.	. ● l1uvi.l deposits are uncommon in the alpine zone. where they do occur, Orthic Regosols have developed, with or Without Ah horizons, depending on age end vegetative cover. On pure gravel, Typic Folisols occur ..g. upper Burwash Ck at Amphitheatre Ht. Cumulic Regosols occur adjacent to active streamcourses.	very gravelly to gravelly loamy sands to undy low.. exceptions along low velocity reecho. of major rivers where silt predominates. only minimal soil development due to continuing deposition and recent formation. Brunisols develop under better vegetation on older, more sta-bl. deposits. Soils are generally excessively well-drained and drouyhty Dystric Brunisols (pH < 5.5) L,F,H OF Ah < 10 cm Bm ≥ 5 cm C Eutric Brunisols (pH ≥ 5.5) L,F,H Bm ≥ 5 cm C Melanic Brunisols (pH ≥ 5.5) Ah > 10 cm Bm ≥ 5 cm C Typic Folisols L,F,H R

Table 7.1 General soil type distribution - Kluane National Park (concluded).

PARENT MATERIAL	BIOGEOCLIMATIC ZONES: Montane (upper limit 1100 m)	BIOGEOCLIMATIC ZONES: Subalpine (upper limit 1500 m)	BIOGEOCLIMATIC ZONES: Alpine (above 1500 m)	SOIL PROFILE DESCRIPTIONS/COMMENTS
EOLIAN MATERIAL windblown sand or silt-sized material. silt is called loess. very well graded. landforms include dun.. in sand (in Alsek and Slims valleys) and . loess blanket cover other materials and landforms.	Brunisolic or Regosolic soils with some Cumulic Regosols where thick loess deposits occur, particularly in the Slim. valley where . Brunisolic paleosol hr. been completely burled (Slims soil). Soils have high lime content. Active lo... and sand dunes show virtually no soil development and have no vegetative cover.	same as montane. on /S sloper over bedrock, soils are subject to wind erosion, show little soil development and are droughty. vegetation limited to Artemisia - Agropyron - Juniperus communities.	same as subalpine.	the White River Ash is present in th. Ah layer of loess-based soils, particularly north and west of Slim. River.
RGANIC DEPOSITS two type. of organic deposit. are present in the Park area - sedge-moss peat usually 0.2-1.2 m thick, poorly drained with permafrost at shallow depth) and moss peat with wood fragments, 1.5 - 5 m thick, wall-drained but frozen with a high ice content. landforms include marshy, treeless bogs in low, level areas and forested peatland on sloping terrain.	most organic soils in Kluane are Organic Cryosols*. Th. most extensive area occurs in the Hush-Sates lake area where Fibric organic Cryosols pre-dominate. These soils are al.0 present in the Duke and Donjek valleys. Typic Folisols occur on vary coarse, well vegetated alluvial fans, e.g. under spruce forest on the Alder Creek fan. most organic soils are saturated throughout the year. see also ALLUVIUM, Montaine re Duke River Cryosols.	Mesic and Humic Organic Cryosols* predominate in the subalpine.	Mesic and Humic Organic Cryosols predominate but units of mappable size are rare. *Typic* Folisols were found under meadow vegetation on upper Burwash Ck.	Organic soils are classified by their degree of decomposition. Fibric soils are composed of relatively undecomposed fibrous material. Humic soils show most decomposition with few recognizable fibres. Mesic soils are intermediate.

Sources: Blood 1975, Douglas 1980, Douglas & Knapik 1974.

induce thawing. Similarly, a facility constructed in an area susceptible to thaw settlement would face an unacceptable engineering risk. Alpine and subalpine soils in Kluane tend to be thin and in many areas unstable because of steep slopes, creep, and solifluction phenomena. Loess-covered slopes are particularly sensitive. Disruption of the surf ace in these areas could accelerate mass wasting and increase susceptiblity to wind and water erosion, all environmentally unacceptable. From an engineering viewpoint, construction in these areas would be avoided if possible because of the active mass movement processes and inherent surface instability.

The difficulty of assessing soil limitation lies in defining those activities which soils can withstand without risk or damage. For example, in many alpine areas where the vegetative cover is sensitive and integral to surface stability, unchannelled hiking will cause no damage but extensive trail development may, horse trail development probably would, and facility construction certainly would. The problem cannot be assessed at the general. level as each situation is unique and requires individual consideration.

In his study of five potential development corridors in Kluane, Knapik (in Blood 1975) discussed the soil related limitations in several areas. The Duke River valley has extensive areas of peat-covered wet permafrost soils which would be subject to thermokarst if disturbed and caused to thaw. Deeper frozen organic soils also occur in the Mush-Bates area and have similar limitations. In the Goatherd Mountain area, alpine and subalpine soils on steep slopes are quite sensitive because of extensive frost action and peri-glacial mass movement. Here, soils are also quite shallow to bedrock presenting an erosion risk if disturbed. Soils developed on alpine and subalpine slopewash and loess deposits in the Observation Mountain and Vulcan Ridge areas have high erosion potential and exhibit creep and solifluction phenomena, making them unsuitable for many uses. Permafrost is present along the east slims River valley where organics have accumulated in poorly drained areas. The Donjek River valley also has extensive permafrost.

In areas not subject to the limitations discussed above, Table 7.2 can provide general guidelines for the assessment of site suitability for Park use projects.

7.4.2 Features of Scientific and Interpretive Interest

The presence within many soil profiles of the White River Ash provides an important datum for the study of soil-forming processes in Kluane and for correlation of events in the Park with other areas. The ash was deposited throughout southwest Yukon and eastern Alaska about 1250 years ago during an eruption from a vent under the Klutlan Glacier in eastern Alaska (Lerbekmo and Campbell 1969, 1975).

Table 7.2 Soil limitations for development and use Kluane National Park .

	NATURE AND DEGREE OF LIMITATIONS											
	Roads and Parking Lots			Buildings			Campground and Picnic Areas			Paths and Trails		
Parameters	None to Slight	Moderate	Severe	None to Slight	Moderate	Severe	None to Slight	Moderate	Severe	None to Slight	Moderate	Severe
Soil Texture	sand	Clay loam, sand clay loam, silty clay loam, loamy sand	Organic soils, fine clay	Sand	Clay loam, sandy loam, ● ilty clay loam, loamy sand	Organic soils, fin* clay soils	Sandy loam fine sandy loam, silty loam, very fine randy loam	Clay loam sandy clay loam, silty clay loam, loamy sand, sand other than loose sand	Loose sand subject to blowing organic soils	Sandy loam fine sandy loam, silty loam, loamy sand	Clay loam, sandy clay loam silty clay loam, loamy sand	Sandy clay silty clay clay, sand organic soils
Soil Drainage	Rapidly well and moderately well drained	Imperfectly drained	Poorly and vary poorly drained water-logged conditions	With Basement rapidly well drained Without Basement rapidly well and moderately well drained	 Moderately well drained ● aaaonally water-logged imperfectly drained	 Water-logged, and very poorly drained poorly and very poorly drained	Rapidly well and moderately well drained	Moderately wall and imperfectly drained	Poorly and very poorly, drained, water-logged conditions	Rapidly well and moderately well drained	Moderately wall to imperfectly drained	Poorland very poorly drained waterlogge conditions
Slope	0-9%	5-15%	15-30%	0-9%	9-15%	15-30%	0-9%	9-15%	15-30%	0-15%	15-20%	251 +
Flood Hazard	None	Once In 5 years	More than once in 5 years, identified hazard zone	Non.	None	Occasional to frequent, identified hazard zone	None during season of use	May flood 1 or 2 times for short periods during season of use	Floods more than 2 times during season of use	None during season of use	1-2 times for short period during seasons of use	More than 2 times during season of use, identified hazard zone
Stoniness	stone 1.5 m apart	stone .6-1.5 m apart	Stones .6 m apart	stones [illegible] apart	Stones 1.5-7.5 m apart	stones 1.5 m apart	campgrounds stones 1.5 m apart Picnic Sites stones 7.5 m apart	 Stones .6-1.5 m apart Stones 7.5-1.5 m apart	 Stones .6 m apart Stones 1.5 m apart	stones 1.5 m apart	Stones 7.5-1.5 m apart	stones 1.5 m apart
Depth to water Table				With Basement Below 1.5m Without Without Basement Below .75m	 [illegible] .75m Below .5m	 Above .75 m Above .5 m						
Percent Coarse Fragments							0-20%	20-50%	508	0-20%	20-50%	50%

Another unusual feature is the occurrence of a buried well-developed brunisolic soil profile or paleosol, particularly well represented in the Slims River valley and near the Donjek Glacier in Donjek Valley. This profile, called the Slims Soil, developed during the period of climatic amelioration following the Wisconsin Glaciation. During this period, glacier retreat was at a maximrm (the Kaskawulsh Glacier retreated over 20 km upvalley from its present position), loess deposition stopped, and conditions favoured weathering and soil development on the upper 30-40 cm of existing loess deposits. During the Neoglacial Period, about 2600-3000 years ago, the glaciers readvanced, and loess deposition began again, over many years burying the former soil profile. The slims Soil occurs throughout the Kluane Lake area below 1370 m asl. On the west side of the Kaskawulsh Glacier it extends as a continuous zone to 13 km upglacier from the present terminus and discontinuously to 22 km above the terminus (Denton & Stuiver 1967). The paleosol is particularly well exposed in a roadcut along Sheep Creek. This layer provides another datum for the study of the chronology of events in the Park area.

The saline Regosols formed on the fine-grained deposits of the Slims River Delta are unique in the Park. During high flow periods, the water table in the Delta rises and brings soluble salts near to the surface where evaporation leaves a white residue or crust when flows decline. The extremely saline soil environment. has resulted in colonization of the Delta by an unusual assemblage of salt-tolerant plants. Training of the Slims River under the bridge on the Alaska Highway causeway has given a degree of permanence to these delta deposits which would not occur naturally and has allowed vegetation and soil to develop to a much greater extent.

The vegetation developed on ultramafic bedrock near Sugden Creek offers another opportunity for interpretation of the factors influencing vegetation patterns.

Douglas (1980) suggests the Spring Creek-Donjek Glacier divide area as an opportunity to interpret the relation between vegetation, altitude, aspect, soil development and permafrost along transects through the alpine and subalpine zones. Such a transect could include:

a) unvegetated upper alpine soils with permafrost and periglacial features;

b) vegetated middle alpine soils with permafrost and periglacial features;

c) vegetated low alpine and subalpine soils without permafrost; and

d) soils on north aspects (often under forest vegetation) with permafrost.

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APPENDIX

7.1 The Canadian System of Soil Classification

1978

Nomenclature

Source : Canada, Dept. of Agr. (1978).

A Glossary

Brunisols - soils with brownish-coloured textural B horizons formed in cold to temperate climates under a variety of vegetation types.

Cryosols - soils containing permafrost within l-2 m of the surface. cryoturbation of the surface layers is common.

Gleysols - soils saturated with water, formed under reducing conditions for all or part of the year. Gleysols have a grey mottled appearance and are commonly found on flat or depressional topography.

Organic soils - soils developed primarily from organic material (containing 30% or more of organic matter by weight); often saturated for most of the year.

Regosols - soils with horizon development lacking or too weak to meet the requirements of any other soil order.

Paleosol - an ancient soil. A soil profile developed on a now-buried land surface, usually developed during interglacial periods and covered by later deposits of a variety of origins.

B Nomenclature

Mineral Horizons and Layers

Mineral horizons contain 17% or less organic carbon (about 30% organic matter) by weight.

A -- a mineral horizon formed at or near the surface in the zone of leaching or eluviation of materials in solution or suspension, or of maximum in situ accumulation of organic matter or both. The accumulation of orgainic matter is usually expressed morphologically by a darkening of the surface soil (Ah).

B -- a mineral horizon characterized by enrichment in organic matter, sesquioxides, or clay; or by the development of soil structure; or by a change of colour denoting hydrolysis, reduction, or oxidation. The accumulation in B horizons of organic matter (Bh) is evidenced usually by dark colours relative to the C horizon. Clay accumulation is indicated by finer soil textures and by clay cutans coating peds and lining pores (Bt). Soil structure developed in B horizons includes prismatic or columnar units with coatings or stainings and significant amounts of exchangeable sodium (Bn) and other changes of structure (Bm) from that of the parent material. Colour changes include relatively uniform browning due to oxidation of iron (Bm), and mottling and gleying of structurally altered material associated with periodic reduction (Bg).

C -- a mineral horizon comparatively unaffected by the pedogenic processes operative in A and B, (C), except the process of gleying (Cg), and the accumulation of calcium and magnesium carbonates (Cca) and more soluble salts (Cs, Csa). Marl, diatomaceous earth, and rock no harder than 3 on Mohs' scale are considered to be C horizons.

R -- a consolidated bedrock layer that is too hard to break with the hands (3 on Mohs' scale) or to dig with a spade when moist and does not meet the requirements of C horizon. The boundary between the R layer and any overlying unconsolidated material is called a lithic contact.

W -- a layer of water in Gleysolic, Organic, or Cryosolic soils. Hydric layers in Organic soils are a kind of W layer.

Lower case suffixes

g -- a horizon characterized by gray colours, or prominent mottling, or both, indicative of permanent or periodic intense reduction, used with A, B, or C.

h -- a horizon enriched with organic matter. It is used with A alone (Ah), or with A and e (Ahe), or with B alone (Bh).

j -- used as a modifer of suffixes e, q, n, and t to denote an expression of, but failure to meet, the specified limits of the suffix it modifies. It must be placed to the right and adjacent to the suffix it modifies. For example, Bgj means a B horizon with a weak expression of gleying.

m -- a mineral horizon slightly altered by hydrolysis, oxidation, or solution, or all three to give a change in colour or structure, or both. It has:

1. Evidence of alteration in one of the following forms:

   a. Higher chromas and redder hues than the underlying horizons.
   b. Removal of carbonates either partially (Bmk) or completely (Bm).
   c. A change in structure from that of the original material.

2. Illuviation, if evident, too slight to meet the requirements of a Bt or podzolic B.

3. Some weatherable minerals.

4. No cementation or induration and lacks a brittle consistence when moist. This suffix can be used as Bm, Bmgj, Bmk, and Bms.

s -- **a mineral** horizon with salts, including gypsum, which may be detected as crystals or veins, as surface crusts of salt crystals, by depressed crop growth, or by the presence of salt-tolerant plants. It is commonly used with C and k (Csk), but can be used with **any** horizon **or** combination of horizon and lowercase suffix.

z -- a frozen layer. It may be used with any horizon or layer, e.g. OHz, Bmz, Cz, Wz.

Organic Horizons

Organic horizons are found in Organic soils and commonly at the surface of mineral soils. They may occur at any depth beneath the surface in buried soils or overlying geologic deposits. They contain more than 17% organic C (approximately 30% organic matter) by weight. Two groups of these horizons are recognized, the O horizons and L, F, and H horizons.

O -- an organic horizon developed mainly from mosses, rushes, and woody materials. It is divided into the following sub-horizons.

Of -- an O horizon consisting largely of fibric materials that are readily identifiable as to botanical origin.

Om -- **an** O horizon consisting of **mesic** material, which is at a **stage** of decomposition intermediate between fibric and humic materials. The material is partly altered both physically and biochemically. It does not meet the requirements of either **a** fibric or **a** humic horizon.

Oh -- an O horizon consisting of humic material, which is at an **advanced stage** of decomposition. The horizon has the lowest amount of fiber, the highest bulk density, and the lowest saturated water-holding capacity of the O horizons. It is very stable and changes very little physically or chemically with time unless it is drained.

Oco -- is coprogenous earth, limnic material which occurs in some **Organic soils**. It is deposited in **water** by aquatic organisms such as algae or derived from underwater and floating aquatic plants subsequently modified by aquatic animals.

L,F, and H -- These are organic horizons that developed primarily from the **accumulation** of leaves, twigs **and** woody materials with or without a minor component of **mosses**. Usually they are not saturated with **water for prolonged** periods.

L -- an organic horizon that is characterized by an accumulation of organic matter derived mainly from leaves, twigs, and woody materials in which the original structures are easily discernible.

F -- an organic horizon that is characterized by an accumulation of partly decomposed organic matter derived mainly from leaves twigs, and woody materials. Some of the original structures are difficult to recognize. The material may be partly comminuted by soil fauna as in moder, or it may be a partly decomposed mat permeated by fungal hyphae as in mor.

H -- an organic horizon that is characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. This horizon differs from the F by having greater humification due chiefly to the action of organisms. It is frequently intermixed with mineral grains, especially near the junction with a mineral horizon.

CHAPTER8

Vegetation of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

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8.1 Introduction

The flora and vegetation patterns in Kluane National Park are an expression of the influence of all abiotic elements in the landscape on regional to microtopographic scales. Climate, geomorphology, geology, and topography all act together to produce environments suitable for the growth of various plants and the pattern of vegetation type distribution that develops is a reflection of the site-specific interrelation of these elements.

Kluane's landscape is young, having emerged from the Wisconsin glaciation in only the last 10,000 years. The soil and vegetation patterns reflect this short development period.

Active geomorphic processes are preserving the youthful landscape by constantly changing the land surface, creating new habitats, altering or destroying existing ones, and producing corresponding changes in the vegetation patterns. These changes are manifest in disruptions to expected natural patterns of succession, so that communities vary markedly in age, composition and structure.

Regional climatic changes significant enough to influence the vegetation pattern occur from north to south through the Park. The southern areas of the Park have a more maritime climate with significantly more precipitation (both snow and rain), more moderate temperatures and cloudier skies. Towards the north, the climate is colder and drier in all seasons, permafrost is more common, and glaciers are a more prominent part of the landscape. These climatic variations have produced regional phases of essentially similar vegetation communities from south to central to northern areas of the Park. Figure 8.1 shows the regional divisions identified by Douglas (1980).

The varied and mountainous topography of the area causes rapid changes in microclimate due to elevation over short horizontal distances and has produced a discernible vertical zonation of vegetation types. Three life zones have been identified - montane, subalpine, and alpine. All have distinct microclimatic regimes and distinct plant associations and communities. within each life zone further variation occurs with changes in microclimatic factors such as slope angle, aspect, moisture availability, wind exposure, and soil parent material. The alpine and to some extent the subalpine zones are dominated by plants which have adapted in both physical and genetic ways to the harsher conditions in these areas. These adaptations include a prostrate growth mode to protect the plant from desiccating winds, tolerance of frost during the growth cycle, the ability to reproduce successfully in a very short growing season, rapid root growth to ensure stability on steep slopes subject to mass movement, and the ability to exploit shallow, cold, wet soils and snowbank habitats in an essentially arid environment. In Kluane, over 200 plant species have successfully adapted to the alpine zone and many survive under the harshest conditions on nunataks in the midst of the Icefields.

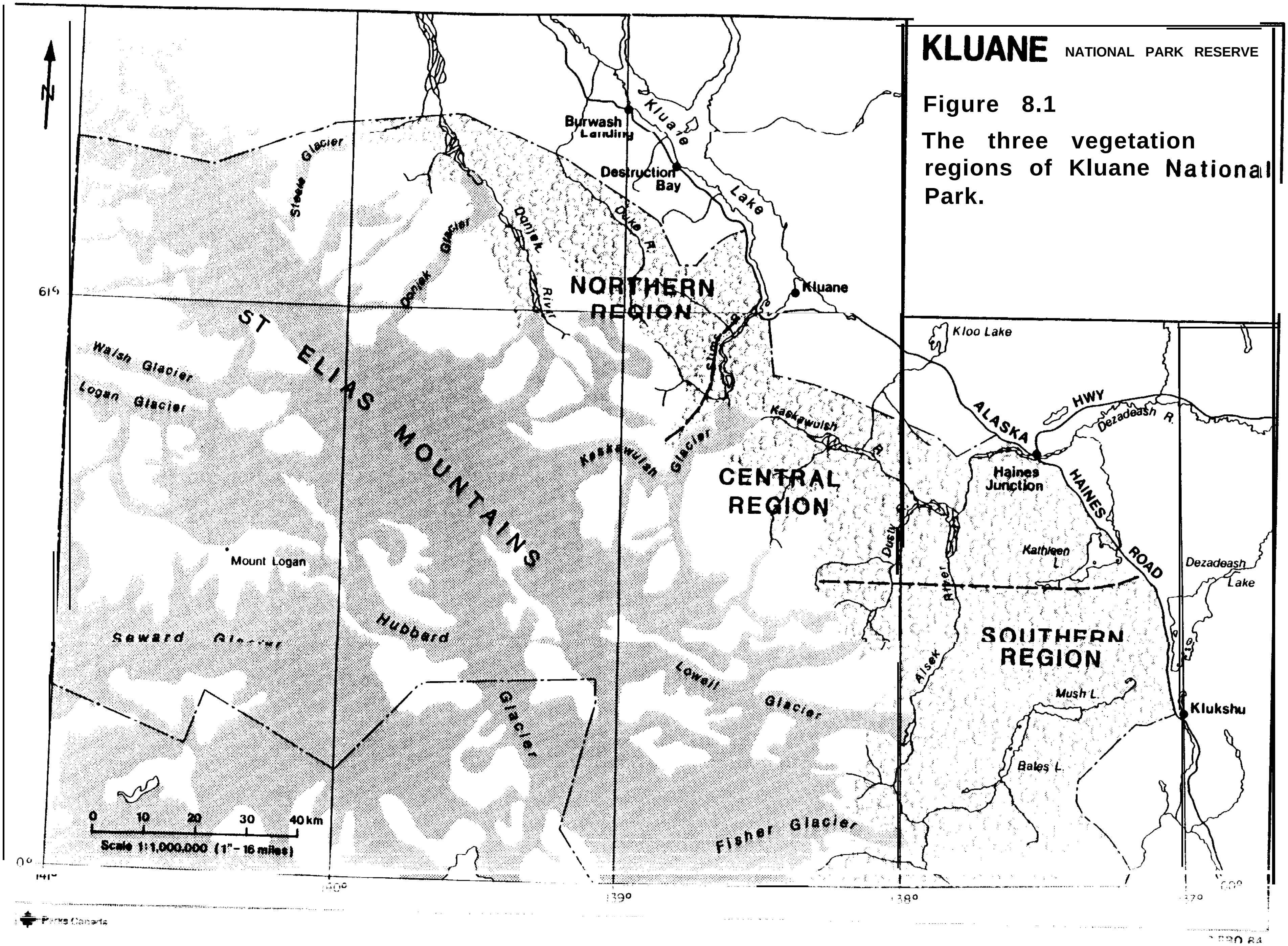

Figure 8.1

The three vegetation regions of Kluane National Park.

Fire is a major factor influencing the vegetation pattern in Kluane and is being in part responsible for the mosaic of plant communities. Section 8.10 examines these effects more fully.

The description of Kluane's vegetation that follows is presented by life zone. Within each zone, the dominant flora are discussed by stratum - overstory, intermediate tree, sapling, tall shrub, low shrub and herb, and cryptogams (mosses, lichens).

Biogeographic origins of the flora of Kluane are complex, diverse, and unexplained. Plants with affinities to the boreal forest, cordillera, northern prairies, Arctic, Eurasian mountain and steppe environments, as well as Yukon-Alaska endemics are present. Many species are rare, present in Kluane as distant outliers far beyond their expected ranges. Section 8.9 discusses the rare plants of Kluane and their origins more fully. Particularly striking is the unexplained absence from the Park of certain species which occur in surrounding areas. These species include Picea mariana (black spruce) and Larix laricina (tamarack). This list of absentees was thought to include Betula papyrifera (paper birch) and Pinus contorta (lodgepole pine) but during Douglas' (1980) fieldwork several specimens were located by Park personnel.

8.2 Data Sources and Limitations

Many of the early explorers in the southwest Yukon made plant collections in the course of their other activities. Hoefs et al (1975) describe these early investigations fully. Comprehensive studies were not undertaken until accessibility was improved with construction of the Alaska Highway. Since that time numerous publications on the vascular flora of Kluane have appeared, some conducted as private or government-sponsored scientific work and others in association with the Icefields Ranges Research Project (Hulten 1941-50, 1967, Bakewell 1943, Love and Freedman 1956, Porsild 1951, 1966, Johnson & Raup 1964, Murray 1968, 1971 a, b, Neilson 1968, Argus 1973, Douglas 1974 a, b, 1978, 1980, Douglas and Ruyle-Douglas 1978, Douglas et al 1981). Study and documentation of the mosses, lichens, and fungi of the area has only begun recently (Miller 1968, 1969, Miller and Gilbertson 1969, Watling and Miller 1971, Hoefs and Thomson 1972, Miller et al 1973, Douglas and Vitt 1976). Hoefs et al (1975) undertook a very detailed study of the vegetation of Sheep Mountain in connection with studies of the Dall's sheep population of the area and produced a map of plant communities in the area at 1:125,000. In 1983, the Kluane Warden Service produced a detailed map of vegetation along the proposed route of the Slims Valley Access Road. Hawkes (1983) investigated the history of fire in Kluane and its role in natural succession. All fires between 1880-1940 in the study area have been mapped and the report contains excellent photographs of forest stand and successional types.

The material contained in this chapter is derived mainly from the Biophysical Inventory of Kluane National Park (Douglas 1980). During this study a carefully designed quantitative soil and botanical sampling program was undertaken over most of the Park area. In total 1570 stands or specific examples of vegetation communities were sampled: sample stands were selected by recognition of relatively homogeneous populations of general combinations of species throughout the region. Vegetation communities refer to groupings of similar stands. Community type names were derived from dominant species in one or more strata. Sampling was limited in rare communities and was more frequent in widespread and variable communities.

Quantitative data were collected from each stand by use of standard methods described in Douglas (1980) and coverted to measures of prominence, percent cover, frequency, and constancy for each species recorded. This approach facilitated the analysis of data for subsequent vegetation type mapping (a prime objective of the study). Maps of vegetation type were prepared at 1:50,000 for the greenbelt areas of the Park with overlays of the locations of rare or unique plants and plant communities.

The biophysical integration of landform, soil and botanical information was done by smaller scale mapping of the entire Park area at 1:1,000,000 on a land region basis on satellite imagery and by land system at 1:250,000 on an uncontrolled vertical air photo mosaic. Units were recognized by recurring landform patterns and associated vegetation and soil types.

From an ecological land classification view this information was less useful than it might have been because of physical difficulties with the photomosaic, lack of community differentiation within the subalpine and alpine zones, and failure of the study to integrate wildlife habitat information into the analysis. The vegetation classification information is however, of great value and is summarized in the following sections.

Appendix 8.1 contains a comprehensive list of the vascular plant species of Kluane National Park. This was compiled in the summer of 1984 from existing data sources as described in the footnotes to the table. Considerable effort was made to standardize nomenclature. Documented occurrences are mapped on Figure 8.2. Mosses and lichens of the Kluane area are listed in Appendices 8.2 and 8.3. The taxonomy of vascular plants is continually undergoing revision, and the species lists are only current to the date of their compilation. References and material derived from older publications may contain scientific names no longer in use.

8-3 Vegetation Zonation

Recognition of the influence of altitude and associated microclimatic factors on vegetation distribution led, many years

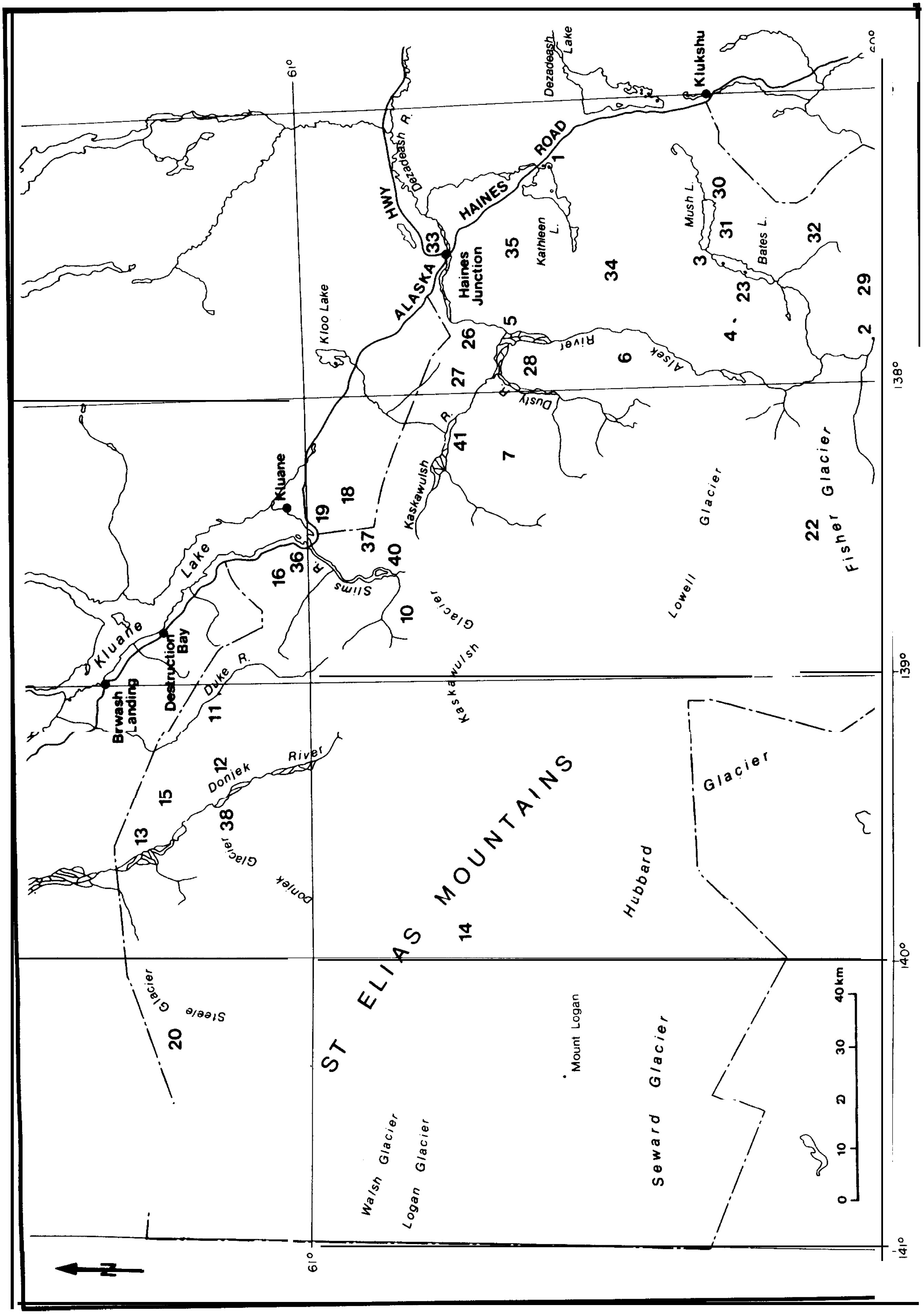
Dezadeash Lake
Klukshu
Dezadeash R.
ALASKA HWY
HAINES ROAD
Haines Junction
Kathleen L.
Mush L.
Bates L.
Kloo Lake
Alsek River
Dusty R.
Kaskawulsh R.
Kluane
Kluane Lake
Destruction Bay
Brwash Landing
Slims R.
Duke R.
Donjek River
Donjek Glacier
Kaskawulsh Glacier
Lowell Glacier
Fisher Glacier
Hubbard Glacier
ST ELIAS MOUNTAINS
Steele Glacier
Mount Logan
Seward Glacier
Walsh Glacier
Logan Glacier
1 2 3 4 5 6 7 10 11 12 13 14 15 16 18 19 20 22 23 26 27 28 29 30 31 32 33 34 35 36 37 38 40 41
61°
138°
139°
140°
141°
0 10 20 30 40km
N

Figure 8.2 Documented occurrences of vascular plant species, Kluane National Park.

1. Kathleen Lake campground
2. Lower Alsek River
3. Small pond between Mush and Bates lakes
4. Goatherd Mtn. (bottom of ephemeral lake bed)
5. Junction of Kaskawulsh and Dezadeash rivers
6. Marble Creek
7. Chalcedony Mountain
8. Guerin Glacier (60°37'N 141°05'W)
9. Sheep Glacier (60°42'N 141°39'W)
10. Observation Mountain (60°48'N 138°43'W)
11. Duke River headwaters
12. Bighorn Creek
13. Hoge Creek
14. St. Elias Mountain-general area
15. Hoge Mountain
16. Sheep-Bullion creeks plateau
17. Rainbow Mountain (60°68'N 145°37'W)
18. Outpost Mountain (60°56'N 138°22'W)
19. South end of Kluane Lake (61°01'N 138°38'W)
20. Steele Glacier-general area
21. Russel Glacier terminus
22. Fisher Glacier area
23. Bates Lake
24. Wade Mountain
25. Kathleen Lake
26. Lower Detadeash River
27. Sugden Creek
28. Profile Mountain
29. Onion Lake
30. Mush Lake
31. Mush Creek
32. Wolverine Creek
33. Mile 1022 Alaska Hwy.
34. Cottonwood Creek Headwaters
38. Auriol Range
36. Sheep Mountain
37. Vulcan Mountain
38. Donjek Creek
39. Jarvis River
40. Slims River Delta
41. Kaskawulsh River

ago, to the development of a system of vegetation zone classification (Merriam 18981. Numerous other systems have evolved to the confusion of all since that time. The system used here is that of Douglas (1971, 1972, 1973). Three biogeoclimatic zones have been identified - montane, subalpine, and alpine.

In Kluane, only 18% of the total Park area is vegetated. The montane zone makes up 7% of this total and comprises the valleys and lower slopes up to about 1080 or 1100 m. The zone is dominated by nearly continuous Picea glauca forest, interspersed with marsh, fen, and shrub and herb community types.

The broad subalpine zone lies above the montane from approximately 1080 m to 1370-1400 m. It is dominated mainly by tall shrubs 3-4 m in height (primarily willow). Individual Picea glauca specimens are scattered throughout the zone.

The alpine zone occurs above 1400 m and is divided into lower and upper parts, dominated by a low krummholtz shrub mosaic, and by dwarfed vascular plants or alpine tundra, respectively.

These zones are readily identified at an overview scale but at any one site a zone boundary may be higher or lower depending on site specific microclimatic factors. Generally, the respective zones occur at lower elevations on north-facing slopes and at higher elevations on south-facing slopes. As well, the boundaries are never distinct lines of demarcation but rather areas within which plants from both adjoining zones mix.

8.4 Montane zone Vegetation

The vegetation of the montane zone in Kluane is quite diverse for an essentially boreal forest area. Besides extensive coniferous and deciduous forest communities, the area includes shrub-dominated communities and bogs and fens. This diversity is in part due to the disturbance of vegetation succession by active geomorphological processes, the presence of poorly drained areas and permafrost, and the influence of fire. The following descriptions of community types are greatly generalized. The reader is referred to Douglas (1980) for more detailed information.

8.4.1 Forest C[redacted]ties

Douglas (1980) recognized 18 forest community types (including regional phases) in Kluane. Ten of these are coniferous, dominated solely by Picea glauca and as a group are the most extensive forest cover type in Kluane. Picea glauca associations are the climax type in the area. The ten types are distinguished by composition and structural differences in response to site factors such as drainage, parent material, and aspect. These communities are described in Table 8.1 Nos. l-10.

Picea glauca communities may be pure white spruce in the tree stratum with either closed or open canopies and different associated shrub and herb undergrowth. The open canopy types tend to occur on drier, better-drained sites and on aeolian parent materials. Picea glauca/Shepherdia (open) occupies the driest sites. The closed canopy phases (such as P. glauca/Salix glauca and P. glauca/ shepherdia (closed) occur on the more mesic sites and usually have a continuous moss and lichen cover, while this stratum is sparse or absent in the open phases.

The wettest forest sites in the Alsek Valley are occupied by the P. glauca - Betula glandulosa - Empetrum nigrum community, occurring only on north and east-facing slopes.

In the northern region, two Picea-dominated communites (P. glauca/ Thuidium abietinum and P. glauca/Aulacomnium palustre) occur on cold, poorly-drained sites underlain by permafrost.

A mixed forest community of P. glauca and Populus tremuloides (Table 8.1 No. 11) occurs as a sub-climax type in the southern region, possibly originating with Picea invasion of the P. tremuloides - Acrostaphylos community after fire. Along the Haines Road these stands are 100-130 years old and studies indicate that they may persist for a considerable time before giving way to the climax P. glauca/Shepherdia community (Douglas 1980).

As well, there are 7 deciduous forest types in the Park, dominated by either Populus tremuloides, P. balsamifera, or Salix scouleriana. These are described m&e fully in Table 8.1 Nos. 12-18. Many of these communities are seral or successional to other types and many have originated after fire. The P. balsamifera communities occur most commonly on coarse, well-drained alluvial gravels.

8.4.2 Bog and Fen Communities

Three bog and fen community types were recognized in Kluane, all occurring in poorly drained, low-lying areas in the central and southern regions of the Park. The fen community (described in Table 8.2 No.1) is characterized by organic or gleysolic soils with relatively high pH (5.8-6.3), high levels of calcium and magnesium, and dominance by aquatic and semi-aquatic sedges. The bog communities (Table 8.2 Nos. 2, 3) have lower pH (less than 5.41, a predominance of Sphagnum in the cryptogamic stratum, and again organic or gleysolic soils. Rampton (1981) indicates that most organic soils in Kluane are underlain by permafrost.

8.4.3 Shrub and Herb Communities

8.4.3.1 General

Douglas (1980) identified 34 montane shrub and herb community types in Kluane. Many are pioneer or seral types which are successional

Table 8.1 Montane forest community types - Kluane National Park.

:ommunity Name (region)[1]	Common Name	Average No. of Species[2]	Dominant Flora: Overstory/Tall Shrubs	Dominant Flora: Low Shrubs & Herb/Cryoptogam	Soils, Drainage, Topography	Comments
.Picea glauca/ Cladina arbuscula (southern region)	hite spruce/ eindeer lichen oniferous forest.	J-11 B-2 L-5 rota1 = 26	icea glauca open verstory/sparse tall hrub stratum of Saliw lauca.	estuca altaica/continuous rypotgamic stratum with ladina arbuscula, tereocaulon sp. dominant	. occurs only on dry, well-drained lacustrine sand and gravel at northeast end of Bates bake. . soils = orthic regosola	climax type
.Picea glauca/ Betula glandulosa/ Empetrum nigrum (all areas)	hite spruce/ hrub birch/ rowberry coniferous forest.	w-15 B-4 L-5 rota1 = 78	icea glauca relatively closed canopy/ lense tall shrub stratum of Betula landulosa and Salix lauca.	mpetrum nigrum abundant/continuous cryptogamic stratum ominated by Pleurozium chreberi, Hylocomium plendens.	restricted occurrence on moist to mesic, poor to moderately drained glacial till on N or E aspects. soils = orthic regosols, orthic eutric brunisols, orthic dystric brunisols	climax type stands 150-200 yrs. old, 50% show a recent fire history
.Picea glauca/ Salix glauca (central and southern phase)	hite spruce/ rayleaf willow/ oniferous forest.	V-14 B-3 L-3 rota 1 = 11c	icea glauca open tree tratum/dense tall hrub Salix glauca, . barclayi, Betula landulosa, Shepherdia anadensis in tall hrub stratum.	aried low shrub & herb/ rypotogamic stratum dominate y Drepanocladus uncinatus, ylocomium splendens.	poorly to well-drained moist to mesic glacial till, alluvial and lacustrine gravel soils - orthic regosols, orthic eutric brunisols, orthic dystric brunisols	one of the most extensive community types in Kluane especially common in the south stands are 130-160 yrs. old no previous fire history climax type

Table 8.1 **Montane** forest **community** types - **Kluane** National Park **(Continued).**

:ommunity Name (region)'	Common Name	Average No. of Species;[2]	Dominant Flora:)verstory/Tall Shrubs	Dominant Flora: Low Shrubs & Herb/Cryoptogam:	Soils, Drainage, Topography	Comments
.*Picea glauca/ Shepherdia canadensis* (closed phase (central and southern regions)	ihite spruce/ ouffaloberry :losed coniferou: :orest.	/-14 3-4 ,-5 rota1 • 12	*Picea glauca* closed :ree stratum/ *Shepherdia canadensis* infrequently *Salix alaxensis, S. barclay* ;. *glauca*.	rich though sparse stratum *Lupinus arcticus*, also *Comandra livida, Linnaea borealis*/continuous mat of bryophytes and lichens *Hylocomium splendene, Drepanocladus uncinatus* predominate. *Hypnum revolutum* dominates on driest sites.	. well drained, mesic to moderately dry glacial till and alluvial and lacustrine gravel . soils are orthic regosols, orthic eutric brunisols, orthic dystric brunisols	• occurs alony the Haines Road and in the Dezadeaeh and Alsek valleys • stands are 90-220 yrs. old; half show fire history . succeeds (5)
.*Picea ylauca/ Shepherdia canadensis* (open phase) (central & southern regions)	/hite spruce/ ouffaloberry open coniferous :orest	r-21 l-3 ,-3 'otal • 67	. open *Picea glauca/ Shepherdia canadensie* and *Sali ylauca* are prominan tall shrubs • abundant *Populus balsamifera* sapling but these seldom achieve tree stature.	*Arctostaphylos uva-ursi, Juniperus communis*/sparse xerophytic cryptogam stratum, *Port&a norvegica, Ditrichum flexicaule* predominate.	dry, well-drained glacial till, alluvial & lacustrine gravels, and aeolian parent material	. most frequent on driest sites along Haines Road in the Deradeash and Alsek valleys stands are 85-135 yrs. old; all have originated after fire, except those on Lake Alsek beach ridges.
.*Picea glauca/ Arctostaphylo:* (central region)	'hite spruce/ iearberry :oniferous forest	'-12 l-4 ,-1 'otal - 28	closed *Picea glauca, Salix glauca*	*Rrctostaphylos uva-ursi, A. rubra* are prominent low shrubs/moderate cryptoyam cover, *Thuidium abietinum, Catoscopium niyritum* are prominent. Epiphytes are rare or absent because of aridity and heavy loess fall.	mesic to dry, well-drained glacial till and loess	common along east side of Slims R. Valley stands are 200-240 yrs. old.

Table 8.1 Montane forest community types - Kluane National Park. (Continued).

:ommunity Name (region)'	Common Name	Average No. of Species[2]	Dominant Flora		Soils, Drainage, Topography	Comments
			Overstory/Tall Shrubs	Low Shrubs & Herb/Cryoptogam:		
'.Picea glauca/ Hypnum revolutum (central region)	hite spruce/ ypnum moss oniferous forest	-7 -3 -1 otal - 26	- closed Picea glauca/ very sparse tall shrub.	'ery sparse low shrub/contin- ious mat of Hypnum revolutum.	occurs on dry, well-drained loess deposits on mesic benches and gulleys on lower slopes soils quite basic (pH 7.9 - 7.9)	occurs on west side of Slims R. Valley loess being deposited at rate of lmm/yr best developed cryptogamic stratum in Kluane - mean cover 89%
ı.Picea glauca/ Salix glauca (northern region)	hite spruce/ rayleaf willow oniferous forest	-21 -4 -4 otal - 45	closed Picea glauca/ Salix glauca only prominent tall shrubs.	'accinium uliginosum, Lupinus rcticus prominent low shrubs, ryptogams dominated by ylocomium splendens.	mesic to dry, well-drained glacial till soils are orthic regosols	infrequent in northern areas differs from the southern phase (3) in low shrub & herb stratum with different dominants and fewer species
'.Picea glauca/ Thuidium abietinum (northern region)	hite spruce/ huidium moss oniferous forest	-11 -2 -1 otal - 53	Picea glauca/sparse tall shrub stratum of Salix glauca, S. planifolia, Alnus crispa.	.rctostaphylos rubra, Lupinus rcticus prominent in low hrub & herb stratum/dominant ryophytes include Thuidium bietinum, Pleurozium chreberi.	moist, poorly to moderately well-drained sites underlain by permafrost soils - orthic regosols, orthic dystric brunisols under the older stands	widespread in Donjek R. area

rable 8.1 **Montane** forest **community** types - **Kluane** National Park (Continued).

:ommunity Name (region)'	Common Name	Average No. of species;	Dominant Flora:)verstory/Tall Shrubs	Dominant Flora: Low Shrubs & Herb/Cryoptogam	Soils, Drainage, Topography	Comments
.O .Picea glauca, Aulacomnium palustre (northern region)	Nhite spruce/ aulacomnium moss coniferous Corest	J-13 B-2 L-l Total - 21	Picea glauca/sparse tall shrub stratum	depauperate low shrub & herb stratum - Festuca altaica is dominant/cryptogams limited t Aulacomnium palustre, Pleurozium schreberi.	• occurs on poorly drained east or north - facing sloper on orthic regosols underlain by perma-frost	. occurs infrequent1 in Donjek R. area
.1 .Picea glauca, Populus tremuloides/ Shepherdia canadensis, Linnaea borealis (southern region)	Nhite spruce/ trembling aspen/ buffaloberry - twin flower nixed forest	/-17 3-4 L-3 Total - 44	closed Picea glauca/ Populus tremuloides overstory/Shepherdia canadensis tall shrub stratum	.innaea borealis prominent in .ow shrub & herb stratum/ moderate cover of bryophytes lichens, Peltigera aphthosa)repanocladus uncinatua,)istichium capillaceum.	• common on mesic, well-drained glacial till • orthic regosols, orthic eutric brunisols	. subclimax, succes-sional to Picea/ Shepherdia (5) . common along Haines Road . may originate directly after fir or as a result of Picea invasion of the Populus tremuloides/ Arctostaphylos uva ursi community stands 100-130 yrs old
2.Salix scouleriana/ Shepherdia canadensis (central and southern regions)	Scouler's willow/ buffaloberry deciduous forest	r-14 I-? ,-2 Total - 78	closed canopy of salfx scouleriana/ Shepherdia canadensis	- high low shrub & herb cover of Linnaea borealis, Epilobium angustifolium/ sparse cryptogamic stratum- Cetraria pinastri, occurrin on fire-killed Picea logs i: only common species.	. mesic to dry, well-drained glacial till . orthic regosols, orthic eutric brunisols	seral community closely related ecologically to Populus tremuloides/ Arctostaphylos community (13) common on burned over sites along the Haines Road, i Sockeye Lake area, and on the north-facing slopes of the upper Alsek River Valley

Table 8.1 **Montane forest community** types - **Kluane** National Park (Continued).

Community Name (region)[1]	Common Name	Average No. of Species[2]	Dominant Flora: Overstory/Tall shrubs	Dominant Flora: Low Shrubs & Herb/Cryoptogams	Soils, Drainage, Topography	Comments
3. **Populus tremuloides/ Arctostaphylos uva-ursi** (central and southern regions)	**rembling** aspen/ **earberry** **eciduous** forest	-19 -1 -1 otal - 94	· **dense overstory of** Populus **tremuloides/** Shepherdia canadenais · **several other tree** species occur in this community including **Populus** balsamifera, **Picea** glauca, Salix **scouleriana**	· **rich** low **shrub & herb** stratum dominated by **Arctostaphylos uva-ursi/** sparse cryptogamic **stratum, no** dominant species	**mesic to dry, well-**drained glacial till deposits **soils - orthic** regosols, **orthic eutric** brunisols	occurs along the Hainea **Road** and Alaska Highway **and** only sporadically elsewhere in central and **south**ern regions **seral** community **which** originates after fire. stands are Jo-90 yrs. old.
4. **Populus** balsamifera **(mesic** phase) **(central &** southern regions)	**alsam** poplar **eciduous** forest	'-14 -2 -1 otal - 91	closed canopy dominated **by** Populus **balsamifera/dense** tall **shrub stratum dominated by** Shepherdia canadensia	· Epilobium **angustifolium &** Mertensia paniculata prominent in low **shrub and herb stratum/depauperate** cryptogamic stratum.	. **mesic,** moderate to well-drained alluvial and lacuatrina gravel deposits **orthic** regosol soils	frequent **throughout the south and central regions.** subclimax community **mesic** phase **communities** on **outwash** fans and stream terraces are probably disturbed by flood before **Picea** glauca can **substantially** invade the community.

Table 8.1 **Montane forest community** types - Kluana **National** Park (continued).

Community Name (region)'	Common Name	Average No. of Species'[2]	Dominant Flora: Overstory/Tall Shrubs	Dominant Flora: Low Shrubs 6 Herb/Cryoptogams	Soils, Drainage, Topography	Comment5
5. **Populus balsamifera/ Arctostaphy-105 uva-ursi (south central phase)**	Balsam poplar/ bearberry deciduous forest	V1-17 B-2 L-2 Total - 60	- closed **Populus balsamifera overstory/** Shepherdia canadensis tall **shrub** stratum	**Arctostaphylos** uva-ursi **dominates** a rich low **shtub &** herb stratum/sparse **cryptogamic stratum. Ceratodon purpureus** and Peltigera canina reflect the **dry habitat.** - **bark** of **P.** balsamifera supports **numerous** epiphytic Lichens.	• dry, well-drained alluvial and **lacustrine** deposit5 and occasionally glacial **till.** • abundant **on** aeolian deposits **on** north side of Dezadeash **R.** . **soils - orthic regosols.**	. eeral type
6. **Populus balsamifera/** Shepherdia (central region)	Balsam poplar/ buffaloberry liciduous forest	V-5 B-1 L-0 Total 16	• closed **Populus balsamifera overstory/** Shepherdia canadensis dominates tall **shrub stratum;** Elaeagnus **commutata may** also be present	sparse low **shrub & herb stratum; only 7** species; **Hedysarum boreale** is the only prominent) sparse **cryptogamic stratum; only** two bryophyte species **present** Distichium **capillacuum,** Hypnum revolutum.	• **dry,** well-drained alluvial gravel5 in Slims River area. . soils are orthic **regosols.**	. similar to **(15)** in Alsek Valley but Shepherdia **canadensis** is **more** abundant and there are fewer total species.
7. **Populus balsamifera/ Festuca** altaica - **Arctostaphylos** uva-ursi **(northern** region)	Balsam poplar/ Buffalo **bunchgrass - bearberry deciduous** forest	r-20 3-2 -2 Total - 33	. open overstory dominated by **Populus balsamifera/Salix glauca** usually pre**sent in tall shrub but not abundant**	**Low shrub & herb** dominated by **Festuca** altaica and **Arctostaphylos uva-ursi/sparse** cryptogamic **stratum;** only 4 **species** present; **Distichium capillaceum,** Peltigera canina **are** common.	. well drained **colluvial** slopes along **the** Duke **R.** . **soils are orthic** eutric brunisols	subclimax type

Table 8.1 **Montane** forest City types - **Kluane** National Park **(Concluded).**

Community Name (region)[1]	Common Name	Average No. of Species[2]	Dominant Flora		Soils, Drainage, Topography	Comments
			Overstory/Tall Shrubs	Low Shrubs & Herb/Cryoptogams		
18. **Populus balsamifera/ Arctostaphylos** uva-ursi **(northern** phase)	Balsam poplar/ bearberry deciduous forest	V-9 B-0 L-0 Total - 14	**Populus balsamifera/** Shepherdia canadensis	Arctostaphyloa uva-ursi **pre-** dominates in low shrub & herb/ no cryptogama	- occurs on **fluvial fans** and terraces in Donjek valley - orthic **regosols**	- differs from **southern** phase (15) in much lower species number

(after: Douglas 1980).

FOOTNOTES:

1. See Figure 8.1.

2. V - Vascular Plants; B - Bryophytes; L - Lichens; Total - all **species** identified in all stands sampled; • - data incomplete.

Table 8.2 Montane fen and bog community types - Kluane National Park.

:ommunity Name (region)'	Common Name	Average No of Species:	Dominant Flora		Soils, Drainage, Topography	Comments
			'verstory/Tall Shrubs	Low Shrubs & Herb/Cryoptogam:		
..Picea glauca/ Betula glandu-losa/Carex aquatilis (central & southern regions)	'hite spruce/ hrub birch/ later sedge fen	'-19 ,-5 ,-1 'otal - 68	widely spaced sap-ling-sized Picea glauca/rich tall shrub stratum dominated by Betula glanduloaa and Sali: glauca	. dense low shrub & herb dominated by Carex aquatilis/ well-developed cryptogam stratum; mostly bryophytes; Aulacomnium palustre, Campyllium stellatum; Distichium capillaceum, Tomenthypnum nitens prominent.	wet, poorly-drained river, lake margins, seepage areas. soils types include regogleysols, humic gleysole and some-times fibrisols or humisols hummocky ground surface	common in Dexadeasl R. valley
.Picea glauca/ Salix plani-folia/Carex aquatilis/ Sphagnum rubellum (southern region)	hite spruce/ ea-leaved illow/water edge/Sphagnum ubellum moss og	-7 -2 -0 ota1 - 10	widely spaced sap-ling-sized Picea glauba/tall u b dominated by Salix planifolia and Betula glandulosa, Salix myrtillifolia	low shrub hi herb dominated by Carex aquatilis; only 4 species in total/ cryptogams dominated solely by Sphagnum rubellum and Tomenthypnum nitens.	poorly-drained low-lands soils are regogley-sols, humic gleysols; occasionally fibri-sols or humieols	common along Alder Creek
.Salix/Carex aquatilis/ Sphagnum rubellum	illow/water edge/Sphapnum ubellum moss og	-5 -3 -0 otal - 10	no Picea overstory/ Salix planifolia, S. noval-anglial and Betula glandu-losa dominate tall shrub stratum	low shrub & herb only 3 species; Carex aquatilis dominates/cryptogams dominated by Sphagnum rubellum and Tomenthypnum nitens.	same as (2)	similar to (2) and found in the same area

(after, Douglas 1980).

FOOTNOTES:

1. See Figure 8.1.

2. V- Vascular Plants; B - nryophytes; L - Lichens; Total - all species identified in all stands sampled: • - data incomplete.

to some of the forest communities but given slow growth in the northern environment and frequent disturbance they may persist for long periods and have become an important part of the vegetation mosaic.

Some meadow-like areas underlain by moist fine-textured soils support lush grassland vegetation not unlike a northern prairie or parkland type. These types are common on the lake bottoms of former glacial lakes, and occupied, for example, the area chosen for the Pine Creek Experimental Farm (now the Kluane Park Warden Compound).

Drier sites with extremely coarse glacial till or alluvial gravel parent material have sparser plant cover and conspicuous bare ground, resembling most closely the steppe-like areas of eastern Asia. These steppe-like areas occur on the bluffs surrounding Kluane Lake, especially in the Sheep Mt. area and on the beaches and terraces of Recent Lake Alsek.

These montane shrub and herb species are described in Tables 8.3, 8.4, and 8.5 classified by geographic area, and region - Recent Lake Alsek, southern and central region, northern region.

8.4.3.2 Slims River Floodplain

Douglas (1980) describes the vegetation of the Slims River floodplain as one of the most unique and interesting botanical phenomena in Kluane. The saline soils of the floodplain support a mosaic of halophytic (salt tolerant) grassland species whose distribution is closely controlled by soil moisture gradients across the floodplain.

The geomorphology, hydrology, and soils of the floodplain have already been described in chapters 6 and 7. Briefly, the floodplain is on average about 2500 m wide with relief of less than 1 m. It ends in a large (11 km^2) delta built into Kluane Lake. The floodplain and delta are comprised almost exclusively of silt.

The eight plant communities on the Slims floodplain contain only 28 vascular and 4 bryophyte species, and exhibit little overlap in floristic composition. Table 8.6 gives prominence values for the species of each community. The boundaries between communities are abrupt and produce a distinct banding effect on the ground. Douglas (1980) interprets this as an indication that the ecological tolerance range of these halophytic species is very narrow during some part of their life cycle. Douglas (1980) studies indicate that the distribution pattern correlates closely with late summer soil moisture gradients and other factors such as fluctuations in salinity and length of the period of soil saturation. These communities are described in Table 8.7 in order of descending soil moisture regime.

Table 8.3 Montane shrub and herb community types - Recent Lake Alsek area.

Community Name	Average No of Species:	Low Shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
1. **Juniperus communis - Arctostaphylos uva-ursi** (Common juniper - bearberry shrub)	I-15 l-1 ;-1 Total = 60	• J. communis and A. uva-ursi predominate • Shepherdia canadensis, Calamagrostis purpurascens also prominent.	sparse cryptogamic stratum Ceratodon purpureus, Ditrichum flexicaule present all xerophytic rocks on beach ridges covered by lichen Xanthoria elegans.	restricted to older, well-drained beach ridges where it is seral & succeeded by Picea/Shepherdia also in Donjek R. area on aeolian deposits; succeeded there by Picea/Shepherdia or Picea/Hypnum.
2. **Salix** setchelliana (Setchell willow shrub)	!-8 l-l ,-0 Total = 17	. open cover of Salix setchelliana and Oxytropis campestris (only community where 0. campestris, an endemic to SW Yukon, was of any importance).	Ditrichum flexlcaule is the only species.	rare; occurs on the gravely lake bed of Recent Lake Alsek only stands Located were south of the junction of Kaskawulsh and Dezadeash rivers may be inundated during flood periods.
3. **Artemisia alaskana** (Alaska wormwood shrub)	r-10 L-2 ,-2 Total - 43	A. alaskana sole dominant Lupinus kuschei, Chamaerhodos erecta, and Agropyron yukonense are frequent.	depauperate cryptogamic stratum.	restricted to Alsek L Dezadeash river valleys occurs on dry, well-drained alluvial and lacustrine gravel &posits which occur as outwash fans 6 beach ridges and lakebed of Recent Lake Alsek pioneer community.
4. **Artemisia frigida - Poa glauca** (Prairie sagewort - glaucous bluegrass shrub grassland)	V'-15 El-2 L-6 Total - 56	open cover of low shrubs & herbs dominated by A. frigida & P. glauca including Carex supina, Agropyron yukonense.	*parse cryptogamic stratum, mainly xerophytic species Ceratodon purpureus, Tortula ruralis.	restricted to aeolian &posits along the Alsek L Dezadeash rivers. extremely dry & well-drained sites invasion by Salix glauca and Populus balsamifera limited to stand peripheries.

Table 8.3 Montane shrub & herb c i t y types -Recent Lake Alsek area[1] (concluded).

Community Name	Average No. of Species[2]	Lou Shrub & Herb Stratum	Cryptogams	Soils, Drainagm and Topography
5. Dryas drununondii (Yellow dryas dry meadow)	V-M B-2 L-2 Total - 66	- continuous cover of Dryas drummondii - tree sapling and tall shrub strata are sparse but increase with stand age - Dryas communities approaching P. balsamifera or Picea/Shepherdia contain Picea glauca 60-65 yrs. old and 6 m tall.	- depauperate cryptoganic stratum; Ceratodon purpureus most important species.	- most widespread pioneer community - rapidly colonizes gravel outwash fans & stream terraces - common on beach ridges & lakebed of Recent Lake Alsek.
6. Agropyron yukonense (Yukon wheatgrass dry meadow)	v-10 B-2 L-l Total - 14	- open low shrub & herb stratum dominated solely by A. yukonense.	- Ditrichum flexicaule only prominent species.	- pioneer community occurs infrequently on lower Recent Lake Alsek beach ridges - dry, well-drained sites
7. Hedysarum boreale (Northern sweet-vetch dry meadow)	v-12 B-l L-l Total - 49	- H. boreale and Agropyron yukonense only prominents.	- sparse or often absent cryptogamic stratum - Ditrichum flexicaule, Ceratodon purpureus xerophytic mosses only prominents.	- occurs on dry, well-drained alluvial & lacustrine parent material in Dezadeash & Alsek valleys - pioneer community commonly invaded by Populus balsamifera.
8. Carex sabulosa (Sabulosa sedge dunes)	v-5 B-O L-O Total - 10	- continuous sparse cover of c. sabulosa - Juniperus communis is a sporadic invader.	- no cryptogamic stratum.	- occurs only on stabilized sand dunes along the Alsek and Dezadeash rivers. - most extensive stands on North side of Dezadeash R. just above junction with Kaskawulsh.

(after: Douglas 1980).

FOOTNOTES

1. See Figure 8.1.

2. V- Vascular plants; B - Bryophytes; L - Lichens; Total - all species identified in all stands sampled; • - data incomplete,

Table 8.4 Montane shrub and herb community types of the southern and central regions - Kluane National Park.

Community Name	Average No. of Species¹	Tall & Lou Shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
1. **Salix** glauca **(Glaucous willow** shrub)	V-17 B-3 L-3 Total - 134	dense 2-4 m high tall shrub stratum dominated by S. glauca. Low shrub & **herb** dominated by Arctostaphyloe **uva-ursi** trees may occur infrequently in openings, usually P. glauca or Salix **bebbiana.**	moderately well-developed cryptogamic **stratum with Bryum** sp. and Cladonia **gracilis** the only prominents.	- common throughout south 6 central **areas on dry, moderate** to **well-drained** glacial till, alluvial 6 lacustrine gravel 6 **aeolian** deposits. - orthic eutric **brunisols** and orthic regosols - successional **to Picea/Salix** glauca.
2. **Betula** glanduloea - **Festuca** altaica **(Glandular birch** shrub - **Altai** fescue shrub)	V-21 n-4 L-5 Total - 77	patchy but **heavy cover of** intensely browsed B. glandulosa; dense **understory** of grasses & sedges (especi-ally F. altaica). **Populus** tremuloides **most** prominent invader.	poorly developed cryptogamic stratum **Polytrichum juniperum,** Dicranum **muchlenbeckii most** prominent.	- **occurs** infrequently along **Haines Road** from Dezadeash R. to south of lower Kathleen Lake in poorly drained depressions on glacial till - most acidic soils in the **montane** zone **(pH** 4.9 **- 5.0)** - orthic dystric brunisols.
3. Phepherdia canadensis (Soapberry shrub)	V-14 B-2 L-2 Total - 39	dense tall shrub stratum dominated by S. canadensis poorly developed low shrub 6 herb stratum **Lupinus** articum **& Dryas drummondii** prominent.	moderately well-developed cryptogamic stratum dominated by Hylocomium splendens and **Stereocaulon sp.**	- occurs infrequently only in southern region mainly in Onion Lake - Wolverine Plateau - **occurs** on dry, well-drained alluvial fans & river terraces - soils - orthic regosols - **community** is short-lived and succes-sional to the **Picea/Shepherdia** type.

Table 8.4 **Montane shrub & herb community types of the southern and central regions[1] - Kluane National Park** (Continued).

Community Name	Average No. of Species[2]	Tall & Low Shrub & Herb Stratum	Cryptogame	Soils, Drainage and Topography
.**Shepherdia canadensis/ Festuca altaica (Soapberry/Altai** fescue shrub)	'-20 ı-2 ,-5 'otal - 86	- tall shrub stratum dominate1 solely by S. canadensie - low shrub & herb stratum is rich and lush, dominated by F. altaica; Arctostaphylos uva-ursi only other prominent.	- moderately rich cryptogamic stratum dominated by Polytrichum juniperum, Stereocaulon sp. and Cladina mitis.	- infrequent in the Alder Creek drainage on alluvial fans - orthic regosols only soil type
ı.**Juniperus** horizontalis (Creeping juniper shrub)	'-10 l-l ,-3 'otal - 22	- J. horizontalis and Arctostaphylos uva-ursi dominate the low shrub & herb stratum.	calcareous dry-site 'prairie' lichens such as Lecidea rubiformis and Fulgensia bracteata are frequent.	- common only on dry, well-drained loess -covered slopes in the Slims R. valley - calcareous soils classified as cumulic regosole.
ı.**Festuca** altaica **(Altai fescue meadow)**	'-20 l-4 ,-8 'otal - 93	- dense, rich low shrub 6 herb stratum dominated by F. altaica, Vaccinium caespitosum, Potentilla diversifolia.	. dense ground cover of mosses and lichens . Cladina mitis, Polytrichum juniperum,m, and Cladonia verticillata are dominant.	- this community succeeds the Dryas drummondii community and tends to persist for many years - common on older alluvial fans 6 stream terraces - soils - orthic regosola
'.**Calamagrostis** canadensis (Canadian reedgrass meadow)	'-21 l-l ,-1 'otal - 65	- lush dense cover of herbs dominated by C. canadensis - C. canadensis was sterile i all stands examined - richest herb community in the Alsek R. area.	sparse, no constant species.	- relatively rare but occurs throughout southern and central regions on mesic, moderately well-drained glacial till - soils - orthic regosols.

Table 8.4 Montane shrub & herb community types of the southern and central regions [1] - Kluane National Park (Concluded).

Community Name	Average No. of Species[2]	Tall & Low Shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
8. Artemisia frigida - Agropyron yukonense (Prairie sagewort-Yukon wheatgrass shrub-grassland)	V-10 B-1 L-4 Total - 42	- open low shrub & herb stratum dominated by A. frigida and A. yukonense.	- moderately well-developed xerophytic cryptogamic stratum - Lecidea rubiformis, Physconia muscigens are prominent.	- most common type on lower loess - covered mountain slopes along the Slims River. - soils - cumulic regosols.

(after: Douglas 1980).

FOOTNOTES:

1. See Figure 8.1.

2. V- Vascular plants; B - Bryophytes; L - Lichens; Total - all species identified in all stands sampled; * - data incomplete.

Table 8.5 **Montane shrub C herb community** types of the northern **region**[1] - **Kluane** National Park.

Community Name	Average No. of Species[2]	Tall & Low Shrub 6 Herb Stratum	Cryptogams	Soils, Drainage and Topography
.Salix alaxensis (Alaska willow shrub)	'-8 l-0 ,-0 'otal - 11	S. alaxensis and S. glauca dominate tall shrub Hedysarum boreale, Dxytropie campestris, and Elaeagnus commutata important in low shrub & herb.	no cryptogams	- common only on recent alluvial gravels along Donjek R. • soils - orthic regosols
.Salix glauca (Glaucous willow shrub)	'-10 l-1 ,-0 'otal - 27	S. glauca and S. bebbiana dominate the tall shrubs Calamagrostis purpurascens & Festuca altaica are major species in low shrub 6 herb.	sparse cryptogamic stratum; only Pleurozium schreberi important.	. occurs same on wide variety of soils and parent materials as S. gluaca (south and central) (See Table 8.4 (1) but has 107 fewer species and slightly different dominants
.Betula glandulosa - salix myrtillifolia/ Festuca altaica (Glandular birch - Bilberry willow/Altai fescue shrub)	'-23 l-4 ,-4 'otal - 43	dense tall shrub with B. glandulosa & S. myrtillifolia only important species low shrub & herb dominated by S. barrattiana and F. altaica.	cryptograms dominated by Pleurozium schreberi.	• rare in Park, encountered only on old alluvial &posits along Duke R. . soils - orthic eutric brunisols.
.Betula glandulosa/ Aulacomnium palustre (Glandular birch/ Aulacomnium shrub)	'-13 l-3 ,-0 'otal - 24	B. glandulosa 6 S. glauca dominate tall shrub Carex atratiformis is prominent in low shrub & herb stratum.	well-developed cryptogamic stratum providing 48% cover A. palustre & Pleurozium schreberi are most important species.	. rare in Duke R. valley • restricted to moist alluvial benches with northerly aspects . orthic eutric brunisols underlain by permafrost

Table 8.5 **Montane shrub & herb community** types of **the northern region[1] - Kluane National Park** (Continued).

Community Name	Average No, of species:	Tall & Low Shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
5. **Elaeagnus commutata** - **Festuca** rubra (**Silverberry,** Red fescue shrub)	v-10 B-l L-0 Total - 15	. floristically poor **low** shrub & herb with **E. commutata,** P. rubra, and Oxytropis **campestris** very important.	Distichum flexicaule only **cryptogam.**	. found only along Donjek R. floodplain associated with old sand dunes and raised terraces. . orthic regosols.
. **Dryas** integrifolia (Entire-leaved white mountain **avens mesic** meadow)	w-12 B-• L-• Total- 23(*)	floristically poor low shrub & herb dominated by D. integrifolia.	no **cryptogams**	infrequent in the northern region occurs **mostly on moist,** montane **snowbe** sites orthic eutric **burnisol** only soil examined.
. **Dryas drummondii** (Yellow **dryas** dry meadow)	v-12 B-l L-l Total - 33	dense cover of D. **drummondii** **Artemisia frigida Oxytropis** campestris, & Hedysarum **boreale** also prominent.	crypotogamic stratum - dominated by Distichum flexicaule.	common as pioneer type on recent alluvial **outwash** fans and floodplains soils - orthic regosols.
. **Calamagrostis** purpurascens (Purple reedgrass dry meadow)	r-11 a-1 L-3 Total - 40	C. **purpurascens** and **Artemisia frigida** dominate low shrub 6 herb.	sparse xerophytic cryptogamic stratum.	**occurs on dry,** southerly **colluvial** slopes orthic dystric brunisols

Table 8.5 Montane shrub & herb city types of the northern region[1] - Kluane National Park (Concluded),

Community Name	Average No. of Species:	Tall & Low shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
. . **Artemisia frigida** - Artemisia **rupestris** (Prairie sagewort dry meadow)	I-7 3-1 .-3 Total - 19	A. **frigida** 6 A. **rupestris** **dominant.**	. xerophytic cryptogamic stratum in **which Bryum sp.,** Physconia muscigena, and Toninia **sp.** are important.	. locally common on the **east** side of Donjek **R.** south of Donjek Glacier . dry, lower **montane** slopes on pest & present loess deposits' • orthic 6 **cumulic** regosols.
10.**Oxytropis** campestris - Artemisia **frigida** (Field oxytrope - Prairie saqewort dry meadow)	I-10 3-1 .-1 Total - 20	0. campeatrie and A. **frigida** dominate.	• Distichum flexicaule only important crypotogam.	• common on alluvial gravels of the Donjek R. floodplain orthic regosols.

(after: Douglas 1980).

FOOTNOTES:

. **See** Figure 8.1.

. V - Vascular Plants; **B** - Bryophytes; L - Lichens; Total - **all** species identified in all stands sampled; • - data incomplete.

Table 8.6 **Composition** of the **plant community types on** the slims River **floodplain, Kluane** National Par
Data are for prominence **volume.** [a]

Species	Caaq[b]	Sabr	Juar	Hoju	Deca	Asyu	Puna	Taca
VASCULAR SPECIES								
Carex aquatilis	609	136	6	4	1			
Carex parryana	18	20						
Juncus arcticus	15	18	260	1	22			
Triglochin palustre	14	14	a		6			
Juncus alpinus	a	2			1			
Eriophorum polystachion	a	2						
Salix brachycarpa	4	292	3				1	
Ranunculus cymbalaria	4	3	2	25	1	1		
Aster yukonensis	3	19	a	9	39	176	37	
Parnassia palustre	3	14						
Hordeum jubatum	2	3	a	296	T	a	13	2
Equisetum palustre	2							
Eleocharis palustris	2							
Salix planifolia	2	9						
Salix alaxensis	1							
Deschampsia caespitosa		20	40	a	255	36	3	
Habenaria hyperborea		3	T					
Puccinellia nuttalliana		2	6	25	3	19	148	12
Calamagrostis inexpansa		2						
Pedicularis sudetica		2						
Hedysarum boreale		1						
Lomatogonium rotatum			T					
Primula stricta			T					
Carex maritima					1			
Plantago maritima							5	
Taraxacum lacerum							4	25
Artemisia alaskana								1
Artemisia frigida								1

Table 8.6 Composition of the plant community types on the Slims River floodplain, Kluane National Park. Data are for prominence volume.[a] (Concluded)

Species	Caaq[b]	Sabr	Juar	Hoju	Deca	Asyu	Puna	Taca
BRYOPHYTES								
Desmatodon cernus	2	1			2			
Catascopium nigritum		5						
Gymnostomum recurvirostre					3			

[a] Prominence values are statistically derived from cover and frequency date for sample stands.

[b] Community abbreviations: Caaq, Carex aquatilis; Sabr, Salix brachycarpa/Carex aquatilis; Juar, Juncus arcticus; Hoju, Hordeum jubatum; Deca, Deschampsia caespitosa; Asyu, Aster yukonensis; Punu, Puccinellia nuttalliana; Taca, Taraxacum ceratophorum.

Table 8.7 Montane shrub and herb community types of the Slims River floodplain'- Kluane National Park.

Community Name	Average No. of Species[2]	Shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
1. **Carex aquatilis** (Water sedge wet meadow)	V-5 B-1 L-0 Total = 17	• dominated by C. aquatilis; C. parryana, Juncus arcticus, Triglochin palustre also present • most floristically rich community.	- only two bryophytes Bryum sp. and Desmatodon cernus - no lichens.	• occupies wettest sites in slight depressions & lower parts of former channels - flooded annually in spring and summer • soil moisture 32-37%.
2. **Salix brachycarpa/Carex aquatilis** (Short-fruited willow/ Water sedge wet meadow)	V-10 B-1 L-0 Total = 20	• floristically rich - dominated by S. brachycarpa & C. aquatilis.	• only two bryophytes - Catascopium nigritum and Bryum sp.	• slightly drier sites than (1); moisture levels 30-33% • flooding occurs annually but not in the early growing season.
3. **Juncus arcticus** (Arctic rush meadow)	V-5 B-0 L-0 Total = 9	- J. arcticus only important species; Deschampsia caespitosa also present.	- no cryptogams.	• sites are topographically identical to (2) but slightly drier - soil moisture 27-28%.
4. **Hordeum** jubatum (Foxtail barley meadow)	V-3 B-0 L-0 Total = 7	- H. jubatum only important species.	- no cryptogams.	- (4),(5), and (6) occupy intermediate moisture zones 25-27%
5. **Aster** yukonensis (Yukon aster meadow)	V-5 B-0 L-0 Total = 5	- A. yukonensis only Alaska-Yukon endemic on the flood-plain with exception of a single specimen of Artemisia alaskana.	- no cryptogams.	- (4),(5), and (6) all occur on slightly elevated sites and may only be inundated during high water periods.

Table 8.1 Montane shrub & herb community types of the Slime River floodplain[1] - Kluane National Park (Concluded),

Community Name[1]	Average No. of Species[2]	Shrub & Herb Stratum	Cryptogams	Soils, Drainage and Topography
. Deschampsia caespitoaa (Tufted hairgrass meadow)	V-3 B-1 L-0 Total = 12	- D. caeepitosa, Puccinellia nuttalliana & Aster yukonense prominent.	- 3 bryophyte species present Desmatodon cernus, Gymnoetomum recurvirostre and Bryum sp.	- no surface water during the growing season - D. caespitosa most widespread community on the floodplain.
.Puccinellia nuttalliana (Nuttall's alkali grass meadow)	V-4 B-0 L-0 Total = 7	- P. nuttalliana only important species - occurrence of Plantago maritima ssp. juncoides is unusual as this species is restricted to maritime sites in North America.	- no cryptogams.	- occupies the most elevated sites on floodplain - rarely inundated except during very high flood levels. - soil moisture 22-239.
.Taraxacum ceratophorum (Horned dandelion meadow)	V-3 B-0 L-0 Total = 5	- poorest community floristically - total cover only 5% contributed entirely by T. ceratophorum and P. nuttalliana as individual plants spaced at 1-2 m intervals.		- occupies driest sites on floodplain - soils moisture 13-15% - most limited in extent on the floodplain.

(after: Douglas 1980).

FOOTNOTES:

1. See Figure 8.1.

2. V = Vascular plants; B = Bryophytes; L = Lichens; Total all species identified in all stands sampled; * = data incomplete.

Douglas (1980) indicates that all of the species on the floodplain are capable of completing their life cycles under non-saline conditions and all occur elsewhere. Studies of seed germination and growth show that many of these species have adapted to germination under highly saline conditions and are not permanently inhibited by prolonged exposure to this condition.

Two rare plants occur on the delta - Puccinnellia nuttalliana (found here far to the west of other populations in the Canadian north and Greenland), and Plantago maritima (common in coastal British Columbia and Alaska but known from only two other inland locations at Great Salt Lake, Utah and in Wood Buffalo National Park).

8.5 Subalpine Zone Vegetation (100 - 1400 m)

The subalpine zone in Kluane is dominated by tall shrubs (2 - 4 m), mostly willows, dwarf birch and alder and only scattered Picea glauca individuals. Alders are not present in the northern areas. Toward the southern end of the Park, the subalpine zone is broad, largely because the mountains are lower and less precipitous than in northern areas, where environmental gradients tend to be steeper. Most soils are orthic regosols; some areas may be underlain by permafrost on north and east aspects.

In the southern areas of the Park tall shrub stands are interrupted by lush herbaceous meadows dominated by species of coastal and mountain floristic affiliations. Meadows in the northern areas are generally drier and are dominated by the Oxytropis and Calamagrostis communities.

The tall and low shrub communities are described in more detail in Tables 8.8 and 8.9. Table 8.10 describes the subalpine herb community types.

8.6 Alpine Zonevegetation (above I.400 m)

Douglas (1980) identified 32 alpine communities (including regional phases). Individual communities are usually limited in area1 extent and form a complex mosaic controlled by microclimatic elements. This diversity of community types within a restricted area ensures use by a variety of wildlife.

The vegetation pattern of the alpine zone is tied more closely than any other to the geomorphic and microclimatic processes occurring at the surface and in the first few centimetres of soil. Abrupt changes in plant cover can occur over very short distances in response to the presence of permafrost, periglacial surface phenomena such as solifluction and other types of surface instability, the provision of shelter by erratics or overhanging rock outcrops, and proximity to moisture sources such as snowbeds or seepage zones. Even on active talus or scree slopes, plants manage to survive in small groups. The variations in soil moisture and

Table 8.8 Subalpine tall shrub community types - Kluane National Park.

Community Name (Region)'	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogame	Soils, Drainage, Topography
.Al nus cr ispa (Green alder shrub) (southern rag ion)	'-9 l-l ,-1 'otal - 49	- A. crispa dominatee - moist habitat reflected by important species Veratrum eschscholtzii, Dryopteris austriaca, Calamagrostis canadensis.	- mosses are numerous but none are abundant.	› occurs on moist, gravelly sites close to streams or areas which receive snow-melt during most of the growing season. e.g. Field Creek area dominated by common Pacific Coast species.
!.Salix planifolia (Plane leaf willow shrub) (southern region)	'-15 l-3 ,-2 'otal - 60	- S. planifolia & Betula glandulosa dominate tall shrub stratum - Artemisia norvegica, Hertensia paniculata important in low shrub 6 herb.	- well-developed cryptogamic stratum - Hylocomium splendene dominant.	closely related to (3) occurs on moist, gravelly sites.
l.Salix glauca (Glaucous willow shrub) (northern & central regions)	r-13)-* ,-* 'otal - 67	- S. glauca B. glandulosa & S. barclayi are dominant in tall shrub - Hertensia oaniculata Festuca altaica are important in low shrub & herb.	- well-developed cryptogamic stratum - Pleurozium schreberi and Aulacomnium palustre are major species.	most common and extensive subalpine vegetation type in Kluane . 2 phases which differ in total cover and species number.
(southern region)	r-24)-2 ,-1 'otal - 113	- S. glauca, B. glandulosa dominant tall shrub - M. paniculata, Epilobium angustifolium, F. altaica, Linnaea boreale important in low shrub and herb.	- no prominant species in southern region.	

Table 8.8 Subalpine tall shrub community types - Kluane National Park (Continued).

Community Name (Region)'	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, Topography
4.Salix barclayi (Barclay willow shrub) (southern region)	V'-20 El-2 L-1 Total - 138	S. barclayi dominates tall shrub Valeriana sitchensis, Mertensia paniculata, Arnia cordifolia important in low shrub & herb.	. numerous crypotogam species bu none prominent.	. closely related to (3) but less common occurs on similar sometimes more moist sites.
5.Betula glanduloaa (Glandular birch shrub) (northern and central regions)	V'-12 El-2 L-2 Total - 52	B. glandulosa and S. glauca dominate tall shrub in north Peatuca altaica, Mertensia paniculata & S. reticulata are important in low shrub & herb.	. Aulacomnium palustre sole dominant.	common on xeric subalpine sites throughout Kluane 2 phases identified on basis of floristic differences 6 species number.
(southern region)	'-17 I-3 ,-3 'otal - 121	B. glandulosa dominates tall shrub Empetrum nigrum, F. altaica important in low shrub 6 herb.	. more cryptogamic species.	
5.Populus balsamifera (Balsam poplar shrub) (southern region)	'-21 I-1 ,-1 'otal - 74	dominated by densely spaced 2-3 m tall P. balsamifera Viburnum edule, S. barclayi, S. glauca most important tall shrubs Epilobium angustifolium, Thalictrum occidentale most prominent low shrubs; also Calamagrostis canadensis.	. very sparse cryptogamic stratum.	occurs on relatively dry well-drained sites not exposed to prevailing winds common in the southern region but rare elsewhere.

'able 8.8 Subalpine tall shrub community types - Kluane National Park (Concluded),

Community Name (Region)'	Average No. of Species[2]	Dominant vascular Flora	Dominant Cryptogame	Soils, Drainage, Topography
'. Elaeagnus commutata (silverberry shrub) (northern region)	v-5 B-O L-O Total - 6	- E. commutata is dominant in open tall shrub - Artemisia alaskana, A. dranunculus, A. frigida are important.	- no cryptogame.	- rare in the northern region - occurs only in steep canyons of creeks entering east side of Donjek R. - occurs on west side of Mt. Hoge.

(after: Douglas 1980).

'OTNOTES:

See Figure 8.1.

v - vascular plants; B - Bryophytes; L - Lichens; Total all species identified in all stands sampled; • - data incomplete.

Table 8.9 Subalpine low shrub community type - Kluane National Park.

Community Name (Region)[1]	Average No. of Species[2]	Dominant Vascular Plants	Dominant Cryptogama	Soils, Drainage, & Topography
1. **Arctostaphylos** uva-ursi (Bearberry shrub) (southern region)	V-20 B-2 L-4 **Total** = 73	- **A. uva-ursi** is dominant - dryness of the sites is reflected in other important species Juniperus **communis**, Festuca altaica, **Saxifraga** tricuspidata.	- 18 species present in total - **Polytrichum** juniperum & Peltigera **canina** **most** **import-ant**.	- occurs on dry ridge tops and southerly slopes.
2. **Empetrum** nigrum (**Crowberry** shrub) (southern region)	V-24 **B-3** L-6 Total = 125	- E. nigrum, P. altaica are dominant in-low shrub & herb.	- 32 species present in total; none dominant.	- more **mesic** habitat than (1) and is probably snow-free later in season.
3. **Dryas** **integrifolia** (Entire-leaved white **mountain** **avens** **mesic** meadow) (northern region)	**V-13** **B-*** **L-*** Total- **19(*)**	- **D.** integrifolia dominant - **Equisetum** sp. and Hedysarum alpinum important.	- only 9 species present - provide only 9% cover - species not differentiated in study.	- occurs on snow bed sites in northern region.
4. **Salix** barrattiana (**Barratt** willow shrub) (northern region)	V-14 **B-*** **L-*** Total- **34(*)**	- S. barrattiana and P. **altaica** are dominant in low **shrub** & **herb.**	- only 8 species in total but provide 39% cover - **Rhytidium** **rugosum**, **Pleurozium** schreberi, & Cetraria culcullata **most** important.	- occurs on day, well-drained sites in northern region.

(after: Douglas **1980**).

FOOTNOTES:

1. See Figure **8.1**.
2. V - Vascular plants; B - Bryophytes; L - Lichens; Total all species identified in all stands sampled; * - data incomplete.

Table 8.10 Subalpine herb community types - Kluane National Park.

Community Name (Region) [1]	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, & Topography
..Lush meadow communities (southern region & occasionally in central region)	Phase:	Phases:	sparse to absent in 411 communities.	, enowbed sites, well-drained but moist through growing season
	1. V-18 B-• L-O Total-69(*)	1. Calamagrostis canadensis		. 5 phases dominated by one or two of seven species. All seven are important in every community
	2. V-24 B-2 L-1 Total = 112	2. Veratrum eschscholtzii = Valeriana sitchensis		. high total mean cover (214-303%) and high total species number (47-102).
	3. V-22 B-2 L-0 Total = 52	3. Heracleum lanatum		
	4. V-29 B-2 L-0 Total = 72	4. Artemisia norvegica = Lupinus arcticus		
	5. V-27 B-• L-O Total-82(*)	5. Epilobium angustifolium		
		Associates: Saussurea americana Sanguisorba stipulata Mertensia paniculata 6 others.		

Table 8.10 Subalpine barb community types - Kluaae National Park (Concluded).

Community Name (Region) [1]	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, & Topography
!. **Festuca** altaica **(Altai fescue lush meadow)** (southern region)	V-29 B-4 L-5 Total - 170	- **F.** altaica, **Artemisia norvegica** dominate.	- no dominant species but high total cover **(49%)** - total 43 species.	- **moist to** relatively **xeric** sites indicating a wide ecological tolerance - one of **the most** floristically rich communities in the Park - 127 **vascular** species.
!. **caespitosus** (Tufted clubrueh wet **meadow)** (southern region)	**V-19** B-3 **L-0** Total - **70**	- **S. caespitosus is** major dominant - **Carex** aquatilie, C. scirpoidea are **wet** aite indicators.	- **Tomenthypnum nitens,** Sphagnum **warnstorfii** 6 Drepanocladus lycopodioides, common to **montane** bogs, fens are **promi**-nent.	- occurs on wet benches throughout southern region - soils remain saturated throughout growing season due **to upslope snowmel**t **&** seepage.
!. **Oxytropis viscida** (Viscid oxytrope meadow) (northern region)	V-11 B-f **L-*** **Total-14(*)**	- 0. **viscida** is dominant **Artemisia frigida, A.** dranuneulus, Agropyron caninum, Potentilla pensylvanica are important xerophytic species 6 together are indicative of **calcareous** soils.	- **Bryophytes** 6 lichens not separated in study.	- common on benches **&** ridges adjoining the canyons of creeks entering the east side of **Donjek** River. - exposed to continuous high winds from Donjek Glacier.
!. **Calamagrostis purpurascens** (Purple **reedgrass** meadow) (northern region)	V-11 B-l L-6 Total - 34	- **C.** purpuraacens 6 **Artemisia Turcata** are major species - Oxytropis **viscida,** Kobresia myosuroides, Aster alpinus are important7	- characterized by many xerophytic lichens.	- **occurs** on dry, well-drained calcareour colluvial slopes with southerly aspects.

(after: Douglas **1980).**

FOOTNOTES :

1. See Figure 8.1.

2. V - Vascular plants; **B** - Bryophytes; L - Lichens; **Total all species identified in all stands sampled; * - data** incomplete.

fertility associated with solifluction lobes produce distinct variations in habitat and plant communities and enhance the visual impression of downslope flow. Snow tends to collect at the base of the 'step' or solifluction terrace, producing a moist but cooler shaded habitat. The tops of the terraces are often blown free of snow and warm up quickly in summer, providing a drier, warmer environment utilized by plants providing a cover of different colour and texture. Price (1971) documented variations in vegetation with microtopography, aspect, and depth of active layer on solifluction slopes in alpine tundra in the Ruby Range to the east of Kluane National Park. Grier and Ballard (1981) described the effect of wind shelter on species distribution in the alpine zone of the Slims River drainage. Here, boulders as small as 10-20 cm in diameter provided leeward zones for snow accumulation and sufficient shelter for clumps of vascular plants to survive while surrounding exposed areas supported only lichens.

Douglas (1980) divided communities of the alpine zone into four categories. The lower alpine zone communities occupy sites up to about 1600 m. These are mostly shrub types (dwarf birch and willow) up to about 1 m in height. Ericaceous shrubs (heathers, Labrador tea, blueberry family) are most common in this zone in the southern areas of the Park. Table 8.11 describes these eleven communities in more detail.

Occurring throughout the alpine zone are communities associated with snowbeds and seepage zones. The snowbed communities (see Table 8.12) are adapted to very short growing seasons in cold soil conditions. Common species include prostrate willows Salix polaris, grasses Phippsia algida, a buttercup Ranunculus pygmaeus, saxifrage, and the moss heath Cassiope stelleriana.

Seepage zones, lying downslope of the snowbeds are provided with soil moisture throughout the growing season and are utilized by rich communities dominated by sedges and colourful herbs (see Table 8.13).

Above 1600 m in the upper alpine zone or alpine tundra, the pattern of community types is controlled by the time of snowmelt, available soil moisture, and aspect; distinct patterns of variation are present along gradients of the factors.

With increasing snow-free period, the dominant community type changes from the Salix polaris and S. reticulata snowbed types through Cassiope tetragona in sheltered areas where snow collects to Festuca altaica to Dryas octopetala and Kobresia myosuroides on exposed ridges and slopes which may be blown free of snow all winter. These communities have many species in common with only the dominant species changing at different sites. Lichens are a prominent component of all of these communities. Communities with south and west exposures and topography which allows winter snow accumulation are the most productive sites in the upper alpine zone (Grier and Ballard 1981).

Table 8.1 1 Low alpine zone community types - Kluane National Park area.

Community Name (Region)'	Average No. of Species'	Dominant Vascular Flora	Dominant Cryptoqams	Soils, Drainage, Topography
1. **Salix** glauca **(Glaucous willow shrub)** (northern phase)	**V-14** B-4 L-3 Total - 30	S. glauca, Petasites **frigida, Artemisia** norvegica dominant.	- **cryptogams** only important in the north - **Aulacomnium palustre, Pleurozium** schreberi major species.	. **common** on mist to **mesic** sites in lower alpine and in protected gullies at higher elevations. , three regional phases differing in floristic composition, total cover, an species number.
(central phase)	V-14 B-l L-l Total - 53	S. glauca, Arctostaphylos **rubra, Mertensia** paniculata are dominant.		
(southern phase)	V-15 **B-2** **L-T** Total - 43	S. glauca, **M. paniculata,** Betula qlandulosa, Juniperus **communis** dominate the low shurb & herb stra-tum.		
2. **Salix barclayi** (Barclay willow shrub) (southern & central regions)	V-11 B-l L-f Total - 40	S. barclayi, M. paniculata, **Equisetum arvense** are dominant.	- Aulacomnium palustre dominant.	. closely related to (1) but sites may b **more** moist.
3. **Salix** brachycarpa (Short-fruited willow shrub) (central region)	V-15 B-l B-1 Total - 33	S. brachycarpa only **major** species. Poa glauca, oxytropis **viscida, Dryas** octopetala also important.		. rare in Kluane, occurs only in Slims drainage **on** dry, well-drained colluvia slopes overlain by loess.

Table 8.11 **Low** alpine **zone community types - Kluane** National Park (Continued).

Community Name (Region)'	**Average No. of Species**[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, Topography
.**Salix** barrattiana (Sarratt willow shrub) (northern and central regions)	-20 -* -* ota1 = 92	**S. barrattiana,** F. altaica prominent **floristically** rich with 92 total species.	numerous xerophytic lichens.	dry, well-drained exposed slopes, associated with **solifluction** terraces.
.**Salix arctica** **(Artic willow** shrub) (central and southern regions)	-18 -2 - 1 **'otal = 81**	**S. arctica, Empetrum** nigrum, **Artemisia** norvegica **domi-** nate.	poorly developed cryptogamic stratum.	**occurs on mesic,** well-drained sites.
.**Picea** glauca **(White spruce** shrub) **(southern** and central regions)	**-8** I-2 **-3** **'otal** = 37	recognized **by** krummholz growth of P. glauca dense **overstorv** of P. glauca understory varies **consider-** ably with no constant species.		**krummholz** groups less common in **Kluane** than in southern areas.
'.**Empetrum** nigrum **(Crowberry** shrub) (central and southern regions)	V-17 E-2 **L-4** **Total** - 103	. E. nigrum, **F.** altaica dominant **Lycopodium alpinum,** Salix **reticulata** 6 **Dryas** octopetala also important.	cryptogamic stratum has **moder- ate cover but no** dominant species.	well-drained upper slopes similar to subalpine phase.

Table 8.11 Low alpine zone community types - Kluane National Park (Concluded).

Community Name (Region)[1]	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, Topography
1. Betula glandulosa (Glandular birch shrub) (northern region)	'-13 I-4 ,-7 'otal - 48	• B. glandulosa dominant • S. glauca, Carex microchaeta, Potentilla fruticosa important.	Pleurozium schreberi dominates cryptogams in north.	- 2 regional phases - common on mesic sites in lower alpine.
(southern and central regions)	'-11 ,-2 ,-5 'otal - 65	• B. glandulosa dominates • F. altaica and E. nigrum important.	Hylocomium splendens, Cladoni mitis, Polytrichum commune dominate cryptogam stratum.	

(after: Douglas 1980).

FOOTNOTES:

1. see Figure 8.1.

2. V - Vascular plants; B - Bryophytes; L - Lichens; Total all species identified in all stands sampled; * data incomplete.

Table 8.12 Alpine snowbed community types - Kluane National Park.

Community Name (Region)'	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, Topography
.Luzula piperi (Small-flowered woodrush snowbed meadow) (southern region)	/-9 3-3 L-6 rota1 - 46	L. piperi only dominant species S. polaris and C. microchaeta major associ-ates.	high total cover (68%) characterized by species able to stand short growing season on cold, wet soil - e.g. Lepraria neglecta, Polytrichum piliferum.	restricted to south where snowfall is 3-5 times as much as north 6 central regions north-facing scree slopes where snow-melt is later than any other community fine scree material often remains saturated all growing season.
.Luetkea pectinata (Luetkea snowbed meadow) (southern region)	i-12 B-* L-* rota1 - 47 (V only)	L. pectinata, S. polaris dominate.	similar to (1) Lepraria neglecta only major species.	late snowmelt areas but soils do not remain saturated throughout growing season due to good drainage.
.Cassiope stelleriana (Alaska moss heath snowbed meadow) (southern region)	v-14 B-3 L-5 rota1 - 81	C. stelleriana dominant Luetkea pectinata, Lycopodium alpinum, Empetrum nigrum important associates.	rich stratum with 50% total cover Solorina crocea is major species.	well-drained sites similar to (2).
.Phyllodoce empetriformis (Pink mountain-heather snowbed meadow) (central & southern regions)	v-19 B-2 L-4 Total - 82	P. empetriformis and Luetkea pectinata are dominant . Lycopodium alpinum, Valeriana sitchensis, S. polaris also important.	moderately high total cover (29%) but no single prominent species.	sites become snowfree slightly earlier than (2) and (3).

Table 8.12 Alpine snowbed community types - Kluane National Park (Concluded),

Community Name (Region)[1]	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogams	Soils, Drainage, Topography
Phyllodoce glandulifera (Yellow mountain heather snowbed meadow) (southern region)	V-16 B-3 L-3 Total - 49	- P. glandulifera & Cassiope stelleriana, Luetkea pectinata are prominent.	- moderate total cover (24%) - no dominant species.	- closely related to (3).
Salix polaris (Polar willow snowbed meadow)	V-14 S-3 L-5 Total - 180	- S. polaris only dominant species - C. microchaeta. Artemisia norvegica are important associates throughout the Park - Luetkea pectinata is an important associate in the southern region.	- high total cover (52%) but no single dominant.	- common througout Kluane - occurs on sites similar to (2) and (3)
Salix reticulata (Netted willow snowbed meadow) (northern phase)	V-22 a-3 L-l Total - 104	- S. reticulata, Carex microchaeta, F. altaica, Dryas octopetala, S. polaris are common to both phases - Epilobium angustifolium important in the north.	- high total cover in both phases but no dominant.	- occurs throughout Kluane - earliest snowbed sites to be free of snow - 2 regional phases identified by floristic composition.
(central and southern phase)	V-18 B-* L-f Total - 113 (V only)	- Artemisia norvegica, Anemone parviflora are important in the central & southern areas.		

(after: Douglas 1980).

FOOTNOTES:

1. See Figure 8.1.

2. V - Vascular plants; B - Bryophytes; L - Lichens; Total all species identified in all stands sampled; * - data incomplete.

Table 8.13 Alpine seepage community types - Kluane National Park.

Community Name (Region)[1]	Average No. of Species[2]	Dominant Vascular Flora	Dominant Cryptogame	Soils, Drainage, Topography
Eriophorum polystachion (Many-spiked cottongrass wet meadow) (northern region)	-7 -* -0 otal - 13	E. polystachion overwhelming dominant also Petasites frigidus, Ranunculus nivalis, Carex microchaeta are important & indicate wet habitat.	high bryophyte cover (65%) Calliergon richardsonii, Aulacomnium palustre important data incomplete.	soils usually saturated due to underlying permafrost may have standing water throughout growing season.
Carex membranacea (Fragile sedge wet meadow) (northern region)	-16 -2 -2 otal - 67	C. membranacea, Salix reticulata dominant	poor cryptogamic stratum (20%) cover Tomenthypnum nitens, Scorpiduum turgescens most common.	similar to (1) but less standing water 6 becomes more mesic towards end of the growing season usually underlain by permafrost.
Carex microchaeta (short-stalked sedge wet meadow)	-17 l-3 -5 otal - 87	C. microchaeta, S. reticulata, S. polaris dominant.	high total cover (50%) Aulacomnium palustre & Pleurozium schreberi major species.	occurs on gentle slopes underlain by permafrost more mesfc than (1) or (2).

(after: Douglas 1980).

FOOTNOTES:

1. See Figure 8.1.

2. V - Vascular plants; B - Bryophytes; L - Lichens; Total all species identified in all stands sampled; * - data incomplete.

The Cetraria nivalis community is the only lichen-dominated community in Kluane. It occurs in the southern region of the Park on rocky exposed alpine ridges. Thirty-six lichen species occur and total cover is 48%. Dryas octopetala is the major vascular species. In the central area of the Park, the Vaccinium uliginosum (blueberry) community occupies exposed ridges and slopes in the upper alpine.

Sheltered sites on south-facing slopes at high altitude provide limited habitat for species more commonly found at lower altitudes. Some montane taxa, such as Artemisia alaskana (sage), Solidago multiradiata (goldenrod), Androsace septentrionalis (Jacob's ladder), and grape fern, death camass, and yarrow attain their altitudinal limits on these dry, warm microsites (Murray & Douglas 1980).

At elevations of more that 2200 m some nunataks in the Icefields become snow-free in summer and support a surprising number of flowering plant species. Three species have been discovered most unexpectedly at 2800 m (Murray & Douglas 1980).

8.7 Successional Trends

Douglas (1980) provides only a brief discussion of successional trends and confines his comments to the montane zone as insufficient data were available to discuss the more complex patterns in the alpine and subalpine.

Kluane's numerous pioneer communities are particularly evident on the outwash fans, stream terraces and extensive lakebed and beaches of Recent Lake Alsek. The Dryas drummondii community is the most common. However, in the Dezadeash Valley, the Hedysarum boreale - Agropyron yukonense and Artemisia alaskana communities dominate the outwash fans and beach ridges. The Agropyron yukonense type is rare and occupies only the driest sites. Dryas drummondii, Artemisia alaskana, and rarely Salix setchelliana - Oxytropis campestris communites occur on the lakebed gravels of Recent Lake Alsek. The most stable parts of dunes in the Dezadeash and Alsek valleys support the Carex sabulosa community. The Artemisia frigida - Poa glauca community dominates in areas where loess accumulation is rapid. All of the above communites represent primary succession.

Based on Douglas (1980), Hawkes (1983) describes shrub to forest successional patterns for different areas of the Park.

south:

- most common succession is from Salix glauca to Picea glauca/Salix glauca.

Northern areas:

- Salix glauca to Picea glauca/Thuidium abietinum and Picea glauca/ Aulacomnium palustre.

- a deciduous forest community (Picea/Populus/Shepherida/Linnaea, Populus/Arcostraphylos, or Salix scouleriana/Sherpherdia) often occurs between the shrub and conifer stages.

Eastern areas along Haines Road:

- on dry sites
  - Shepherdia canadensis to deciduous type Populus/Arctostaphylos or Picea/Populus/Shepherdia/Linnaia to Picea/Shepherdia closed or open phases.
- on wetter sites
  - Betula glandulosa/Festuca altaica to Picea/Betula/Empetrum.

In the Slims Valley:

- from a dry shrub community or Shepherdia to Picea/Arctostaphylos or Picea/Hypnum.

In general, all Populus balsamifera conununities are also subclimax. Douglas (1980) does not indicate their successional sequence.

The Picea glauca forest communities are the climax type in Kluane. The forests are a mosaic of stands from 100-400 years old, reflecting frequent disturbances from fire and geomorphological processes.

Section 8.10 discusses secondary succession after fire and provides a more detailed mode of succession throughout the Park.

8.8 Phytogeography

The flora of Kluane contains plants from several different geographic areas and phytogeographic associations. These include the following (the species in brackets show unusual or rare distribution patterns):

- boreal forest.
- Pacific coast and mountains of Alaska and northern British Columbia (Cassiope stelleriana, Fritillaria camschatcensis, Oplopanax horridus, Vaccinium ovalifolium).
- the northern prairie (Eurotia lanata, Erigeron pumilus, Townsendia hookeri, Carex parryana).
- Rocky Mountains of southern British Columbia and Alberta (Lewisia pygmacea, Arabis lemmonii, and Arabis lyalii in the alpine zone).
- the Arctic (Oxytropis arctica, Smelowskia calycina, Braya purpurascens, Thlaspi arcticum are at their southern limits in the Park).

- the steppes and mountains of northeastern Asia (the only North American populations of the Asian sedge Carex sabulosa are found on beach terraces and sand dunes in the Alsek, Dezadeash and Kaskawulsh Valleys and near Carcross, where there are steppe-like assemblages of sage, juniper and grasses. Similarly the only North American populations of the Eurasian sage Artemisia rupestris occur in the Slims and Donjek valleys, near Jarvis River and Sugden Creek. The nearest known population occurs on the Lena River in central Siberia (Neilson 1972).

- Yukon-Alaska **endemics** - species which are unique to Alaska, the Yukon and northern British Columbia, such as Stellaria alaskana, salix setchelliana, Aphragmus eschscholtzianus, Androsace alaskana, Castilleja **yukonis,** Artemisia alaskana, Aster yukonensis, and Claytonia bostockii.

Explanations for the presence of these unusual species, many far from other populations, are difficult to prove. Two theories have been suggested:

1. The distribution of these disjunct **taxa** was once more extensive, but intervening events have eradicated them from all but a few isolated areas. Using the existence of many plant species on modern nunataks in the Icefields as a model, this theory proposes that plants survived on nunataks above the ice during the major glacial periods. During the Kluane Glaciation ice filled the **valleys** but most alpine **areas** were ice-free and could have provided refugia for plants adaptable to the harsh environment on high mountain slopes and peaks. This theory is supported by the existence of isolated populations of species adapted to this specific environment.

2. Isolated populations are the result of post-glacial dispersion of species from unglaciated refugia. During the Kluane Glaciation much of the Yukon plateau to the east and interior Alaska were unglaciated and probably supported a diverse flora from which plant propagules were dispersed to newly glaciated areas at the end of the glacial period.

This theory is more sound in many respects than the first, but does not explain the presence of the disjunct **taxa** unless long distance dispersal by unknown means (probably wind) is invoked. An example of such dispersal exists in the occurrence of Rumex graminifolius, otherwise restricted to coastal areas, on surface exposures of the white River ash in the northern St. **Elias** Mountains. Murray and Douglas (1980) postulate that wind-borne seeds exploited the volcanic ash as a substitute for coastal sands, their more common **seedbed** medium.

The presence of Asian species is more readily explained by the existence of the Bering Land Bridge during glacial maxima (see Chapter 12). It is postulated that extension of the Eurasian steppe-tundra or Arctic-steppe environment into North America at that time brought large herds of grazing animals (bison, caribou, moose) across to North America and, in their wake, nomadic hunting people to exploit them.

This tundra environment is thought to have covered most of the unglaciated area of Alaska and Yukon and has no modern analogue. Pollen analyses from the area indicate that spruce was absent from the flora and that the tundra was comprised of grasses, sedges, and a high proportion of sages. Many prairie species now disjunct from their main populations were also present (Neilson 1972). In the postglacial period, this grassland environment prevailed in the Kluane area as well but about 3000 years ago climatic changes brought the invasion of spruce forest and with it the concurrent disappearance of the large herds of grazing animals. Since the establishment of the boreal forest, the flora of the Kluane area has remained largely unchanged (Murray & Douglas 1980).

8.9 Rare Plants

Many of Kluane's rare plants are mentioned in the previous section in connection with unusual phytogeographic distributions. The designation of 'rare' in Kluane has not been documented authoritatively and new species previously unknown in the Park are still being reported. Table 8.14 presents an incomplete list of the rare, unusual, and newly reported plants of Kluane, based on Douglas (1980).

Nearly all of the Special Preservation Areas in Kluane have been established at least in part to protect rare plant communities or particularly fragile habitat. Appendix 2.1 in Chapter 2 and section 8.12.3 describe the Special Preservation Areas in &tail.

8.10 Fire in Kluane National Park

8.10.1 Fire as a Natural Ecosystem Element

Fire has been a major evolutionary factor in the development of the Northern Boreal Forest, of which Kluane is a part. Repeated wildfires have produced a mosaic of forests of many different ages and created a dynamic ecosystem much richer in plants and animals than it would be otherwise (Revill 1978).

In 1979, Parks Canada Policy recognized fire as a natural phenomenon in the National Park environment and decided that through the use of Fire Management Plans wildfire should be allowed to play its natural role in ecosystem development within the bounds of safety to life and property (Parks Canada 1979; Hawkes 1983). Prior to 1979, it had been policy to exclude fire from National Parks. With long-standing, efficient fire exclusion the boreal forest tends toward a relatively sterile homogeneous climax and ultimate decay. In the shorter term, absence of fire encourages high intensity fires

Table 8.14 Rare, unusual and newly reported plants in Kluane National Park.

Scientific Name (Common Name)	Previously Known From	Locations in Kluane National Park/Comments
Androsace alaskana (Cov. & Standl.) (androsace)	- Mt. Decoeli, Outpost Wt.	Yukon-Alaska endemic) rare in Kluane. Marble Creek and at Wile 132 Haines Road on rocky alpine fellfields and talus slopes at elevations of 1525-2075 m.
Angelica lucida L. (angelica)	- Itei Range, Yukon	lush herbaceous meadows along the lower Alsek River.
Aphragmus eschscholtzianus (Andrz.)	- Kluane Lake and Steele Glacier areas	wet alpine talus slope on Goatherd Mt.
Arabis lemmonii s. Wats	- disjunct from southern Rocky Mts.	open alpine scree slopes.
Arabis lyallii s. Wats	- disjunct from southern Rocky Mts.	dry calcareous rocky alpine sites.
Arnica mollis Hook. (arnica)	- Rose R.	Populus balsamifera forest near Onion L. and a lush herbaceous subalpine meadow in the Auriol Range.
Artemisia rupestris L. ssp. Woodsii Neilson. now Artemieia frigida Willd. -(Prairie sagewort)	- Yukon endemic known only from Sheep Wallace Mt. area.	collections made from Sugden Creek, Jarvis R., Slims River (E) and Donjek River on loess &posits from montane to exposed alpine ridges.
Aruncus Sylvester Rostel. (Goat's-beard)	- not previously known in Yukon.	found on gravel river bar on lower Alsek R.
Rater yukonensis Cronq. (Yukon aster)	- known only from a single collection at Kluane L. and one from Alsek.	found on saline silt deposits along the Slims and Kaskawulsh rivers. Yukon endemic.
Braya purpurascens (R.Br.) Bunge	- first collection made on Sheep-Bullion Plateau	only other collection made on steep alpine scree slop in Duke R. valley.
Carex parryana Dewey	- disjunct from Prairie Provinces	salt falts, wet fens, saline floodplains. Slims River floodplain.

Table 8.14 Bare, unusual, and newly reported plants in Kluane National Park[1] (Continued)

Scientific Name (Common Name)	Previously Known From	Locations in Kluane National Park/Comments
Carex sabulosa Turcz. sap. Ceiophylla (Hack.) Porsild. (sedge)	Lake Rennett, Yukon only known occurrence in North America.	on semi-stabilized sand dunes at junction of Kaskawulsh and Deradeash rivers.
Cassiope stelleriana (Pall.) DC.	common along Pacific coast	moist alpine slopes in southern Kluane area.
Castilleja parviflora Bong. (castilleja)	Pacific Coast species.	new to Yukon collected in the alpine zone of the Auriol Range and near Onion Lake.
Draba kluanei Mulligan (draba)	. no previous collections.	rocky alpine slope at 1980 m near Hoge Creek. endemic to Yukon
Draba ogiliviensis Huet. renamed Draba sibirica (Pall.) Thell. (draba)		alpine zone at Bighorn Creek and Observation Ht.
Draba paysonii Macbr. (draba)	. California to southern B.C.	alpine talus slope at 2000 m on Hoge Creek.
Draba ruaxes Payson & St. John	. 2 previous collections in Kluane Ranges.	rocky alpine slopes on Hoge Creek.
Draba ventosa Gray (Wind river draba)	. not known before north of its range in southern B.C.	fellfields and talus slopes in alpine zone on Marble Creek and Sheep-Bullion Plateau.
Erigeron pumilus Nutt.	. disjunct from southern Prairies.	dry montane slope, Kluane Lake area.
Eurotia lanata (Pursh) Moq.	• Prairie species, disjuct distribution in Yukon.	. dry montane slopes.
Fritillaria camschatcensis (L.) Ker-Gawl. (rice-root lily)	• Pacific coast species collected only once at white Pass, Yukon.	lush subalpine meadow along lower Alsek R.

Table 8.14 Rare, unusual, and newly reported plants in Kluane National Park[1] (Continued),

Scientific Name (Common Name)	Previously Known From	Locations in Kluane National Park/Comments
Galium triflorum Michx. (Sweet-scented bedstraw)	• 2 collections from Kluane Ranges & Pelly Mountains.	. subalpine Salix barclayi stand along Mush Creek.
Geranium erianthum DC. (Northern geranium)	. Pacific coast species collected only once near Watson Lake and at Mile 100 Haines Rd.	common in lush subalpine meadows in the southern and central areas of the Park.
Lewisia pyqmaea (Gray) Robins.	disjunct from southern Rocky Mts.	alpine tundra in easter Kluane Park area.
Luzula piperi (Cov.) Luzula spadicea (All.) DC. (woodrush)	. 2 collections on Canol Road.	moist alpine scree slopes on Marble Creek and Chalcedony Mt.
Montia parviflora (Moc.) Green var. parviflora		wet alpine meadows 6 seepage areas Yukon endemic; 'rare' in Canada (Douglas et al 1981)
Oplopanax horridum (Sm.) Miq. (Ginseng)	. western Cordilleran species reported only from Haines Road.	subalpine Alnue crispa var. lacinata stand on lower Alsek River.
Oxytropis arctica R.Br	arctic tundra	gravel bars, ridge tops Observation Mt.
Oxytropis campestris (L.) DC. var. dispar (Nels.) Barnaby (formerly O. campestris (L.) DC. var. jordalii (Porsild) Welsh	Ogilvie Mountains.	alpine Dryas octopetala community on Sugden Creek.
Phippsia algida (Soland) R.Br.	Kluane Ranges 6 Ogilvie Mountains.	collected from an ephemeral alpine lake on Goatherd Mountain. 'rare' in Yukon (Douglas et. al, 1981).
Plantago maritima L. (seaside plantain)	restricted to maritime sites, common in coastal B.C. and Alaska; known from 2 other inland sites at Great Salt Lake, Utah and Wood Buffalo National Park	Slims River Delta
Polystichum lonchites (L.) Roth. (Holly fern)	only reported from the Selwyn Mountains.	lush subalpine meadow on the lower Alsek R. rare in Kluane.

Table 8.14 Rare, unusual, and newly reported plants in Kluane National Park[1] (Continued).

Scientific Name (Common Name)	Previously Known From	Locations in Kluane National Park/Comments
Potentilla villosa Pallas. (cinquefoil)	known from only 2 collections in Yukon.	alpine tundra and alpine talus slopes on Hoge, Wade, and Chalcedony Mountains.
Puccinellia nuttalliana **(Schultes) Hitchc.** (alkali grass)	known from the Canadian Arctic and Western Greenland	Slims River Delta.
Ranunculus gelidus Kar. **& Kir.** (crowfoot, buttercup)		collected from Steele Glacier area.
Rhinanthes crista • galli L. (Rattlebox)	known only from Whitehorse and the **Haines** Road.	montane **calcareous** meadows and fens at Mile 1017 and 1022 Alaska **Highway** and along the Lower Dexadeash **River.**
Ribes laxiflorum Pursh. (Trailing black currant)		new to Yukon collection taken from a subalpine Alnus **crispa** var. lacinata stand at 793 m near **Fisher Glacier.**
Sagina inter-media **Fenzl.** ex Ledeb. (Snow pearlwort)	known only from Pelly **Mts.** and the Arctic coast.	ephemeral alpine lake on **Goatherd** Mountain.
Sambucus racemosa L. var. arborescens (T. **& G.)** Gray (Red-berried or stinking elder)	Pacific Coast **taxa** not previously reported in **Kluane.**	collected from a subalpine Alnus **crispa** var. lacinata stand near Fisher Glacier. --
Saussurea americana Eat. (American saussurea)	Western Cordilleran species only reported once from Yukon	lush subalpine meadows in the southern region of the Park where it is common.
Sorbus sitchensis Roemer **(Sitka** mountain-ash)	Western Cordilleran species not previously known in Yukon.	lush subalpine meadow along lower Alsek River **and an** alpine Empetrum nigrum stand near Bates Lake.

Table 8.14 **Rare, unusual,** and newly reported **plants in Kluane National** park [1] **(Concluded).**

Scientific Name (Common Name)	Previously Known Prom	Locations in Kluane National Park/Comments
melowskia calycina (Steph.) Wey. var. **integrifolia (Seeman)** Rollins.	- arctic **taxa**	- rocky alpine slopes, **Russel** Glaicer area.
tellaria alaska Hult.	- Yukon endemic	- alpine tundra - 'rare' in Canada (Douglas et al **1981)**
hlaspi arcticum **Pors.**	- arctic alpine tundra **speices,** Yukon endemic	- alpine tundra
ownsendia hookeri **Beaman**	- disjunct from **montain** prairie of Alberta	- dry calcareous **montane** slopes - Kluane Lake area.
accinium ovalifolium Sm. (Tall **huckleberry,** Early huckleberry)	- Western **Cordilleran** species not previously known in Yukon	- collected from **montane** and subalpine zones in the southern region of the Park.
iola renifolia (Gray) (White violet)	- known from 2 other southern Yukon locations.	- wet creek bank in the **montane zone** near Bates Lake.

FOOTNOTES:

1. **Source:** Douglas, 1980; Douglas et. al. 1981; Theberqe et. al. 1980.
   The rare plants of Kluane have not been documented in an authoritative manner and this list should not be viewed as complete.

when they do eventually occur, invasions of forest insects and disease, the disappearance of rare plants, and development of a sterile climax environment which provides poor habitat for birds and wildlife. At present much of Kluane's montane forest is comprised of even-aged stands of white spruce climax forest, in some areas showing signs of decadence.

One of Kluane's objectives is to:

> "preserve the wide variety of unique and significant resources of Kluane including representative ecosystems of the Northern Coast Mountains, rare plant species and communities, and characteristic wildlife populations"
>
> (Parks Canada 1980)

To achieve this result, a Fire Management Plan setting out a detailed and long term strategy for suppressing fire, initiating fire, and allowing fire to burn must be a priority as identified in the Kluane National Park Conservation Plan (Parks Canada 1984). In a first step toward this, Hawkes (1983) studied the fire history and fire environment of Kluane and made suggestions on a fire management strategy for the Park. This study was the first of its kind in Prairie Region.

In the interim, fire suppression will continue. Parks Canada and the Yukon Forest Service, the agency responsible for fire detection and control in Yukon, have signed a cooperative agreement covering provision of fire detection and suppression services by Yukon Fire Service with cost recovery from Parks Canada.

8.10.2 Fire History in Kluane

Hawkes (1983) studied the fire history and ecology of Kluane by examining 6 areas in the Park. In each vegetative zone (north, central, south) as defined by Douglas (1980), he chose two areas, one which had received heavy human use from the indigenous Southern Tutchone population and since 1880 by European miners, explorers, hunters, trappers etc., and one which had not. Aerial and ground surveys and analyses of stand age, composition, evidence of previous fire, and dates of previous fires were undertaken in each area to meet the following objectives:

- to describe the ecological role of fire in vegetation renewal and succession in Kluane; and
- to determine, within the sample areas, the importance of man-caused fires, the extent of vegetation types not of fire origin, and the historical role and impact of new fires on Special Preservation Areas.

The study areas and fires occurring in these areas during the period 1880-1940 are shown in Map 8.1. This time period was chosen as it

Table 8.14 Rare, unusual, end newly reported plants in Kluane National Park[1] (Concluded),

Scientific Name (Common Name)	Previously Known From	Locations in Kluane National Park/Comments
Smelowskia calycina (Staph.) Mey. var. integrifolia (Seeman) Rollins.	- arctic taxa	- rocky alpine slopes, Russel Glaicer area.
Stellaria alaska Hult.	• Yukon endemic	• alpine tundra • 'rare' in Canada (Douglas et al 1981)
Thlaspi arcticum Pore.	- arctic alpine tundra speices, Yukon endemic	• alpine tundra
Towneendia hookeri Beaman	- disjunct from montain prairie of Alberta	• dry calcareous montane slopes - Kluane Lake area.
Vaccinium ovalifolium Sm. (Tall huckleberry, Early huckleberry)	• Western Cordilleran species not previously known in Yukon	• collected from montane and subalpine zones in the southern region of the Park.
Viola renifolia (Gray) (White violet)	• known from 2 other southern Yukon locations.	- wet creek bank in the montane zone near Bates Lake.

FOOTNOTES:

1. Source : Douglas, 1980; Douglas et. al. 1981; Theberge et. al. 1980.
The rare plants of Kluane have not been documented in an authoritative manner and this list should not be viewed as complete.

Table 8.15 Fire history study areas - Kluane National Park.

study Area	Climatic Zone and Type of Use	Description of Fire History[1]/Comments
1A - slims and Jarvis rivers	northern climate zone - dry cold continental climate heavy human use area.	• archaeological and paleobotanical evidence indicates spruce has been in the Slime for about 200 years. • valley contains a mosaic of white spruce stands which probably originated after a number of fires in the 1700's. • a snag which died in one of the 18th century fires dates the stand origin to the 1400's. • fire size limited in the past by topographic barriers and changes in vegetation type. • only 3 fires since 1880 - all outside the Slims Valley proper. • smallest (100 ha) near Kaskawulsh Glacier in 1930's. • largest in Jarvis R. Valley (2700 ha) in 1885. • no evidence of fire associated with mining activity 1900-1905 in the area.
.B - Upper Donjek River	northern climate zone - dry cold continental climate remote human use area.	• area with the highest proportion of stands with no evidence of fire origin. • some fires occurred in the early 1900's and were the first experienced by by many of these stands since their establishment. • the early 1900's fires will mostly small (40 ha). • largest fire in the area was just outside the Park in 1924 (819 ha). • stands with evidence of fire date from the 16, 17 and 1800's. • there was actually considerable mining and outfitting activity in the area between 1905-1930 and some of the early 1900's fire were probably man-caused.
!A - Kathleen Lakes, Sockeye Lake, Quill Creek	. central climate zone - transition from northern to southern regions . heavy human use area.	• most forest and shrub communities showed evidence of fire. • stands show evidence of fires in the 1500's, 1600's, and 1700's with no concentration in any particular century. • large number of fires from 1880-1900; only 3 in the early 1900's. • activity associated with the Dalton Trail in late 1800's. • used frequently by the southern Tutchone. • the largest fire in the area is near Kathleen Lake on both sides of the Haines Road. It occurred about 1924 and burned 800 ha.

Table 8.15 **Fire history study areas - Kluane** National Park (Continued).

Study **Area**	Climatic Zone and Type of use	**Description of** Fire **History**[1]**/Comments**
!B - **Dusty River,** Trout Lake,, Disappointment River	-. central climatic zone traneition from northern to southern regions . remote human use area.	at **least** 9 fires have occurred in the **areas since** 1900. Size **ranges** from 5 to **1800** ha. -**stand** origins with fire evidence range from the **1500's** to the **1800's.** - **1/3** of **stands** showed no evidence of fire. -2 **stands** were on an old **lakebed** and an **outwash** fan. - the area of a **small (5** ha) fire in 1919 in the Disappointment R. valley contains spruce seedlings which germinated 60 yrs. after the fire. - the largest fire in the area occurred near Trout Lake probably about 191 L burned **1800** ha. Some spruce regeneration **has** occurred but the vegetation **is mostly** trembling aspen. - much of the area wae covered by Recent Lake Alsek and other phases. As a result, areas below 610 m **asl** are still in primary succession and have never been burned. - the **Alsek** valley portion of the area is prime **grizzly** habitat and is designated a Special Preservation Area. - little evidence of man-related fire but the eouthern Tutchone had **good access** to the area before **1850** when the lake existed.
A - Alder Creek, Mush Lake, Fraser Creek	southern climatic region - wet, maritime climate heavy human **use** area.	- this area has had the largest **fires (3** greater than 1700 ha) all in the late **1800's.** - 2 small **fires** along the **Haines** Road in the **1940's** were probably related to road construction. - a 4000 ha fire, occurred about 1759 in the Alder Creek Valley. - stand origins with evidence of **fire go** back to the **1600's.** - a fire about **1876** in the Fraser Creek area was not mapped because the regeneration stand is about the same size as the previous stand when burned. - this area has seen the **most** human activity in the Park. Dalton Post and the Dalton Trail are nearby; southern Tutchone settlements were located at Klukshu and Nesketakeen. A gold **rush** in the early 1900's does not appear to have produced many fires although much of the area had recently burned in **1884** and **1892.**

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Table 8.15 **Fire history** study areas - **Kluane National Park** (concluded).

Study Area	Climatic Zone and Type of Use	Description of Fire History[1]/Comments
B - Bates Lake, Bates River, Onion Lake	- southern climatic zone - wet, maritime climate - remote human use area.	- only 4 fires occurred in this area in the 1880-1940 period. - the largest fire was on the north side of Bates Lake about 1900 when 330 ha were burned. - all plots showed evidence of fire; none originated before 1670, in either 3A or 3B, whereas older stands were found in all other areas. - European human hietsory is similar to that in 3A; Southern Tutchone use was probably leas because of difficulty of access. - Placer mining activity on Iron Creek in the 1920's and 30's probably caused a fire near Bates River in 1930.

Source : Hawkes 1983.

FOOTNOTES:

[1] All references to dates of fires and areas burned are approximate.

Table 8.16 Fire dates, stand origins and the number of separate burns per fire date that could be mapped in each study area in Kluane National Park.

Century	Study Area					
	Slims IA	Donjek 1B	Kathleen 2A	Dusty 2B	Mush 3A	Bates 3B
1900	1934*(1) 1930*(1)	1938*(1) 1934*(1) 1930*(1) 1924*(1) 1900*(1)	1924*(1) 1923*(2) 1911*(1)	1940*(1) 1932*(1) 1919*(2) 1915*(2) 1902*(1) 1901*(1) 1900*(1)	1940*(3) 1922*(1)	1939*(1) 1930*(1) 1900*(1)
1800	1885*(1) 1854	1803	1895*(1) 1894' 1893*(1) 1889* 1886*(1) 1884' 1882' 1854* 1842' 1835 1806	1895*(1) 1886*(1) 1875*(1) 1861*(1) 1835 1831	1893*(1) 1892*(1) 1884*(1) 1876* 1865* 1851*(1) 1821 1811	1893*(1) 1842 1826 1825 1805 1802
1700	1792. 1777 1773 1764 1751 1746 1745 1712	1785. 1736. 1722 1716. 1702	1795. 1759* 1741 1740 1709	1796 1793. 1766 1763. 1755. 1713	1785 1759* 1754 1740 1735 1726. 1707.	1775 1771 1756 1753 1724 1712
1600	1694. 1668 1661	1694. 1686 1680. 1642.	1695 1681. 1679 1600	1673 1663 1649.	1670 1610	

Table 8.16 **Fire dates, stand** origins **and** the **number** of **separate burns** per fire **date in** brackets that could **be mapped in** each study area **in Kluane National** Park **(Concluded).**

century	Study Area					
	Slims 1A	Donjek 1B	Kathleen 2A	Dusty 2B	Mush 3A	Bates 3B
1500	1589 1518. 1563 1504		1592	1578 1559.		
1400	1473 1422	1447				

Source : Hawkes 1983.

(*) Fire dates from scar record. (No mark) stand origin with evidence of fire.

(.) Stand origin with no evidence of fire.

Table 8.17 Mean fire interval (MFI) data - Kluane National Park.

Parameter	Study Area: Slims 1A	Donjek 1B	Kathleen 2A	Dusty 2B	Mush 3A	Bates 3B	Park Average
Mean Fire Interval (Plots with fire history) (years)	205	226	152	175	113	162	172
Range	80-293	135-295	30-290	9-373	14-274	105-218	
No. of fire intervals used	11	8	15	15	17	11	
Wan Fire Interval (All plots) (Adjusted for man-caused fires) (years)	243	255	190	185	155	178	200
No. of fire intervals used	16	11	13	14	14	11	
Mean Fire Interval (All plots) (Ajueted for the existence of stands which have not seen fire as yet)	300	500	200	200	180	180	260
Total park forested area (ha)	11 500	25 000	11 000	16 500	18 000	18 000	Total Area 155 000
Estimated area burned/year %	0.33	0.20	0.50	0.50	0.56	0.56	Park Average 0.39
Estimated area burned/year (ha)	40	50	55	180	100	100	Park Total 600
Actual area burned/year (1880-1940 (ha)	50	15	40	SO	147	10	342
Total area burned for the period 1880-1940 (ha:)	2 946	897	2 401	4 756	8 826	559	20 387
Actual area burned/year (1880-1940) (%)							0.31
Average fire size	983	179	200	394	1 600	140	
Range	92-2 700	2-819	S-790	5-l BOO	1-5 000	3-329	

Source: Hawkes 1983.

by fire, and others are associated with Recent Lake Alsek and are im primary succession. Area No. 5 Loess Steppes-Sheep Mountain was influenced by fire in the 1740's, and Area No. 9 Shaft Creek white spruce - lichen stand originated fran a fire in the 1840's. Both areas are in late successional stages and will change very little if not disturbed. A fire would initiate an ecosystem which would take about 100 years to redevelop to the present stage.

8.10.3 Post-Fire Recovery and Succession

Hawkes (1983) describes six stages of succession after fire in the context of a montane closed white spruce forest as the climax type. This represents the most comprehensive discussion of succession available for Kluane. The six stages are described in Table 8.18.

8.10.4 Fire Management Concerns in Kluane

Hawkes (1983) also examined the present fire environment in Kluane, and on the basis of past patterns and present conditions, made recommendations on a fire management strategy for the Park.

Hawkes concluded that past fires have played an important role in ecosystem development in Kluane. The decision to return to a natural fire regime will allow these patterns of renewal and succession to be reestablished. However, the decision also presents Parks Canada with several key issues, all related to the need to develop a vegetation management plan before proceeding to the fire management plan stage. The object of allowing wildfire in Kluane is to recreate a natural vegetation succession pattern. Van Wagner & Methven (1980) state that what the Park Manager really wants is not the natural fire regime per se but rather the vegetation complex that the natural fire regime would have created. Given the level of human interference in the Park both in causing and latterly suppressing fire, Parks Canada must first decide what the natural vegetation pattern is and whether perpetuation of that pattern will meet vegetation management objectives. There are three vegetation regime options according to Hawkes (1983):

1. the regime which results from only lightning fires:
2. the regime which resulted from lightning and Indian-caused fires (i.e. the pattern existing about 1880); and
3. the regime which resulted from lightning, Indian, and European-caused fires (i.e. the pattern existing about 1940 before active fire suppression).

Policy decisions will also be required to deal with fire in Special Preservation Areas. In some cases, fire would 'destroy' the community being given special protection. Alternatively in areas like the Alsek Valley, fire could be used to perpetuate the vegetation complex which makes the area excellent grizzly bear habitat.

Table 8.18 Stages of post-fire recovery and succession - Kluane National Park.

Stage	Duration	Description/Comments	Example Locations in Kluane National Park
- Newly burned	1 month - 1 yr.	- forest floor dominated by charred mosses, shrub snags, and exposed mineral soil. -no living vegetation is present -duration depends on the time of year of the burn, the depth of burn, and the available seed source.	-. only example outside Kluane near Canyon ck. where the effects of a fire in 1980 were observed by Hawkes in 1981.
I - Seedling/Herb	- 15 years.	duration again depends on depth of burn. if depth is low to moderate, sprouts from live roots and rhizomes in the organic layer & soil appear in several weeks. species such as trembling aspen, balsam poplar, shrub birch, willows, alder, buffaloberry, and rose sprout quickly in these situations. herbs such as fireweed and various grasses sprout or seed in from nearby areas. pioneer mosses such as Polytrichum juniperum, invade on bare mineral soil. except for feathe mosses and lichens most trees and other plant species become established at this stage,	. Canyon Creek 1980 fire in an adjacent area which was not burned intensively.
II - Tall shrub/ Sapling	- 80 years.	tall willow and alder shrubs and sapling-sized white spruce, trembling aspen and balsam poplar dominate. herb layer continues to expand vegetatively. the Salix glauca community type is the most widespread example of this stage of succession. a 120-year old stand of S. glauca resulted from a 55-year white spruce regeneration delay.	. areas burned about 1915 near Kathleen Lake and the Haines Road are in this stage.

Table 8.18 Stages of post-fire recovery and succession - Kluane National Park (Concluded),

Stage	Duration	Description/Comments	Example Locations in Kluane National Park
V - Pole	.0 - 100 years	dominated by pole-sized trees of small diameter with the canopy starting to close. may be predominantly deciduous, mixed, or coniferous. initial shrubs and herbs are shaded out and feather mosses start to dominate the forest floor in conifer stands. deciduous and mixed stands retain an extensive low shrub/herb understory.	P. tremuloides/Arctostaphylos uva-ursi community between Dezadeash and Kathleen lakes on the Naines Road. stand originated about 1889. well developed shrub/herb understory which includes some white spruce saplings also P. glauca/S. glauca community originating about 1884 near Quill Creek on Naines Road.
' - Mature Tree	.00 - 200 years	dominated by mature deciduous, mixed, or coniferous stands. hardwood species reach their pathological age and are replaced by white spruce. extensive understory in deciduous and mixed stands. coniferous stands retain their feathermoss understory.	Hush Lake road in a mature P. glauca/P. tremuloides/Shepherdia/Linnaea stand originating about 1851. near Kathleen Lake burn mature P. glauca/S. glauca community originating around 1835. Few shrubs and herbs remain in the understory.
'I - Mature White Spruce	150 400 years	only minor changes in overstory and understory will occur. white spruce tends to develop stem rot which results in decreasing stand density and more openings with age. susceptible to the Spruce Bark beetle at this stage, an outbreak of which occurred in KNP in the 1940's. feathermosses still dominate the forest floor but the shrubs and herbs understory is moderately well developed.	Fraser Creek area, mature P. glauca/S. glauca community originating about 1592. Stand shows effects of beetle infestation in 1940's.

Source : Hawkes 1983.

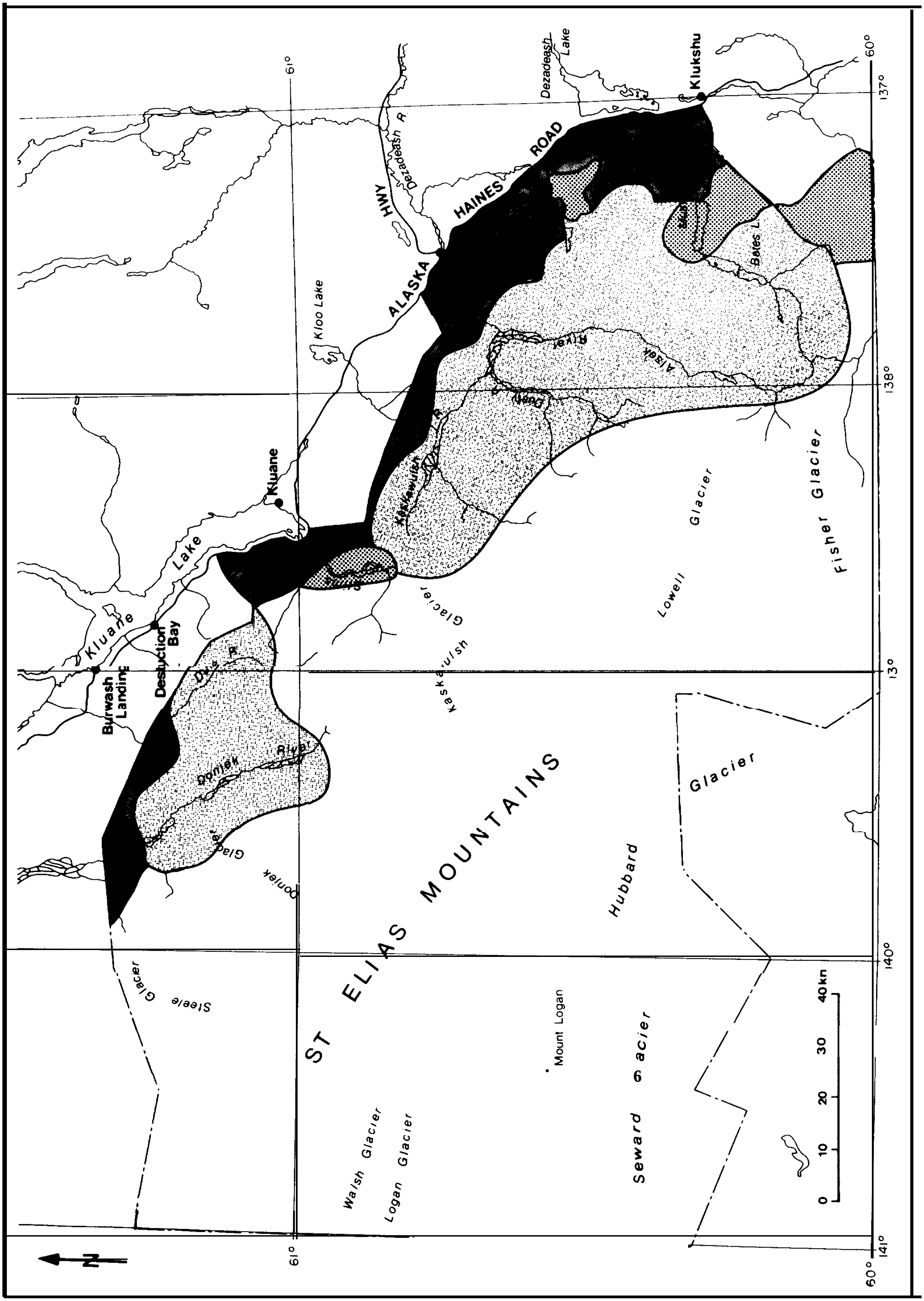
The Fire Management Plan which evolves must have considerable flexibility to deal with problems imposed by largely artificial Park boundaries, by public safety concerns, and special preservation areas, among others.

As a point of initial discussion, Hawkes (1983) proposed a range of fire management strategies each appropriate to the special constraints and conditions occurring in various areas of the Park, park management objectives, and the fire control capability at hand. Figure 8.3 shows the four proposed fire management zones in Kluane. Critical protection zones are confined to the Alaska and Haines highways where lodges, Park facilities, and public safety considerations make immediate and aggressive suppression of all fires necessary. Full Protection Zones comprise the side valleys off the main Shakwak Valley where continuous forest cover would allow fire to spread rapidly. The lower Slims Valley and Alder creek Valley are included here. Fires in these areas would receive immediate suppression. Prescribed fire would be the only means of manipulating the vegetation complex in these areas. The Modified Action Zone would receive initial fire suppression activity only at certain times of the year (e.g. summer). If initial attack fails, continued action may or may not be taken depending on specific conditions at the time. Action would be taken if fire threatened to burn into the full protection zone, particularly in summer or in spring and fall in deciduous areas, or if the fire could burn across the border into British Columbia. The Slims Valley is included in this zone to take account of the public safety concerns tied to extensive use of the area by hikers. If the Slims Valley Access Road and associated facilities are constructed, fire protection for this area would be upgraded. The Limited Action Zone covers most of the backcountry areas of Kluane. Natural topographic breaks and features and low fire hazard would provide the prime control for fire in these areas, but monitoring would be essential to ensure containment within this zone.

8.11 Forest Insects and Diseases

The Kluane Park Conservation Plan (Parks Canada 1984) described the potential forest insect and disease problem in the following way.

> "Over 80 species of endemic forest insects and diseases have been identified through random, low intensity field surveys in the Kluane ecoregion. Several of these capable of sudden, damaging outbreaks, of an intensity and extent to produce catastrophic epidemics, affecting neighbouring lands and the aesthetic value and quality of visitor experience. Since most insects and diseases of forest trees are limited rather sharply to one or a few host species, the pure white spruce stands covering large areas of Kluane present great opportunity for epidemic outbreaks. Every tree offers food and a breeding place and potentially destructive concentrations can readily multiply


ALASKA HAINES HWY ROAD
Klukshu
Dezadeash Lake
Dezadeash R.
Kloo Lake
Kluane
Kluane Lake
Destruction Bay
Burwash Landing
Alsek River
Duke R.
Kaskawulsh R.
Kaskawulsh Glacier
Donjek River
Donjek Glacier
Bates L.
Lowell Glacier
Fisher Glacier
Hubbard Glacier
ST ELIAS MOUNTAINS
Steele Glacier
Mount Logan
Seward Glacier
Walsh Glacier
Logan Glacier
N
0
10
20
30
40km
60°
61°
137°
138°
139°
140°
141°

KLUANE NATIONAL PARK RESERVE

Figure 8.3 Proposed fire management zones - Kluane National Park.

- Critical protection
- Full protection
- Modified action
- Limited action

resulting in widespread defoliation and deforestation. the form, type and distribution of the vegetation itself has far-ranging effects on insect distributions since it provides not only nutrient input but also physical protection from the vagaries of climate - closely linked to the virulence of populations.

Further ecological interrelationships produce significant effects on wildlife species. Epidemics can also pose a real danger to rare flora, plant associations, or other facets of Special Preservation **Areas, as** identified in the Park Management Plan. Indirectly, forest insects and diseases can **create a** hazard to Park facilities or developments by providing dead stands which **are easily** ignited and supply excellent fuel for wildfire to burn over **large areas.".**

(Parks Canada **1984:58)**

The following discussion is based on a **summary** of observations in Yukon since 1952, provided by staff of the Forest Insect and Disease Survey, Pacific Forest Research Centre **(Unger & Loranger** 1983).

8.11.1 Spruce Pests

Spruce beetle - Dendroctonus rufipennis

Infestations of spruce beetle are associated with site disturbances, such as construction, blowdown, logging, and road salt damage. Populations build up in dead or damaged trees and can increased **dramtically** if climatic conditions are favourable, resulting in extensive areas of spruce mortality. An infestation occurred as a result of highway construction in the early 1940's and extended from the B.C. border through the Mush-Dezadeash lakes area to Champagne. **Mortality** varied from 90% in the Tatshenshini Valley to 40% near **Dezadeash Lake and** River. Between 1977 and 1980, beetle activity was confined to occasional weakened and road side trees near Haines Junction. Unger **& Loranger (1983)** consider that the spruce beetle poses **a** threat to spruce stands in the Park and recommend that in **areas** where construction or natural phenomena (landslides, flooding, blowdown) kill or weaken trees, **carefuly** evaluation should be made of the need to remove or destroy the trees or at least to monitor the possible build up of a beetle population.

Root and **heart rot -** Polyporus tomentosus, P. sulphureus, and Fomes pini.

These diseases structurally weaken the trees they infect. In 1981-82, about 15% of trees in the Congdon Creek and Horseshoe Bay campsites (just outside but adjacent to the Park along the west side of Kluane Lake) were infected and, as **a** result of the associated public safety hazard from blowdown, the Horseshoe Bay campsite **was** closed. Unger & Loranger (1983) suggest that tree by tree examination is warranted when declining tree vigour, distress cone crops, and windthrow are noted as indicators of suspected root or heart rot.

Spruce broom rust - Chrysomyxa arctostaphyli

This perennial and systemic rust forms large withces' brooms on spruce, causing branch, top, and occasionally tree mortality. The large brooms can be hazardous in public areas and removal may be recommended. The disease is common the white and black spruce from Kathleen Lake to Beaver Creek.

Spruce budworm - Choristoneura sp.

The only infestation of spruce budworm in the Park area occurred in 1962-64 when 1000 ha of spruce near sheep Mountain were lightly to moderately defolaited. No significant tree damage was recorded.

Blackheaded budworm - Acleris gloverana

In 1979, the blackheaded budworm caused light defoliation of white spruce near Haines Junction. It is not a major pest in the Park area.

Spruce needle rust - Chrysomyxa woronii

This and other needle rusts occasionally cause extensive foliage discolouration but little long term damage other than incremental loss to spruce stands in the Kluane area. Infections occurred near Kluane Lake in 1966 and 1974.

8.11.2 Trembling Aspen Pests

Large aspen tortrix - Choristoneura conflictana

In the Kluane area, outbreaks of large aspen tortrix have occurred about every ten years and last approximately two to three years. During infestation, larvae totally destroy early spring foliage. Population collapse occurs when the foliage supply is exhausted before the larvae mature. Refoliation usually occurs during summer. Successive years of defoliation result in reduced growth, branch mortality, and sometimes tree mortality, the latter usually only on submarginal sites. Only one infestation has occurred in the Park area proper. In 1968-69, light to severe defoliation was concentrated in the Dezadeash Valley near Haines Junction. Natural control usually keeps infestations of C. conflictana in check but in high use areas where P. tremuloidesis dominant, control may be warranted if populations persist for more than two years.

Mortality due to Unknown Causes

Trembling aspen mortality of up to 50% over one to five hectares was observed in the Haines Junction area between 1980 ad 1982. Climatic factors are believed to be important but the exact cause has not been identified.

8.11.3 Multiple Host Pests

Winter dessication can cause discolouration of foliage and bud damage: successive years of severe winter drying may kill trees. All conifers are susceptible but damage is most conspicuous on lodgepole pine. In 1981 and 1982, winter dessication was noted on lodgepole pine and white spruce along the Alaska Highway north of Kluane Lake.

Application of road salt, calcium chloride, on the Alaska Highway causes shoot mortality and eventually tree mortality in trees within about 6 m of the road. Less severe damage occurs up to 10 m from the road. Injured trees have been recorded annually along the Highway since 1979.

8.12 Evaluation

8.12.1 Scientific Research

Douglas (1980) has documented the montane vegetation patterns of Kluane but considerable work remains to be done on the alpine and subalpine communities, particularly in terms of succession.

No authoritative designation of rare or unusual plants is available for the Park. This could be tied to the need for detailed documentation of the resources of the Park's 14 Special Preservation Areas, at least 10 of which support unique or important vegetation communities. Information on these areas is essential for development of the vegetation and fire management plans.

The study and mapping of wildlife habitat on the basis of vegetation patterns is a necessary tool in planning for future Park development. Studies of this nature would be particuarly useful for species such as grizzly bear. If development of backcountry access in the Mush-Bates area goes ahead as planned, the potential for man-bear encounters will increase markedly. Habitat mapping in this area would aid in location of trails and primitive camping areas and perhaps in the timing and control of activities in the area to minimize the changes of an encounter. This approach would reduce the need for intrusive bear studies involving tranquillizing and collaring etc., actions the Warden Service does not want to initiate in Kluane where man-bear contact has been essentially non-aggressive to this time. Wildlife-related habitat studies are also essential to the development of the vegetation and fire management plans so that appropriate decisions on vegetation patterns and the extent to which fire should be allowed to intervene in certain areas can be made.

The Slims Delta provides an opportunity for study of a unique halophytic vegetation community. Training of the Slims River under the Alaska Highway bridge has changed the character of the parts of the Delta immediately upstream and provided protection from disturbance which would not exist naturally. Vegetation succession is beginning to occur in these areas and offers an excellent opportunity for study. The Slims Delta was designated a Special Preservation Area on the basis of these unusual plant communities. If the communities or their relative locations are now changing in response to both natural and man-caused events, research in this area would aid Parks Canada in making appropriate longtenn management decisions.

8.12.2 Interpretation

Douglas (1980) suggests the following areas as potential interpretation points in Kluane:

1. The halophytic plant communities on the Slims Delta and floodplain, and the dry steppe grassland communities of the lower slopes of Sheep Mountain could be integrated into a detailed interpretation program for the Slims Valley area.

2. The following areas are suggested as providing examples of typical or representative vegetation communities:

   - Sheep-Bullion Plateau, Observation Mountain -- subalpine and alpine vegetation typical of the central region.
   - Marble Creek, Shorty Creek, and Goatherd Mountain -- examples of subalpine and alpine vegetation typical of the southern region of the Park.
   - Hoge Creek and the Steele Glacier areas -- examples of subalpine and alpine communities typical of the northern region.
   - Alder Creek near Mush Lake -- examples of fens and bogs typical of Kluane National Park.

3. The primary succession communities on the beach ridges and lakebed of Recent Lake Alsek could provided the starting point for interpretation of succession in the Park and could also form part of an interdisciplinary interpretation of the formation of glacier-dammed lakes and their extent and role in the Park.

4. Sand dunes colonized by the rare sedge, Carex sabulosa, are located near the Dezadeash-Kaskawulsh river junction. Discussion of other rare plants could include the unusual disjunct taxa present in the Park and the theories proposed to account for their present distributions. This ties in well with interpretation of the glacial history and human prehistory of the Park.

8.12.3 Limitations to Use

Special Preservation Areas

The Kluane National Park Management Plan designates 14 Special Preservation or Zone 1 areas in the Park. These have been set aside for special protection and management because they contain unique or representative plant or animal communites or landscape features. The following Zone 1 areas, numbered according to the Management plan, have a notable vegetation component:

1. Steele creek Alpine - this area contains several rare plants and is the best representation in the Park of the Northern Alpine Ecosystem.

2. Mt. Hoge/Donjek Valley - contains rare and fragile plant communities such as Oxytropis viscida; mainly a wildlife area.

3. Duke River Headwaters - the only known Yukon occurrence of Braya purpurascens (R. Br.) Bunge has been documented in this area.

6. Slims River Delta - three plant communities occurring in this area are considered rare - Aster yukonensis, Puccinellia nuttalliana, and Taraxacum ceratophorum - and all communities on the Delta are uniquely adapted to their saline environment.

7. Alsek Valley - a rare plant community, dominated by Carex sabulosa, occurs on stabilized sand dunes near the junction of the Kaskawulsh and Dezadeash rivers. This species of sedge is known from only one other location in North America. The alpine and subalpine areas of Profile Mountain area also notable as zones overlap in the ecosystems of the coastal and northern areas of North America.

8. Shaft Creek - the Picea glauca-Cladina arbuscula community occurring at the northeast end of Bates Lake is unique in the Park. It is characterized by a scattered white spruce overstory, a very sparse or absent understory, and a continuous moss cover.

LO. Fraser Creek fen - this area is an extremely productive marsh-swamp complex in the Alder Creek Valley. The scarcity of wetlands in Kluane increases its importance as a genetic and ecological reservoir in the Park.

12. Goatherd Mountain - the alpine area of Goatherd Mt. provides the best representation in the Park of the Coastal Alpine Ecosystem.

13. Lower Alsek River - this area experiences the more moderate climate prevalent in southern areas of the Park, provides the best examples of these ecosystems, and protects a landscape and plant species not common in Yukon.

14. Logan Nunatak - the nunataks of Rluane area oases of life in the midst of the Icefields. Despite its extreme isolation, the Logan Nunatak supports a surprising number of plant and animal species.

The Kluane Management Plan states that special management practices will be developed to adequately protect these areas. Currently Zone 1 status prohibits motorized access and provides for strict control or prohibition of activity of **any other** type. However, specific management guidelines have not been prepared for these areas and detailed knowledge of these sites is lacking. The Kluane Park Conservation Plan states:

> "Detailed resource description and analyses, of each Zone 1 **area** do not presently exist to define zone boundaries, resource significance, scientific importance, use restrictions, and special management requirements...no process **has** been developed to make changes to the special preservation areas (additions **or** deletions) as more knowledge of Park resources becomes available...".
>
> (Parks Canada **1984:91**)

The Park Conservation Plan proposed that a Special Preservation Area **Resource** Management Plan be prepared to meet the following objectives:

- establish **and** maintain a resource data base for each area;
- map each area at a **scale** of **1:50,000** or larger;
- **analyze each area** to identify resource significance, resource management objectives and requirements necessary to perpetuate the special natural features in the area;
- identify the type of use compatible with resource protection in each **area:** and
- establish a program to monitor environmental impacts resulting **from** visitor use, management activities, research programs in each area.

<u>Other areas of the Park</u>

In his early work in Rluane Douglas (1974) developed a three-level fragility rating system for the plant communities of the Park, based on the species present, site drainage, soil type and the resistance of te community to various levels of human use. "Very fragile" communities have:

- poor drainage and/or high water tables:

- sparse vegetative cover and periodic high water tables; and
- sparse vegetative cover with soils that contain large percentages of sant or silt which may be **susceptible** to wind erosion.

Fragility is therefore largely related to susceptibility to man-caused surface disturbance in areas Of **wet** surface soil and possible permafrost and in areas subject to wind erosion if the surface is disturbed. "Moderately fragile" **communities** are composed of more resistant plant species or better drained soils. Damage will still occur under conditions of heavy human use. "Moderately resistant" communities generally occur on well-drained soils and are comprised of sturdy and hardy plant species. Areas occupied by these communities would be best able to withstand intensive human activity such as trail **or** campground development. Table 8.19 lists the Park's plant communities and the fragility ratings assigned them by Douglas **(1980).** This classification provides a starting point for planning of new facilities, to be followed by site-specific investigations.

Table 6.19 Vegetation-soil relationships and fragility ratings.

Plant Community	Soil Type	Soil Drainage	Fragility Rating
MONTANE ZONE			
Picea glauca/Cladina arbuscula	orthic regosols	rapidly drained	very fragile
Picea glauca/Betula glandulosa/Empetrum nigrum	orthic regosols, orthic eutric and orthic dystric brunisol	moderately well drained	moderately fragile
Picea glauca/Salix glauca (south-central phase)	orthic regosols, orthic eutric and orthic dystric brunisol	well drained	moderately fragile
Picea glauca/Shepherdia canadensis (closed phase)	orthic regosols, orthic eutric and orthic dystric brunisol	well drained	moderately resistant
Picea glauca/Shepherdia canadensis (open phase)	orthic regosols	rapidly drained	moderately resistant
Picea glauca/Arctostaphylos	orthic eutric and orthic dystric brunisol	well drained	moderately fragile
Picea glauca/Hypnum revolutum	cumilic regosol	well drained	moderately fragile
Picea glauca/Salix glauca (northern phase)	orthic regosols	well drained	moderately fragile
Picea glauca/Thuidium abietinum	orthic regosols, orthic dystric brunisol	moderately well drained	very fragile

Table 8.19 Vegetation-soil relationships and fragility ratings (Continued).

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Picea glauca/Aulacomnium palustre	orthic regosols	moderately well drained	very fragile
Picea glauca-Populus tremuloides/Shepherdia canadensis-Linnaea borealis	orthic regosols orthic eutric brunisol	well drained	moderately resistant
Salix scouleriana/Shepherdia canadensis	orthic regosols orthic eutric brunisol	well drained	moderately resistant
Populus tremuloides/ Arctostaphylos uva-ursi	orthic regosols orthic eutric brunisol	well drained	moderately resistant
Populus balsamifera (mesic)	orthic regosols	well drained	moderately fragile
Populus balsamifera/ Arctostaphylos uva-ursi (south-central phase)	orthic regosols	well drained	moderately resistant
Populus balsamifera/ Shepherdia canadensis	orthic regosols	rapidly drained	moderately resistant
Populus balsamifera/Festuca altaica-Arctostaphylos uva-ursi	orthic eutric bunisol	well drained	moderately resistant
Populus balsamifera/ Arctostaphylos uva-ursi (northern phase)	orthic regosols	rapidly drained	moderately resistant

Table 8.19 Vegetation-soil relationships and fragility ratings (Continued).

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Picea glauca/Betula glandulosa/Carex aquatilis fen	rego and humic, gley-sols, fibrisols, humisols	very poorly drained	very fragile
Picea glauca/Salix planifolia/Carex aquatilis/Sphagnum rubelleum bog	rego and humic gleysols, fibrisols, humisols	very poorly drained	very fragile
Salix/Carex aquatilis/Sphagnum rubellum bog	rego and humic gleysols, fibrisols, humisols	very poorly drained	very fragile
Juniperus communis/Arctostaphylos &a-ursi	orthic regosols, cumilic regosol	rapidly drained	moderately fragile
Salix setchelliana	orthic regosols	well drained	very fragile
Artemisia alaskana	orthic regosols	rapidly drained	moderately resistant
Artemisia frigida/Poa slauca	orthic regosols	rapidly drained	moderately resistant
Dryas drummondii (south-central phase)	orthic regosols	rapidly drained	moderately resistant
Agropyron yukonensis	orthic regosols	rapidly drained	moderately resistant
Hydysarum boreale	orthic regosols	rapidly drained	moderately resistant
Carex sabulosa	orthic regosols	rapidly drained	very fragile

Table 8.19 Vegetation-soil relationships and fragility ratings (Continued).

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Salix glauca (south-central phase)	orthic regosols, orthic eutric brunisol	moderately well drained	moderately fragile
Betula glandulosa/Festuca altaica	orthic dystric brunisol	poorly drained	very fragile
Shepherdia canadensis	orthic regosols	well drained	moderately fragile
Shepherdia canadensis/ Festuca altaica	orthic regosols	well drained	moderately fragile
Juniperus horizontalis	cumulic regosol	rapidly drained	moderately fragile
Festuca altaica	orthic regosols	rapidly drained	moderately fragile
calamagrostis canadensis	orthic regosols	well drained	moderately fragile
Artemisia frigida/Agropyron yukonensis	cumulic regosol	rapidly drained	very fragile
Carex aquatilis and other Slims River floodplain types	saline rego gleysols	poorly drained	very fragile
Salix alaxensis	orthic regosols	rapidly drained	moderately fragile
Salix glauca (northern phase)	orthic regosols, orthic eutric brunisol	moderately well drained	moderately fragile
Betula glandulosa/Salix myrtillifolia/Festuca altaica	orthic eutric brunisol	well drained	noderately fragile

Table 8.19 Vegetation-soil relationships and fragility ratings. (Continued)

Plant Community	Soil Type	Soil Drainage	Fragility Rati
Betula glandulosa/ Aulacomnium palustre	orthtc eutric brunisol	well drained	very fragile
Elaeagnus commutata/Festuca rubra	otthic regosols	rapidly drained	moderately fragile
Dryas integrifolia	orthic eutric brunisol	very poorly drained	very fragile
Dryas drummondii (northern phase)	orthic regosols	rapidly drained	moderately resista
Calamagrostis prupurascens	orthic dystric brunisol	well drained	moderately fragile
Artemisia frigida/Artemisia rupestric	orthic and cumulic regosol	well drained	very fragile
Oxytropis campestris/ Artemisia frigida	orthic regosols	rapidly drained	moderately fragile
SUBALPINE ZONE			
Alnus crisoa var. lacinata	orthic reqosols	well drained	moderately fragile
Salix planifolia	orthic regosols	well drained	modetately fragile

Table 6.19 Vegetation-soil relationships and fragility ratings. (Continued)

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Salix glauca	orthic regosols, alpine dystric brunisol	well drained	moderately fragile
Salix barclayi	orthic regosols	well drained	moderately fragile
Betula glandulosa	orthic regosols	well drained	moderately fragile
Populus balsamifera	orthic regosols	rapidly drained	moderately fragile
Elaeagnus commutata	orthic regosols	rapidly drained	very fragile

Table 8.19 Vegetation-soil relationships and fragility ratings (Continued).

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Arctostaphylos uva-ursi	orthic regosols	well drained	moderately fragile
Empetrum nigrum	orthic regosols	well drained	moderately fragile
Salix barrattiana	orthic regosols, alpine dystric brunisol	well drained	moderately fragile
Calamagrostis canadensis and other lush meadow types	orthic regosols	well drained	moderately resistant
Festuca altaica	orthic regosols	well drained	moderately fragile
Scirpus caespitosus	gleysols	very poorly drained	very fragile
Oxytropis viscida	orthic regosols	well drained	aoderately fragile
Calamagrostis purpurascens	alpine dystric brunisol	well drained	moderately fragile
ALPINE ZONE			
Salix glauca	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	well drained	noderately fragile
Salix barclayi	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	well drained	moderately fragile
Salix brachycarpa	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	well drained	noderately fragile

Table 8.19 Vegetation-soil relationships and fragility ratings (Continued).

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Salix barrattiana	orthic regosols, alpine dystric brunisol	well drained	moderately fragile
Salix arctica	orthic regosols	well drained	moderately fragile
Picea glauca	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	well drained	moderately fragile
Empetrum nigrum	orthic regosols	well drained	moderately fragile
Betula glandulosa	orthic regosols	well drained	moderately fragile
Eriophorum polystachion and other seepage types	gleysols, folisols, peaty orthic regosols	very poorly drained	very fragile
Luzula piperi	orthic regosols	very poorly drained	very fragile
Luetkea pectinata and other snowbed types	orthic regosols	poorly drained	moderately fragile, moderately resistant
Cassiope tetragona	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	well drained	moderately fragile
Festuca altaica	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	well drained	moderately fragile
Vaccinium uliginosum	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	rapidly drained	moderately fragile

Table 8.19 **Vegetation-soil relationships and fragility ratings (Concluded).**

Plant Community	Soil Type	Soil Drainage	Fragility Rating
Dryas octopetala	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	rapidly drained	moderately fragile
Kobresia myosuroides	orthic regosols, alpine eutric brunisol, alpine dystric brunisol	rapidly drained	moderately fragile
Cetraria nivalis	orthic regosols	rapidly drained	very fragile

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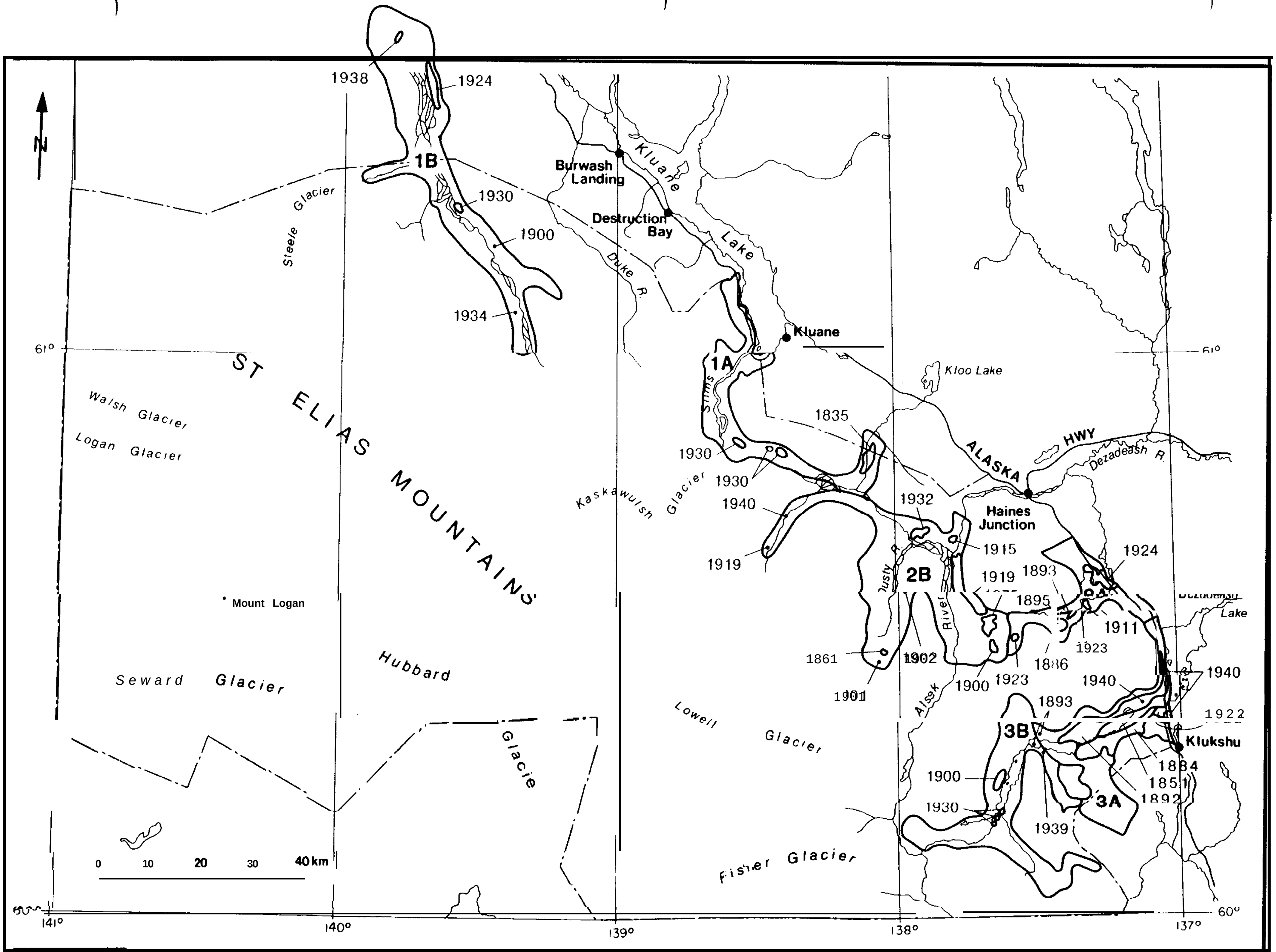

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Map 8.1 Fire history study areas and fires occuring therein 1880-1940, Kluane National Park.

APPENDIX

8.1 The vascular plants of Kluane National Park.

8.2 Mosses of the Kluane National Park area.

8.3 Lichens of the Kluane National Park area.

IX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Lily Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
etaceae	quisetum arvanae	Common or Field Horsetail		D, Me	1	Y-G, D-2, D,N
	fluviatile L.	Water horsetail		Aq, R		D-2, N
	hyemale L.	Scouring-rush		Me, H		D-2
	hyemale L. var. callfornicum Milde	Scouring-rush		Me-H		N
	palustre L.	Marsh horsetail		Me-H, Ri	20	12, D-2 D, N
	pratense Ehrh.	Shady horsetail, Meadow horse-tail		H, Me		D-2, D, N
	scirpoides Michx.	Sedgelike horsetail		H, Ri	1, 20	12, M-G. 3-2, D, N
	sylvanicum L.	Wood horsetail		H		D-2
	variegatum Schleich.	Variegated horsetail		Ri, We	1	4-G. D-2
	variegatum Schleich. var. alaskanum Eat.	Variegated horsetail		Ri, Me		N
	variegatum Schleich. var variegatum	Variegated horsetail		ii, Me		N

X 8.1: **The Vascular Plant Species of Kluane National Park Reserve.**

ly Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
diaceae						
	Athyrium filix-femina (L.) Roth.	Lady fern		Me, H, S-Sl		3-2
	Cryptogramma criopa **(L.)R.Br.** **ssp.** aeroetichoidas **(R.Br.) Hult.** var. eitcheneis **(Rupr.)** Chr.	Mountain-parsley		R, T		N
	C. crispa (L.) R.Br.	**Mountain-parsley**		R, T		)-2
	C. stelleri **(Gmel.)** Prantl	Slender cliff-brake		Si, R		N
	Cystopteris fragilis (L.) Bernh. var. fragilis **f.** dickieana **(Sim)** Boivin	Fragile fern		1, Sl, R, T		3
	C. fragilis **(L.)** Bernh.	Fragile fern		A, R	20	42, D-2
	C. fragilis **(L.)** Bernh. var. fragilis	**Fragile** fern		1, Sl, R, T		N
	C. montana (Lam.) Bernh.	**Mountain** bladder-fern		T, H, R		)-2, N
	Dryopteris austriaca **(Jacq.)** Woynar var. auatriaca	**Spinulose** shield-fern		I, He		N
	D. austriaca **(Jacq.)** Woynar	**Spinulose** shield-fern		1, Me		)-2
	D. fragrans **(L.) Schott**	**Fragrant** cliff-fern		R		)-2, N
	Gymnocarpium dryopteris (L.) **Newm.**	**Oak-fern**		I		1-2, N
	Polypodium vulgare L. var. columbianum Gilbert	**Licorice** fern		?, H		)-2

APPENDIX 8.1: The Vascular Plant **Species of Kluane National Park Reserve.**

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	eferences[6]
olypodiaceae Cont'd.)						
	Polystichum braunii (Spenner) Fée var. braunii		R	, T		
	P. lonchitia (L.) Roth	Iolly fern	R	;, Me	2	)-D, D-2, N
	Thelypteris phegopteris (L.) Slosaon	,ong beech fern		Ri, H		3
	Woodsia alpina (Bolton) S.F. Gray	lorthern woodsia		', R		j-2, N
	W. glabeila R. Br.	imooth woodsia		I	20	12, D-2, N
	W. ilvensis (L.) R.Br.	lusty or Fragrant uoodsia		R, T		)-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Pinaceae (Pine family)	Juniperus communis L. var. montana hit.	Common juniper		le, R		)-2, D, N
	J. communis L.	Common mountain juniper		la, R	1	4-G
	J. horizontalis Moench	Creeping eavin (juniper)		ι, Ri		b-2, D, N
	Picea glauca (Moench) Voee	White spruce			1	4-G, D-2D), N
	P. glauca Wench) Voss var. porsildii Raup	White spruce				
	P. mariana (Hill.) BSP.[7]	Black spruce[7]				)-2
	Pinus contorta Dougl.	Shore pine, Lodgepole pine				)-2
Sparganiaceae (Bur-reed family)	Sparganium anguatifolium Michx.	(Narrow-leaved bur-reed)		\q		)-2, N
	S. hyperboreum Laest.	(Northern bur-reed)		\q		)-2, N
	S. multipedunculatum (Morong.) Rydb.	bur-reed		\q		)-2

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumanted ccurrences[5]	eferences[6]
osteraceae (Pondweed family)	otamogeton alpinus Balbis	ondweed		q		)-2
	). alpinus Balbis var. tenuifolius (Raf.) Ogden	ondweed		q, Ri		
	). bsrchfoldii Fieber	ondweed		q		b-2, N
	). filiformis Pers.	ondweed		q		b-2, N
	). gramineus L.	various-leaved pondweek)		q		)-2, N
	). natans L.	ondweed	R	q		
	). pectinatus L.	Sago pondweed, fennel-leaved ondweed		q		l-2, N
	). perfoliatus L. ssp. richardsonii (Benn.) Hult.	ondweed		q		)-2
	annichellia palustrie L.	orned pondweed		q	3	)-D, D-2
uncaginaceae (Arrow-grass family)	riglochin maritima L.	Seaside arrow-grass)		la, Ri		)-2, N
	r. palustris L.	Marsh arrow-grass)		le, Ri		)-2, D, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
raminae (Grass family)	**grohordeum macounii (Vasey)** Lepage					¦
	rgropyron **macrourum (Turcz.) Drobov**			le, **Ri, H**		(
	. trachycaulum (Link) **Malte** var. **latiglume (Scribn. & Sm.)** Beetle	Broad **glumed wheatgrass)**		la, **Ri,** H, A , **Sl**	20	a-2, N, D d-2
	. trachycaulum (Link) **Malte** var. **majus (Vasey) Fern.**	Broad **glumed** wheatgrass)		le, **Ri, H**		, D, D-2
	. trachycaulum (Link) Malte var. **unilaterale (Cassidy)** Malta	Broad **glumed** wheatgrass)		la, **Ri, H**		)-2, D
	. yukonense **Scribn. 6 Herr.**	**Yukon** wheatgrass)				)-2, D, N
	grostis borealis Hartm.	entgraes		)		(
	. exerata **Trin.** var. exarata	pike **redtop**		)		)-2
	. hyemalis (Walt.) **BSP var. geminata (Trin.) Hitchc. f.** geminata	airgrass, Ticklegrass		)		(
	. hyemalis (Walt.) **BSP. var. tenuis (Tuck.) Gl. f. tenuis**	airgrass, Ticklegrass		)		)-2, N
	ira caryophyllea **L.**	ilver hairgrass		), O		)-2

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Gramineae (Grass family) (Cont'd.)						
	Alopecurus aequalis Sobol.			q, Ri, D		D-2, N
	A. alpinus Sm.	Alpine foxtail		, Me, Ri		D-2, N
	Arctagrostis latifolia (R. Br.) Griseb.	[Polar grass)		e	20	M2, D-2
	A. latifolia (R. Br.) Griseb. var. arundinacea (Trin.) Griseb.	[Polar grass)		e		D, N
	A. latifolia (R. Br.) Griseb. var. latifolia	[Polar grass)		e		N
	A. latifolia (R. Br.) Griseb. var latifolia f. latifolia					
	Arctophila fulva (Trin.) Rupr.			i, He		D-2, N
	Beckmannia syzigachne (Steud.) Fern	Slough grass		q, Me		D-2
	B. syzigachne (Steud.) Fern. var. uniflora	Slough grass		q, Me		N
	Bromus carinatus Hook. & Arn.	California brome		le, 0, H, D		D-2
	B. ciliatus L.	Fringed brome		le, H		D-2, D, N
	B. inermis Leyss.	Awnless or Hungarian brome			1	M-G, D-2

APPENDIX 8.1 : The Vascular Plant species of Kluane National Park Reserve.

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat'	ocumented ccurrences[5]	teferences[6]
raminae (Grass family) **(Cont'd.)**	Festuca altaica Trin.	tough fescue		I, He, R		I-2, H-G,)-2, D, N
	F. baffinensis Polunin	fescue		), R		I-2, D-2, N
	F. ovina L.	iheep's fescue		), R		)-2
	F. ovina L. var. brachyphylla (Schultes) Piper	Alpine fescue		I, O, R	1, 10	12, M-G, D-2), N
	F. ovina L. var. saximontana (Rydb.) Gl.	iheep's fescue		), R		j-2, N
	F. ovina L. var. vivipara L.	iheep's fescue		), R		I
	F. rubra L.	ted fescue		ti, O	20	)-2, D, N
	F. rubra L. var. arenaria (Osbeck) Fries	ted fescue		ti, O	20	62
	Glyceria borealis (Nash) Batch.	small floating manna-grass		le, Aq		I
	G. grandis Wats.	teed-meadow grass		ti, Me		)-2
	G. maxima (Hartm.) Holmb.	nanna-grass				I
	G. pauciflora					I
	G. pulchella (Nash) Schum.	lanna-grass		lq, Me		I
	Helictotrichon hookeri (Scribn.) Henrard	spike oat		il, Me		)-2

APPENDIX 8.1: The Vucular Plunt Species of Kluane National Park Reserve.

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	References[6]
raminae (Grass family) (Cont'd.)						
	Hierochloë alpina (Sw.) R.& S.	(Holy grass)		), R	20	M2, Q-2, N
	H. odorata (L.) Beauv.	Vanilla, Indian or Sweet grass		le, Ri	20	M2, Q-2, D,[illegible]
	Hordeum jubatum L.	Squirrel-tail grass		), Ri, D		D-2, D, N
	Koeleria asiatica Oomin			Ri, 0		D-2
	Muhlenbergia richardsonis (Trin.) Rydb.			I, Ri, R		D-2. N
	Phalarie arundinacea L.	Reed canary-grass		Ri, Me		D-2
	Phippsia algida (Soland.) R. Br.			), T	4	M2, D-D, D-[illegible] N
	Phleum alpinum L.	Mountain timothy		Ri, Sl, Me		D-2, D, N
	P. pratense L.	Common timothy				D-2, N
	Poa abbreviata R. Br.	bluegrass		il, Ca		N
	P. alpigena (Fries) Lindm.	bluegrass				N
	P. alpina L.	Alpine bluegrass		Ri, R, Ca	20	M2, D-2, D,[illegible]
	P. ampla Herr.	Big bluegrass (Alkali blue-grass)	R	le, Sl		D, N
	P. arctics R. Br.	(Arctic bluegrass)		Ri, O	20	M2, D-2, D,[illegible]
	P. arctica R. Br. var. arctica f. arctica	bluegrass		Ri, 0	20	t42, D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Gramineae (Grass family) (Cont'd.)						
	Poa canbyi (Scribn.) Piper	bluegrass		R, Ca		D-2, N, D
	P. compressa L.	Wiregrass				Q-2
	P. cusickii Vasey	(Cusick's bluegrass)		D, R, Sl		D-2, D, N
	P. glauca Vahl	(Glaucous bluegrass)		Ca, R	20	M2, D-2, D, N
	P. glauca Vahl ssp. _conferta_ (Blytt) Lindm.	bluegrass		Ca, R		N
	P. glauca Vahl ssp. glauca	bluegrass		Ca, R		D-2, D
	P. juncifolia Scribn.	Alkali bluegrass		D, He		D-2
	P. leptocoma Trin.	(Bog bluegrass)		Ri, Me		3-2, D, N
	P. nemoralis L.	bluegrass		M, Sl, Ri		3-2, N
	P. nemoralis L. var. _interior_ (Rydb.) Butters & Abbe	bluegrass		M, Sl, Ri		
	P. nevadensis Vasey	Nevada bluegrass		Me, Ri		D-2
	P. palustris L.	Fowl meadow-grass		I, Me, Ri	1	I-G, b-2, N
	P. pratensis L.	Kentucky bluegrass		Me, Ri, O		D-2, N
	P. sandbergii Vasey	(Sandberg's bluegrass)		M, O, Sl, R de		1-W. D
	P. stenantha Trin.	bluegrass				D-2

APPENDIX 8.1: The Vaaoular Plant Species of Kluane National Park Reserve. (Continued)

Family Name	Scientific Name[1]	Common Name[2]	Status'	Habitat[4]	Documented Occurrences[5]	References[6]
Graminae (Grass family) (Cont'd.)	Puccinellia anguatata (R.Br.) Rand & Redf.	alkali grass		O, D		N
	P. arctica (Hook.) Fern & Weath.	alkali grass		Ri		D-2
	P. deschampsioides Soer.	alkali grass		O		N
	P. distans (L.) Parl.	alkali grass		Ca, D		D-2
	P. hauptiana (Krecz.) kitagawa	alkali grasa		Ri		N
	P. interior Soer.	alkali grass		O		D, N
	P. nutkaënsis (Presl) Fern. & Weath.	alkali grass		Ri		N
	P. nuttalliana (Schultes) Hitchc.	alkali grass		Ri		D-2, N
	P. sibirica Holmb.	alkali grass		Ri		N
	Stipa comata Trin. & Rupr.	Needle-and-thread, Speargrass		O		N
	S. occidentalis Thurb.	feathergrass		O		D-2, D
	S. occfdentalis Thurb. var. minor (Vasey) Hitchc.	feathergrass		O		N
	Trisetum spicatum (L.) Richter			O, Me, Sl, Ri	20	D, D-2, M2
	T. spicatum var. molle (Michx.) Seal			M, A, O, Me, Sl, Ri	1	M-G, N
	T. spicatum var. spicatum			O, Me, Sl, Ri		I

APPENDIX 8. 1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	References[6]
yperaceae (sedge family)	ırex aenea Fern.	sedge		), H		N
	albonigra Mack.	sedge		), Sl, Ri	20	M2, D-2, N
	aquatilis Wahl.	(Water sedge)		Ye, Ri, M	1	Y-G, D-2, D
	. aquatilis Wahl. var. aquatilis	(Water sedge)		Me, Ri		N
	aquatilis Wahl. var. stans	sedge		Me, Ri	20	M2, N
	. anthoxanthea Presl	sedge		H		N
	. argyrantha Tuckerm.	sedge		Ri, M	1	U-G
	. atherodea Spreng.	sedge		Me, Ca, Ri		D-2, N
	. atrata L.	(Blackened sedge)		O, Sl, Me		D
	. atrata L. var. atrosquama (Mack.) Cronq.	sedge		O, Sl, He		D-2, N
	. atraformis Britt.	sedge		Ri, Sl, Ca		D-2
	. atraformis Britt. ssp. raymondii (Calder) Scoygan	sedge		Ri, Sl, Ca		N
	, atrofusca Schkuhr	sedge		), Ca	20	M2, N
	, aurea Nutt.	sedge		Me, Sl, Ca		D-2, N
	, bicolor All.	sedge		Me, Ri, Ca		N
	, bigelowii Torr.	sedge		3, Sl, Me		J-2, N
	brunnencens (Pars.) Poir.	sedge		H		D-2
	brunnescens (Pers.) Poir. var. brunnescens	sedge		H		N
	buxbaumii Wahl.	sedge		Ri, Me		N
	canescens L.	sedge		Me, H		)-2, N
	capillaris L.	sedge		Ri, M, H, Me Ca	1, 20	M2, M-G, D-2 N

APPENDIX 8.1: The Vascular Plant **Species of Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	Reference&
Cyperaceae (sedge **family) (Cont'd.)**						
	Carex capillaris L. ssp. capillaris	sedge		**Ri,** N, **Me,Ca**		N
	C. **capillaris L.** ssp. **krausei (Boeck.) Böcher**	sedge		**Mi,** H, He, Ca		N
	C. capitata **L.**	sedge		**O, Sl**		D-2, N
	C. circinnata Meyer	sedge				D-2
	C. concinna **R. Br.**	Low northern sedge		H, 81, Ca		D-2, D, N
	C. crawfordii Fern.	sedge		0		D-2
	C. deflexa Hornem.	sedge		H, **Sl**		N
	C. diandra **Schrank**	sedge		**C,** Me		D-2, N
	C. disperma Dewey	sedge		**H**		D-2, N
	C. eburnea **Boott**	sedge		Ca, **R**		N
	C. eleusinoides Turcz.	sedge		**Sl, R**		N
	C. filifolia Nutt.	(Thread-leaved sedge)		**O, Sl**		D-2, **D,** N
	C. flava **L.**			Me. **Ri**		D-2, N
	C. garberi Fern. var. bifaria Fern.	sedge		Ca. **R**		N
	C. glacialis Hack.	sedge		Ca, **R**		D-2, N
	C. gynocrates Wormsk.	(Yellow bog sedge)		C		D-2, D. N
	C. heleonastes Ehrh.	sedge		Me, **Ri,** Ca		N
	C. kelloggii **Boott**	sedge		**Me, Ri**		N
	C. lachenalii Schkuhr	sedge		Ca		D-2, N
	C. lenticularis Michx.	sedge		Me, **Ri**		D-2, N
	C. leptalea Wahl.	sedge		**H**		D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status [3]	Habitat[4]	Documented Occurrences[5]	References[6]
Cyperacea (Cont'd.)						
	Carex limosa L.	edge		C, Ri		)-2, N
	C. livida (Wahl.) Willd.	edge		Ca, Me, C		
	C. loliacea L.	edge		Ri		
	C. lugens Holm	edge		0		
	C. macloviana d'Urv.	edge		0, Sl, A-Me		)-2
	C. macloviana d'Urv. var. macloviana	Thick-headed sedge)		0, Sl, A-He		), N
	C. maclovians d'Urv. var. microptera (Hack.) Boivin	edge	R	0, Sl, A-Me		
	C. macrochaeta May.	edge		Ri, Me		b-2, N
	C. maritima Gunn.	Maritime sedge)		0	20	l2, D-2, D,N
	C. media R. Br.	edge		H, Ri, Ca		)-2, N
	C. membranacea Hook.	edge		Ri, 0	20	l2, D-2, N
	C. mertensii Prescott	edge		Sl		l-2
	C. microglochin Wahl.	edge		Ca, C		'-2, N
	C. misandra R. Br.	edge		T, R	20	l2, D-2, N
	C. nardina Fries	edge		Ca, 0, R		)-2, N
	C. nesophila Holm	edge		Sl, He, 0	20	l2, D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Puk Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Cyperaceae (Cont'd.)	Carex nigricans Meyer	sedge		Ca, Sl, 0		D-2
	C. obtusata Lilj.	sedge		O, Sl		D-2, N
	C. parryana Dewey	(Parry sedge)		O, Sl		D-2, D, N
	C. pauciflora Lightf.	sedge		C		D-2, N
	C. paupercula Michx.	sedge		C		D-2
	C. petasata Dewey	sedge		Me, H		D-2
	C. petriocosa Dewey	sedge		Ca, R, 0, Sl		D-2, N
	C. phaeocephala Piper	(Dunhead sedge)		A-Me, Sl		D-2, D, N
	C. podocarpa R. Br.	sedge		A-Ue, Sl		D-2, N
	C. praegracilis Boott	sedge		0, Sl		D-2, N
	C. praticola Rydb.	sedge		Me, H		D-2, N
	C. rossi Boott	(Ross sedge)		O, Me, H		D-2, N
	C. pyrenaica Wahl.	sedge		Ca-A-Sl		D-2
	C. roetrata Stokes	sedge		Ri, Me, Aq		D-2, N
	C. rupestria Bellardi	sedge		Sl, A, R	20	M2, D-2. N
	C. aabuloaa Turcz.	sedge		O, D		D-2
	C. aabulosa Turcr. sap. leiophylla (Mack.) Porsild	sedge		O, D	5	D-D
	C. aaxatilia L.	sedge		Ri, C, Me		D-2, N
	C. acripoidea Michx.	(Single-spike sedge)		M, Me, R, Ri	1,20	M2, M-G, D,N
	C. scirpoidea Michx. var. scirpoidea	sedge		Me, R, Ri		D-2
	C. scirpoidea Michx. var. stenochlaena Holm	sedge		Me, R, Ri		D-2
	C. scopulorum Holm	sedge		A, Sl		N
	C. spectabilia Dewey	sedge		He, A-Sl		D-2

APPENDIX 8.1: **The Vascular** Plant **Species of Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Cyperaceae (Cont'd.)						
	Carex etenophylla Wahl.	sedge		0		D-2
	stenophylla Wahl. var. enervie (Mey.) Kiik.	sedge		0		N
	atylosa Meyer	sedge		0		D-2, N
	supina Wahl. ssp. spaniocarpa (Steud.) Hult.	sedge		R		D-2, N
	tenuiflora Wahl.	sedge		Ri, Me, C,		N
	vaginata Tausch	sedge		Ca, C		D-2, N
	viridula Michx. f. viridula	sedge		Ri, Me, Ca		N
	williamsii Britt.	sedge		R, O		D-2, N
	Eleocharis acicularis (L.) R. & S.	spike-rush		Ri, Aq		D-2, N
	palustris (L.) R. & S.	spike-rush		Me, Aq, Ri		D-2, D, N
	quinqueflora (Hartm.) Schwarz	spike-rush		Ca, Ri, Me		D-2, N
	uniglumis (Link) Schultes	spike-rush		Me, Ri		N
	Eriophorum angustifolium Honckeny	spike-rush		Ri, O		D-2
	angustifolium Honckeny var. triste Fries	cotton-grass		Ri 0	20	D, N . M-2
	brachyantherum Trautv.	(Short-anthered cotton-grass)		Ca, Ri, Me,		D-2, N
	callitrix Cham.	cotton-grass		3, Ca	20	M2, D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane national Park Reserve (Continued).

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
:yperaceae (Cont'd.)						
	Eriophorum russeolum Fries	cotton-grass		Pi		D-2, N
	E. scheuchreri Hoppe	cotton-grass		), Ri		D-2, N
	E. vaginatum L. ssp. vaginatum	cotton-grass		:, Me		M-2, M
	Kobresia bellardii (All.) Degl.	(Bellard's kobresia)		), Ca, R, M	1, 20	M2, M-G, D-2 D, N
	K. sibirica Turcr.			?, O	20	M2, D-2, N
	K. simpliciuscula (Wahl.) Mack			), Sl, Ca		D-2, N
	Scirpus caespitosue L. var. caespitosus	bullrush		., O		D-2
	S. hudsonianus (Michx.) Fern.	bullrush		Me		D-2
	S. lacustris L. ssp. validus (Vahl) Koyama	bullrush		Me, Ri, Aq		N
	S. pumilus Vahl	bullrush	R	:a, Ri, R		D-2, N
.emnaceae (Duckweed family)	Lemna minor L.	Duckweed		Aq		D-2, N
	L. trisulca L.	Star-duckweed		Aq, Ri		D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences	References[6]
Iuncaceae (Rush family)	Juncua alpinus Vill.	(Northern rush)		Me, Ri		D-2, D. N
	J. balticus Willd. var. alaskanus (Hult.) Porsild	(Baltic rush)		Aq	20	M2, D-2, N,[illegible]
	J. balticus Willd. var. montanue Engelm	(Baltic rush)		Aq	2u	M2, D-2, D,N
	J. biglumis L.	rush		T, Ri, O	20	M2, D-2, N
	J. bueonius L.	Toad-rush		O, D		'D-2, N
	J. castaneus Sm.	rush		O, A-Me, Ri	20	M2, D-2
	J. castaneus Sm. ssp. castanaus	(Chestnut rush)		O, A-Me, Ri		D, N
	J. drummondii Meyer	rush		Me, Sl		D-2, N
	5. filiformis L.	rush		Ri, He		D-2, N
	J. mertensianua Bong.	rush		Me, Sl		D-2, N
	J. tenuie Willd.	rush		0		N
	J. triglumis L.	rush		O, Ri, Ca	20	D-2, M2, N
	Luzula arcuata Wahl.	woodrush		0, Sl, Ri		D-2, N
	L. confusa Lindeberg	woodrush		A-Sl, 0	20	M2, D-2, N
	L. multiflora (Retz.) Lejeune ssp. frigida (Buch.) Krecz.	woodrush		O, Me, H		N
	L. nivalis (Laest.) Beurl.	woodrush		0	20	M2, N, D-2
	L. parviflora (Ehrh.) Desv.	(Small-flowered woodrush)		H, Sl		D-2, D
	L. parviflora (Ehrh.) Desv. var. parviflora	(Small-flowered woodrush)		H, Sl		N
	L. rufescens Fisch. & Mey.	woodrush		0, Sl		D-2, N
	L. spadicea (All.) DC.	woodrush		O, Ri, R, T	6,7	D-D, D-2, D
	L. spicata (L.) DC.	woodrush		0, Sl, R	20	M2, D-2, N

APPENDIX 8.1: The Vascular Plant Specie8 of **Kluane National Park Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Liliaceae (Lily family)	Allium schoenoprasum L.	Chives, (Wild chive)		:a, R, Ri		)-2, c
	A. echoenopraeum L. var. sibiricum (L.) Hartm.	Chives		:a, R, Ri		
	itillaria camschatcensis (L.) Ker-Gawl.	Rice-root lily		3, Me, H	2	)-D, N
	oydia serotina (L.) Rchb.	Alpine lily		), Me, Sl	20	12, D-2, c,t
	ilicina etellata (L.) Desv.	Star false solomon's seal		4e, H, Ri		'-2, D, N
	reptopus amplexifolius (L.) DC.	Liverberry, Scootberry, (Cucumber-root, Clasping twisted stalk)		I		)-2, N, C
	streptopoidee (Ledeb.) Frye & Rigg	twisted stalk		I, Sl		I-2
	fieldia coccinea Richards.	false asphodel		:a		'-2, D, N
	pusilla (Michx.) Pare.	(Scotch asphodel, False asphodel)		:a, M, Me	1, 20	12, M-G, D-2, I, N, C
	ratrum viride Ait.	White hellebore, Indian poke		Me		I-2, D
	gadenus elegans Pureh	White camass, Alkali grass, (Elegant death camass)		), Me, H, M, Ri	1, 20	12, D-2, H-C, I, N, C

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
:ridaceae (Iris family)	**Iris setosa** Pallae	Beachhead-iris, Beachhead-flag		Ri		D-2
	Sisyrinchium angustifolium Mill.	blue-eyed grass		Me, H, Ri		D-2, C
	S. **idahoense** Bickn.	blue-eyed grass				C
	S. montanum Greene	blue-eyed grass		Me, O		N
rchidaceae (**Orchis** family)	Calypso bulbosa (L.) Oakes	Calypso		H, Ri		D-2
	Corallorhiza trifida Chat.	Early or Pale coral-root		H, C	20	D-2, M2, N
	Cypripedium passerinum Richards.	Sparrow's-egg lady's-slipper (Northern lady's slipper)		C, Ri, T, O		D-2, N, C
	Goodyera rupens (L.) R. Br.	Dwarf rattlesnake-plantain		C, H		Q-2, N, C
	tiabenaria dilatata (Pursh.) Hook	Bog candle, scent-bottle, (White bog-orchid)		He, H		D-2, N, C
	H. hyperborea (L.) R. Br.	Northern green orchis, (Northern bog-orchid)		C, H		D, N, C
	H. obtusata (Pursh) Richards.	Blunt-leaf **orchis**, (Small bog orchid, Small northern bog orchid)		H, O	1	D-2, M-G
	i. saccata Greene	Slender bog-orchis		4e, C		ɨ
	i. unalascensis (Sprang.) Wats.	rein-orchis		3l, Ri, H		)-2
	L **viridis (L.)** R. Br. var. bracteata (Muhl.) Gray	Frog-orchis		:a, He, H		ɨ

APPENDIX 8.1 : The Vascular Plant Species of Kluane National Puk Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Orchidaceae (Orchis family) (Cont'd.)						
	Listera borealis Morong	Northern twayblade		C, H, Ca		D-2, D, N
	L. cordata (L.) R. Br.	Heartleaf twayblade		Ii, Me		N
	Orchis rotundifolia Banks	Small round-leaved orchie		Ca, H, Me		N, C, D-2
	Spiranthes romanroffiana Cham.	Hooded ladies' tresses		Me, H		D-2, N, C
Salicaceae (Willow family)						
	Populus balsamifera L.	Balsam poplar		H, Ri		D-2, D
	P. balsamifera L. ssp. balsamifera	Balsam poplar		H, Ri		N
	P. tremuloidee Michx.	Trembling or Quaking aspen		H, D, O, M	1	M- G, D, N
	Salix alaxensie (Anderss.) Cov.	Alaska willow)		Ri	20	M2
	S. alaxensie (Anderas.) Cov. var. alaxensis	Alaska willow)		Ri		D-2, D, N
	S. alaxensis (Anderss.) Cov. var. longistylis (Rydb.) Schn.	Alaska willow)		Ri		D-2, D, N
	S. arbusculoides Anderss.	Little tree willow)		R, H		D-2, D, N
	S. arctica Pallas sens lat.	Arctic willow		Sl, 0, R, M	1, 20	U-2, U-G, D-2,N
	S. barclayi Anderse.	Barclay's willow)		Ri, Me		D-2, D, N
	S. barrattiana Hook.	Barratt willow)		Sl, He, Ri		D-2, D, N
	S. bebbiana Sarg. var. bebbiana	Long-beaked willow		T, Ri		D-2, D, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Salicaceae (Willow family) **(Cont'd.)**						
	Salix brachycarpa Nutt.	Willow				D-2, N
	S. brachycarpa Nutt. var. brachycarpa	Willow				D-2
	S. brachycarpa Nutt. ssp. niphoclada (Rydb.) Argus var. niphoclada	Barren ground willow				D-2, D. N
	S. candida Fluegge	Hoary willow		Me, Aq		D-2, N
	S. commutata Bebb.	Willow		Ri, Me		D-2, N
	S. exigua Nutt. ssp. interior (Rowlee) Cronq. var. interior f. interior	Sandbar willow		Ri, O		D-2, N
	S. glauca L. Rocky Mountain phase	(Greyleaf willow)		., Me, H,		N
	S. glauca L. Western phase	(Greyleaf willow)		A, Me, I		M2, H-G, D-2
	S. monticola Bebb.	Willow		Ri		D-2
	S. myrtillifolia Anderss.	(Low blueberry willow)		H, Me	1	H-G, D-2, D, N
	S. pedicellaris Pursh var. pedicellaris	Bog willow		Me, Aq		N
	S. phylicifolia L. ssp. planifolia (Pursh) Hiitonen var. planifolia	(Diamondleaf willow)		H, Sl, Me		D-2, D, N, H-G
	S. phylicifolia L. asp. planifolia (Pursh) Hiitonen var. subglauca (And.) Scoggan	(Diamondleaf willow)		H, Sl, Me		N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Salicaceae (Cont'd.)						
	Salix planifolia ssp. pulchra (Cham.) Argus var. yukonensis (Scheid) Argus			H, Sl, Me		D-2
	S. polaris Wahl.	Polar willow		Sl, n, Me	1, 20	M2, D-2, D, M-G, N
	S. reticulata L.	Netleaf willow		Sl, M	1, 20	M2, M-G, D-N
	S. reticulata L. var. reticulata	Netleaf willow		Sl, M		N
	S. richardsonii Hook	willow		R, Ri, O, A	20	M2, N, D-2
	S. rotundifolia Trautv.	willow		R, Sl, A	20	M2, D-2, N
	S. scouleriana Barratt	(Scouler's willow)		H, R, Sl	1	M-G, D-2, D N
	S. setchelliana Ball	(Setchell's willow)		Ri		D-2, D, N
Betulaceae (Birch family)	Alnus crispa (Ait.) Pursh ssp. crispa	Green or Mountain alder		H, Ri, Sl		D-2, N
	A. crispa (Ait.) Pursh ssp. sinuata (Regel) Hult.	Green or Mountain alder		H, R, Sl		D-2
	A. rugosa (Du Roi) Spreng. var. occidentalis (Dippel) Hitchc.	speckled alder		Ri, Me, M	1	D-2, M-G, D N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	Referenced
Betulaceae (Birch family) **(Cont.d.)**	**Betula** glandulosa Michx.	Dwarf or Shrub birch		M, R, A	1, 20	M2, M-G, D-), N
	B. nana L.	Dwarf birch		R, O		N
	B. occidentalis Hook.	Black, Red or Mountain birch		H, Me, Ri		D-2, N
	B. papyrifera Marsh.	White birch, Canoe or Paper birch		I, Sl, R		D-2
	B. papyrifera Marsh. var. neoalaskana (Sarg.) Raup	White birch, Canoe or Paper birch		H, Sl, R		N
	B. pumila L. var. glandulifera Regel	Low or Swamp birch		Me, H, Ri		D-2
Urticaceae (Nettle family)	**Urtica** dioica L. ssp. gracilis (Ait.) Selander var. gracilis	Stinging nettle		S, H, Ri, D	2	D-D, C, D-2
Santalaceae (Sandalwood family)	**Comandra** umbellata (L.) Nutt.	Bastard toadflax		D		D-2
	C. umbellata (L.) Nutt. var. pallida (DC.) Jones	Bastard toadflax		D		N
	Geocaulon lividum (Richards.) Fern.	Northern commandra		M, C		M-G, D-2, N

APPENDIX 8.1 : The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	eferences[6]
olygonaceae (Buckwheat family) (Cont'd.)	Oxyria_digyna (L.) Hill	ountain eorrel		Sl, A	20	12, D-2, N,
	Polygonum amphibium L.	ater emartweed		Aq, Me, D		-2
	P. arenastrum Jord.	notweed, emartweed		I		-2, N
	P. avicularo L.	roetrate knotweed		I		-2, N, C
	P. bistorta L. ssp. plumosum	Meadow bietort)		Me		-2, c
	P. erectum L.	notweed, emartweed		O, D, Me		-2, N
	P. penneylvanicum L.	inkweed		D, T, Ri, H		
	P. phytolaccaefolium Meisn.	lpine knotweed		S, A, Me, T, R		, D-2
	P. viviparum L.	lpine bistort		M, Me, Ri, Sl	1, 20	2, M-G, D-2, C
	Rumex acetosa L.	arden or Meadow sorrel		I		-2
	R. acetosa L. ssp. alpestris (Scop.) Löve	arden or Meadow sorrel		I		
	R. arcticus Trautv.	rctic dock		Me, Ri		-2, N. C
	R. graminifolius Lamb.	ock		0	8, 9	
	R. occidentalis Wats.	eetern dock		Aq, Ri		, D-2
	R. salicifolius Weinm.	Beach dock)		Ri, A-Me, R-81		-2, c
	R. • alicifoliue Weinm. ssp. salicifolius	ock		Ri, A-Me, R-Sl		
	R. salicifolius Weinm. ssp triangulivalvie	ock		Ri, A-Me, R-Sl		

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
henopodiceaa (Goosefoot family	Atriplex patula L. var. patula	Spearscale		), O		N
	Chenopodium album L.	Lamb's quarters, Pigweed		), O		N
	C. berlandieri Moq.	Goosefoot				N
	C. capitatum L. (Aschers)	Strawberry blite		)		D-2, N, C
	C. glaucum L.	Oak-leaved gooeefoot		)		l-2
	C. glaucum L. var. salinum (Standl.) Boivin	Mk-leaved gooeefoot		)		I
	C. rubrum L.	Coast-blite		Me, Aq		)-2, N
	Eurotia lanata (Pursh) Moq.	Winter-fat, White or Winter Sage		)		)-2
	Monolepis nuttalliana (R. 6 S.) Greene			)		B-2, N
	Salicornia europaea L.	Glasswort, Samphire, Chickenclaws		Aq, Me		)-2
	Suaeda maritima (L.) Dumort. var. americana (Pers.) Boivin	Sea-blite		li		I
	S. occidentalis Wats.	Sea-blite		)		l-2, N

APPENDIX 8.1: **The Vascular Plant Species of Kluane National Puk Reserve.**

Family Name	Scientific Name'	C - n Name[2]	Status[3]	Habitat[4]	ocumented ccurrences	eferences[6]
Portulacaceae (Pursland family)	Claytonia caroliniana Michx. var. tuberosa (Pall.) Boivin	spring-beauty		l, H		b-2, N, C
	C. perfoliata Donn	pring-beauty		I		I
	C. scammaniana Hult.	ea-blite			20	l-2, M2, N
	Lewisia pygmaea (Gray) Robins.		R	l, A		l-2, N, C
	Montia parvifolia (Hoc.) Greene var. parvifolia				20	l2, D-2, N-(
aryophyllaceae (Pink family)	Arenaria arctics Stev.	rctic sandwort		, Ri		I, M2
	A. capillaris Poir.	andwort		, R, Sl		'-2, N
	A. chamissonis Maguire	Matted sandwort,Meadow arnica)				
	A. humifusa Wahl	andwort		, O		I, D-2
	A. lateriflora L.	rove sandwort		, Me, O		, D-2
	A. macrocarpa Pursh	Long-podded sandwort)				, D-2, C
	A. obtusiloba (Rydb.) Fern.	andwort		, S, Me, A		, D-2
	A. Fisch Jes	andwort		, R		, D-2
	A. rossii R. Br.	Ross sandwort)				, D-2, C
	A. rubella (Wahl.) Sm.	Reddish sandwort)		, R		, N, D-2
	A. sajanensis Willd.	andwort		, R		-2
	A. stricta Michx. var. uliginosa (Schleich.) Boivin	andwort		, R		
	A. stricta Michx. var. dawsonensis (Britt.) Scoggan	Dawson's sandwort)		, R		, N, D-2

APPENDIX 8.1: **The Vascular** Plant **Species** of **Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Caryophyllaceae (Pink family) **(Cont'd.)**						
	Cerastium arvense L.	'ield chickweed		ι, O		D-2, N, C
	C. beeringianum C. & S.	Bering chickweed)		ι, O	20	D-2, C, Ma
	C. beeringianum C. & S. rep. beeringianum var. beeringianum					N
	C. beeringianum C. & S. ssp. beeringianum var. grandiflorum Hult.			ι, O		N
	C. vulgatum L.	ommon mouse-ear chickweed		)		N
	Lychnis apetala L.	Nodding lychnis)		ιi, O	20	D-2, C, M2,
	L. furcata (Raf.) Fern.	ampion		)	20	N, D-2, M2
	L. triflora R. Br. ssp. dawsonii (Robins.) Maguire	ampion		), R		N
	Sagina intermedia Fenzl. ex Ledeb.	now pearlwort				N, C
	S. nivalis (Lindbl.) Fries var. nivalis	earlwort		,, O	4	D-D, D-2
	S. saginoides (L.) Karst.	rctic pearlwort		', R		D-2, N
	Silene acaulis L.	oss campion		i, R	1, 20	M2, U-G, D-; C, N

APPENDIX 8.1 : The Vascular Plant Species of Kluane National Puk Reserve (Continued).

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Caryophyllaceae (Cont'd.)	Silene acaulis L. var. subacaulescens (Williams) Fern. & St. John	loss campion		ι		
	S. douglasii Hook.	atchfly, campion		ι		I
	S. menziesii Hook.	Menzies campion, Menzies silene)		), D, H, Ri		I- D-2
	S. menziesii Hook. var. menziesii			I, Ri, Me		
	S. menziesii Hook. var. williamsii (Britt.) Boivin	Menzies campion)		), D, H, Ri		I, c, D-2
	S. repens Patrin	Creeping silene)		)		)-2, D, N
	S. repens Patrin ssp. purpurata (Greene) Hitchc. & Maguire			)		)-2
	Stellaria alaskana Hultèn		R			l-3
	S. calycantha (Ledeb.) Bong.	Chickweed, Starwort)		ι, He, Ri		)-2, C
	S. calycantha (Ledeb.) Bong. var. calycantha	:hickweed, starwort		ti, He		
	S. crassifolia Ehrh.	:hickweed, starwort		le, Ri		I-2, N
	S. longifolia Huhl.	:hickweed, starwort		ι, Me, Ri		I-2, N
	S. longipes Goldie var. longipes	Long-stalked starwort)		le, Me, R	1, 20	I-G, D, N,)-2, M2
	S. media (L.) Cyrillo	:ommon chickweed		)		)-2, N
	S. umbellata Turcz.			le, H, S	10, 14	ι, N

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Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Nymphaeceae (Water lily family)	Nuphar polysepalum Engelm.	Rocky mountain cow-lily		Aq		D-2, N
Ranunculaceae (Crowfoot family)	Aconitum delphinifolium DC.	monkshood		Me, H	20	M2, C
	A. delphinifolium DC. var. delphinifolium			Me, H		D, N, D-2
	A. delphinifolium DC. var. paradoxum Reichenb.					N
	Acteae rubra (Ait.) Willd.	Red baneberry		H		N, D-2, D,
	Anemone drummondii Wats.	anemone		A, S, Me, R		D-2, N
	A. multifida Poir.	(Cutleaf anemone, Pacific anemone		M, O	1, 20	M-[illegible], D-2, N, C
	A. narcissiflora L.	anemone		A, S, Me, R		D-2, N
	A. narcissiflora L. ssp. interior Hult					N
	A. narcissiflora L. ssp. villosissima (DC.) Hult.	anemone		Me, Sl, O		N
	A. parviflora Michx.	Northern anemone, Small-flowered anemone		M, S, A, Me	1, 20	M2, M-G, D D, N, C

APPENDIX 8.1: **The** Vascular Plant Species of **Kluane** National Park **Reserve.**

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Ranunculaceae (Cont'd.)						
	Anemone patens L.	Pasque-flower, Wild crocus		He, O		), N, D-2,
	A. richardsonii Hook.	yellow anemone, Richardson's anemone		Sl, H		l-2, D, N,
	Aquilegia bravestyla Hook.	(Small-flower columbine)		R, Me, H		)-2, D, N,
	A. formosa **Fisch.**	Sitka columbine, (Western columbine)		Ii, Sl		)-2, D, C
	Caltha leptosepala DC.	**Elkslip** (Mountain marsh-marigold)		A, S, Aq		)-2, C
	Delphinium brachycentrum Ledeb.	delphinium, larkspur		3, Me		I
	D. glaucum Wats.	**(Glaucous** larkspur, Pale larkspur		M, Me, Ri	1, 20	I-G, D-2, I I, C
	Ranunculus acris L.	Tall buttercup		Aq, Ri		
	R. aquatilis L.	White water **crowfoot**		Aq, Ri		I, D-2, C
	R. cymbalaria Pursh	(Shore buttercup), Seaside **crowfoot**		Me, Aq, Ri		)-2, D, N,
	R. eschscholtzii Schlecht.	Eschscholtr buttercup		P-Me, T		l-2, N, C
	R. flammula L.	(Creeping spearwort)				l-2, C
	R. gelidus **Kar.** 6 **Kir.**	crowfoot, buttercup	R	Me, T	20	12, N, D-2
	R. gmelinii DC.	Small yellow water **crowfoot**		Ri, Aq, Me		)-2, C
	R. gmelinii DC. var. hookeri (Don) Benson	Small yellow water **crowfoot**		Ri, Aq, Me		I

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Ranunculaceae (Cont'd.)						
	Ranunculus hyperboreus Rottb.	(Arctic buttercup)		Aq	20	M2, D-2, N,C
	R. lapponicus L.	Lapland buttercup		C		D-2, N
	R. macounii Britt.	crowfoot, buttercup		Me, H		D-2, N
	R. nivalis L.	(Snow buttercup)		T, Ri	20	M2, D-2, N,C
	R. occidentalis Nutt.	Western buttercup				D-2
	R. occidentalis Nutt. var. occidentalis	Western buttercup				D-2, N
	R. pedatifidus Sm.	(Northern buttercup)		M, Me, A		D-2, C
	R. pedatifidus Sm. var. leiocarpus (Trautv.) Fern.			M, Me, A		N
	R. pygmaeus Wahl.	Dwarf buttercup, (Pygmy buttercup)		Gl, A-Me, Ri	20	M2, D-2, C
	R. pygmaeus Wahl. var. pygmaeus	Dwarf buttercup		A-Me, Ri		N
	R. repens L.	Creeping buttercup		Ri, Aq, 0, I		D-2, N
	R. sceleratus L.	Cursed crowfoot, (Celery-leaf crowfoot)		Aq, Ri		C
	R. sceleratus L. var. multifldus Nutt.	Cursed crowfoot		Aq, Ri		D-2, N
	R. sulphureus Soland.	(Sulphur buttercup)		la, 0		N, D-2, C
	R. uncinatus Don var. parviflorus (Torr.) Benson	crowfoot, buttercup		Me		N
	R. uncinatus Don var. uncinatus	crowfoot, buttercup		Me		D-2, C
	Thalictrum alpinum L.	Alpine meadow-rue		4, Me, Ri		D-2, N, C
	T. occidentale Gray	Western meadow-rue		Me, H		D-2, D, N
	T. sparsiflorum Turcz.	meadow-rue		I, Ri		D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve (Continued).

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[1]
Papaveraceae (Poppy family)	Papaver alaskanum Hult.	POPPY		O		D-2, N
	P. alboroseum Hult.	POPPY		O	9	M
	P. macounii Greene	(Macoun poppy)		O		D-2, N, C
	P. radicatum Rottb.	Arctic poppy		O		D-2, C
	P. radicatum Rottb. var. radicatum	Arctic poppy	R	O	20	M2, N
Fumariaceae (Fumitory family)	Corydalis aurea Willd.	Golden corydalis		I, O		D-2, N
	C. pauciflora (Steph.) Pers.	(Few-flowered corydalis)		Me, C	20	M2, D-2, N
Cruciferae (Mustard family)	Aphragmus eschacholtzianus Andrz.		R	A, T	4,17,18,20	M, M2,D-2,
	Arabidopsis salsuginea (Pall.) Busch			Ri, O		D-2
	A. divaricarpa Nels.	(Spreading pod rockcress)		Sl, O, R		D-2, D, N
	Arabis drummondii Gray	(Drummond rockcress)		R, H		D-2, D, N,
	A. glabra (L.) Bernh.	Tower-mustard		I, H, R		D-2
	A. hirsuta (L.) Scop.	rockcress		D, R, O, M	1	M-G
	A. hirsuta (L.) Scop. var. pycnocarpa (Hopkins) Rollins	(Hairy rockcress)		D, R. O		D, N
	A. holboellii					N
	A. holboellii Hornem. var. retrofracta (Graham) Rydb.	(Holboell's rockcress)		D, R		D-2. D, C
	A. lyallii Wats	rockcress	R	S, A, R, Me		D-2, N
	A. lyrata L.	rockcress		D, R,		D-2
	A. lyrata L. var. kamchatica	rockcress		D, R		N, C

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences	References[6]
Cruciferae (Cont'd.)	Barberea orthoceras Ledeb.	winter-cress		Ri, Me		D-2, N
	Brassica juncea (L.) Czern.	Chinese or Leaf-mustard		I		N
	B. rapa L.	Bird's rape		D		N
	Braya humilis (C.A. Hey.) Robins.			SC, O	20	M2, D-2
	B. humilis (C.A. Mey.) Robins. var. humilis					N
	B. purpurescens (R. Br.) Bunge			A, O, Sc	11. 19	D-D, M, D-2, N
	Capsella bursa-pastoris (L.) Medic.	rhepherd's-purse		D		N
	C. rubella Reut.	rhepherd's-purse		I		N
	Cardamine bellidifolia L.	bittercress		D, R	20	M2, D-2, N
	C. oligosperma Nutt. var. kamtschatica (Regel) Detling	bittercress		Ri, He		N, D-2
	C. pratensis L.	Cuckoo-flower, Lady's smock		Me, O		D-2
	C. pratensis L. var. angustifolia Hook.	Cuckoo-flower, Lady's smock		Me, O		N
	C. purpurea C. & S.	bittercress		Sl, S	20	M2, D-2, N, 2
	Cochlearia officinalis L.	scurvygrass		Ri, Aq		D-2

APPENDIX 8.1: The Vascular Plant Species of **Kluane National** Perk **Reserve.**

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	References[6]
ruciferae (Cont'd.)	escurainia pinnata (Walt.) Britt.	tansy-mustard		)		D-2, N
	. richardsonii (Sweet) Schultz	(Richardson tansy-mustard)		), O, I		D-2, N, C
	. sophia (L.) Webb	tansy-mustard		), I		D-2, N
	D. sophioides (Fisch.) Schulz	tansy-mustard		)		
	raba alpina L.	Alpine rockcress		), R	20	M2, D-2, N,C
	. alpina L. var. nana Hook	draba		), R, A		N
	D. aurea Vahl	Golden rockcress		I, Sl, Me,	18, 20	M, D-2, N, C
	D. borealis DC.	(Northern rockcress)		A, Sl, Me,		N, D-2, C
	D. caesia Adams	draba				D-2, N
	D. cineria Adams	draba		r, A, R		D-2, N
	D. crassifolia Graham	draba		R		D-2, N, C
	D. densifolia Nutt.	draba	R	I, A, R		D-2, N
	D. eschscholtrii Pohle	draba				
	ii. fladnizensis Wulfen	draba		R	20	M2, D-2, N
	D. fladnizensis Wulfen var. heterotricha (Lindbl.) Ball	draba		R		D-2, N
	D. qlabella Pursh	draba		Ri, R, He	20	M2, D-2, C,N
	D. incerta Payson	draba		R, Sl, M		D-2, N, C
	D. kluanei G.A. Mulligan	draba				D-2
	D. lanceolata Royle	(Lance-leaved draba)				D-2, D, C, N

APPENDIX 8.1: **The Vascular Plant Species of Kluane National Park Reserve** (Continued).

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Cruciferae (Cont'd.)						
	Draba longipes Raup	Draba		R		D-2, N, C
	D. nemorosa L.	Draba		3, Sl		N
	D. nivalis Lilj.	Draba		R		D-2, N, C
	D. nivalis Lilj. var. elongata Wats	Draba		A, R	18, 20	M, D-2
	D. oblongata R. Br.	Draba		51	20	M2
	D. oligosperma Hook.	(Few seeded draba)		R, Sl		D-2, D, N
	D. paysonii Macbr.	Draba		A, T, S, R	13	D-D, D-2, C
	D. prealta Greene	Draba		A, H, S. R		D-2, N
	D. ruaxes Payaon & St. John					
	D. sibirica (Pall.) Thell.	Draba		A, Sc	10, 12	D-D, D-2, C
	D. stenoloba Ledeb.	Draba		Ri, Me, Sl		D-2, N, C
	D. stenoloba Ledeb. var. nana (Schulz) C.L. Hitchc.	Draba		Sl, Me, Ri		N
	D. ventosa Gray	Wind river draba		A, T, Sl, Sc	[illegible], 14, 15, 16, 20	M2, M, D-D, D-2, D, C, [illegible]
	Erysimum angustatum Rydb.	Wallflower		Sl		N
	E. chieranthoides L.	Worm-seed mustard		D		D-2
	E. chieranthoides L. ssp. altum			[illegible], D		N
	E. inconspicuum (Wats.) MacM.	Prairie violet, Small wallflower)		D		D-2, D, N, [illegible]
	E. pallasii (Pursh.) Fern.	Pallas wallflower)		Sl, 0		D-2, N, C
	Eutrema edwardsii R. Br.			Sl	20	M2, D-2, N

APPENDIX 8.1: The **Vascular** Plant Species of **Kluane** National Park **Reserve** **(Continued).**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences	References[6]
ruciferae (Cont'd.)	Halimolobus mollis (Hook.) Rollins	(Northern halimolobos)		Sl		D-2, D-N
	Lepidium densiflorum Schrad.	pepperwort, peppergrass		D		D-2,N
	Lesquerella arctica (Wormsk.) S. Wats.	(Arctic bladderpod)		O, Sl		D-2,N,C
	Parrya nudicaulis (L.) Regel	(Parrya		A-Me, Sl, R	20	M2,D-2,N,C
	Rorippa islandica (Oeder) Barbas var. femaldlana Butt. 6 Abbe	yellowcress		Ri, D		N
	R. islandica (Oeder) Barbas var. hispida (Desv.) Butt. & Abbe	(Marsh yellowcress)		Ri, D		D-2,C
	R. islandica (Oeder) Barbas var. islandica	Marsh yellowcress		Ri, D		D-2,C
	Smelowskia borealis (Greene) Drury & Rollins	(Smelowskia)		SC, T		D-2,N,C
	S. calycina (Steph.) Mey. var. integrifolia (Seeman) Rollins			A, R, T	21	M
	Subularia aquatica L.	Awlwort		Ri, Aq		N
	Thalspi arcticum Pors.					D-3
	T. arvense L.	F'ield penny-cress		I, D		D-2, N
	T. fendleri Gray var. hesperium (Pays.) Hitchc.	penny-cress	R	A-Sl		D-2, N

APPENDIX 8.1: The **Vascular** Plant **Species** of **Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Droseraceae (Sundew family)	Drosera anglica Rude.	sundev		C, Ri		N
	D. rotundifolia L.	Round-leaved sundev		Me, D, Ri		D-2, N
Crassulaceae (Stonecrop or Orpine family)	Sedum lanceolatum Torr.	(Lanceleaved stonecrop)		M, S, R		D-2, D, N
	S. lanceolatum Torr. var. lanceolatum	(Lanceleaved stonecrop)		M, S, R		C
	S. roseum (L.) Scop.	Roseroot		T, A, R	20	M2, S-2, C
	S. roseum Torr. var. integrifolium (Raf.) Hult.	Roseroot		T, A, R		N
Saxifragaceae (Saxifrage family)	Chrysosplenium alternifolium L.	golden saxifrage		Ri		D-2, N
	C. wrightii Franch. & Savat.	(Wright water-carpet)		Sl, T	20	M2, D-2, N, C
	Leptarrhena pyrolifolia (Don) R. Br.			Ri, Me, A, S, Sl		D-2
	Mitella nuda L.	(Mitrewort, Bishop's-cap)		M, H, Ri	1	U-G
	Parnassia fimbriata Konig	(Fringed grass-of-parnassus)		Me, Ri		D-2, N, C
	P. kotzebuei Cham.	(Kotzebue's grass-of parnassus)		Ri	20	M2, D-2, D, N, C
	P. palustris L.	(Northern grass-of-parnassus)		Me, H		D-2, C
	P. palustris L. var. neogaea Fern.	(Bog star)		Me, H		D, N
	Ribes glandulosum Grauer	Skunk-currant		R, Sl, H, Me		D-2, N, C
	R. hudsonianum Richards.	currant, gooseberry		H, Sl		D-2, N
	R. lacustre (Pers.) Poir.	(Swamp gooseberry, Bristly black current)		H, Me		C

APPENDIX 8.1: The Vascular Plant Species of **Kluane** National Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
iaxifragaceae (Continued)						
	Ribes laxiflorum Pursh	Trailing black currant		S, H	22	D-D,D-2,C
	R. oxyacanthoides L.	Canada (Northern) gooseberry		H		D-2,D,N,C
	R. triste Pallas	(American red currant, Northern red currant)		H, M	1	M-G,D-2,D,N, C
	Saxifraga adscendena L.	saxifrage		A-Ue, R		N, D-2
	S. bronchialis L. ssp. funstonfi (Small) Hult.	saxifrage		R, T		D-2, N
	S. bronchialis L. ssp. funstonii (Small) Hult. var. cherlerioides (Don) Engl.	saxifrage		R, T		N
	S. caespltosa L.	(Tufted saxifrage)		O,M,S,A,Sl		D-2, N. C
	S. caespitosa L. ssp. exaratoides (Simm.) Engl. & Irmsch.	saxifrage		O,M,S,A,Sl		n-2, N
	S. cernua L.	Nodding (Bulbet) saxifrage		Sl	20	M2,D-2,N,C
	S. davurica Willd.	saxifrage		T	20	M2,D-2,N,C
	S. flagellaris Willd. (Pursh) Tolm.	(Spiderplant)		Ri, T	20	M2, D-2
	S. flagellaris Willd. ssp. platysepala (Trautr.) Porsild	(Flagellate saxifrage, Spiderplant)		Ri, T		N, C
	S. flagellarfs Willd. ssp. setigera (Pursh) Tolm.	saxifrage		Ri, T		N
	S. hieracifolia Waldst. 6 Kit.	(Hawkweek-leaf saxifrage, Stiff-stemmed saxifrage)		A, Me	20	M2,D-2,N,C
	S. hirculus L.	Yellow marsh saxifrage, (Bog saxifrage)		Ri, Me	20	M2-D-2,N,C
	S. lyallii Engl.	(Red-stemmed saxifrage)		Ri, Me		N, D-2, C
	S. nivalis L.			Sl		D-2, N
	S. nivalis L. var. tenuis Wahl.	Alpine saxifrage		Sl	20	M2

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	›ocumented ›ccurrences	References[6]
iaxifragaceae (Continued)	Saxifraga oppositifolia L.	Purple mountain eaxifrage		31	20	M2, D-2, c
	S. oppositifolia L. f. oppositifolia	Purple mountain saxifrage		31		N
	S. punctata L.	saxifrage		ti, A-Me		D-2
	S. punctata L. ssp. insularis Hult.	saxifrage		ti, A-Me		N
	S. punctata L. ssp. nelsoniana (Don) Hult.	saxifrage		ti, A-Me		N
	S. punctata L. sap. pacifica Hult.	Brook saxifrage		ti, A-Me		N
	S. punctata L. sap. porsildiana Calder & Savile	saxifrage		ti, A-ne		N
	S. reflexa Hook.	[Yukon saxifrage)		)	20	42,D-2,N,C
	S. rivularis L.	‹lpine-brook saxifrage		', Ri, Sl	20	42,N,D-2,C
	S. serpyllifolia Pursh	[Thyme-leaf saxifrage)		', Sc	20	42,D-2,N,C
	S. sibirica L.	laxifrage		;l, A-Me		(
	S. stellaris L.	laxifrage		;l, Ri		', D-2
	S. tricuspidata Rottb.	(Prickly eaxifrage, Three-tooth saxifrage)		l, R	1,20	42,M-G,D-2,),N,C
	Piarella trifoliata L.	‚aceflower, Sugar-scoop		I		(

APPENDIX 8.1: **The Vascular Plant Species** of **Kluane National** Park **Reserve**.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Rosaceae (Rose Family)	Amelanchier alnifolia Nutt.	Saskatoon-berry, (Northern service-berry)		H, Me		D-2,N,C
	Aruncus sylvester Kostel.	Goat's-beard		Ri, H	2	D-D,C-2,C
	Chamaerhodas erecta (L.) Bunge	(American chamaerhodoa)		O, Sl		N,D-2,C
	Dryas drummondii Richards.	(Yellow dryas)		T, R		D-2,D,N,C
	D. integrifolia Vahl	(White mountain-avens)		T, R	20	M2,D-2,D,C
	D. integrifolia Vahl ssp. integrifolia var. integrifolia	dryas, montain avens		T, R		N
	D. integrifolia Vahl ssp. sylvatica Hult.	dryas, mountain avens		T, O		N
	D. octopetala L.	dryas, mountain avens		A, M, Me	1,20	M2,M-G,D-2,(
	D. octopetala L. ssp. alaskensis (Porsild) Hult.	dryas, mountain avens		A, Me		N
	D. octopetala L. ssp. octopetala var. octopetala	dryas, mountain avens		Me		N
	Fragaria virginiana Dcne.	(Wild strawberry, Blue-leaved strawberry)		H, Me		D-2,C
	F. virginiana Dcne. var. glauca Wats.	strawberry		H, Me		D,N
	Geum aleppicum Jacq.	avens		H, Ma		N,D-2
	G. macrophyllum Willd.	avens		H, Me		D-2
	G. macrophyllum Willd. var. perincisum (Rydb.) Raup	avens		H, Me		D-2,N
	G. rossii (R. Br.) Ser.	avens				D-2
	Luetkea pectinata (Pursh) Ktze.	Partridgefoot				D-2,D,N,C

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	)ocumented)ccurrences[5]	References[6]
Rosaceae (Cont'd.)	Potentilla anserina L.	Silverweed		ii, C		)-2,D,N
	P. arguta Pursh	Tall cinquefoil (Glandular cinquefofl)		R, O		),N,D-2,C
	P. biflora Willd.	(Two-flower cinquefoil)		Sl	20	12,D-2,N,C
	P. diversifolia Lehm.	Diverse-leaved cinquefoil		;, A, Me, S:		)
	P. diversifolia Lehm. var. diversifolia	Diverse-leaved cinquefoil		3,A,Me,Sl,R		)-2,N
	P. egedii Wormsk. var. groenlandica (Tratt.) Polunin	(Pacific silverweed)		Ri		:,N
	P. flabellifolia Hook.	cinquefoil		Ri, Me,A, T		|
	P. fruticosa L.	Shrubby cinquefoil, (yellow rose, Tundra rose)		I, S	1,20	12,M-G,D-2,
	P. gracilis Dougl.	cinquefoil		le, s, 0		I
	P. gracilis Dougl. var. glabrata Lehm. Hitchc.	cinquefoil		le, S, 0		-2,D
	P. gracilis Dougl. var. gracilis	(Slender cinquefoil)		le, S, 0		-2,D
	P. hyparctica Malte	(Arctic cinquefoil)		', R	20	-2. M2, N,
	P. multifida L.	potentilla		t, O	20	-2, N,C
	P. nivea L.	(Snow cinquefoil)		t, Sl	20	2,D-2,N,C
	P. nivea L. ssp. hookeriana (Lehm.) Hiitonen	cinquefoil		t, Sl		-2,D,N

APPENDIX 8.1: **The Vascular Plant** Species of **Kluane** National Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Rosaceae (Cont'd)	Potentills nivea L. sap. nivea Var. tomentosa Nilsson-Ehle	cinquefoil		Rl, Sl		N
	P. norvegica L.	Rough cinquefoil		D		D-2, C
	P. norvegica L. var. norvegica	cinquefoil		D		D-2, C
	P. palustris (L.) Scop.	(Marsh cinquefoil)		Aq, Me		D-2, N,C
	P. pensylvanica L.	(Pennsylvania cinquefoil, Prairie cinquefoil)		a	20	M2,D-2,D,C
	P. pensylvanica L. var. glabrata (Hook.) Wats.	cinquefoil		a		N
	P. pensylvanica L. var. pensylvanica	(Pennsylvania cinquefoil, Prairie cinquefoil)		a		N,D-2,C
	P. vahliana Lehm.			AI, 0	20	M2,D-2,N,C
	P. villosa Pallas	cinquefoil		A, T, R	7,15,24	D-2,D-D
	Rosa acicularis Lindl.	Prickly rose		MI, H, Sl	1	M-G,D-2,D, N,C
	Rubus arcticus L.	(Nagoon berry, Kneshenaka, Arctic raspberry)		MI	1	M-G,N,D-2, D,C
	R. chamaemorus L.	Baked-apple-berry, (Cloudberry)		C		D-2. N,C
	R. idaeus L.	Red raspberry		H, D		D-2, C
	R. idaeus L. var. aculeatissimus Regel 6 Tiling f. aculeatissimus	Red raspberry		H, D		D, N
	Sanguisorba canadensis L. ssp. latifolia (Hook.) Calder & Taylor	Canada burnet		Ri, Me		D-2,D.N.C
	Sibbaldia procumbens L.	(Sibbaldia)		S, A, Me		D-2, N,C
	Sorbus scopulina Greene			S, A. A		D-2, N
	S. sitchensis Roemer	(Sitka mountain-ash)		S, A, Me	2,23	D-D.D-2,C

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	)ocumented)ccurrences[5]	References[6]
,eguminosae (Pea Family)						
	Aetragalue aboriginum Richards.	milk-vetch		Ri,O,Sl,S,R		D-2,D-N
	A. adsurgens Pallas var. robustior Hook	milk-vetch		), Sl		N
	A. adsurgens Pallas var. tananaicus (Hult.) Barneby	nilk-vetch		), Sl		D-2,D,N
	A. agrestis Dougl.	nilk-vetch		\, Me, Sl		D-2, N
	A. alpinus L.	[Alpine milk-vetch)		Ri,M,Sl,T		D-2,D,C
	A. alpinus L. var. alpinus	nilk-vetch		Ri,M,Sl,T		N
	A. alpinus L. var. alpinua f. alpinua	\lpine milk-vetch		Ri,M,Sl.T		C
	A. americanue (Hook.) Jones	(American milk-vetch)		4e, Ri		D-2,N,C
	A. bodinii Sheldon	ailk-vetch		4e, Ri		D-2,N
	A. eucosmus Robins.			4e, n		D-2
	A. eucosmus Robins. f. eucosmus			4e, H		N
	A. nutzotinensua Rousseau	(Nutzotin milk-vetch)	R	Ri	20	M2,D-2,N,C
	A. robbinsii (Oakes) Gray var. harringtonii (Rydb.) Barneby	milk-vetch		4e,Ri,R,T		N
	A. umbellatue Bunge	(Tundra milk-vetch)		4e, Sl	20	M2,D-2,N,C
	A. williamsii Rydb.	'Williams milk-vetch)		ki, n		D-2,D,N,C
	Hadysarun alpinum L.	Alpine sweet-vetch, American hedysarum)		51	20	M2,D-2,C
	H. alpinum L. var. alpinum			(		N
	H. alpinum L. var. americanum Michx.			(	1	D,N,M-G
	H. boreale Nutt. var. mackenzii (Richards.1 Hitchc. f. mackenzii	Northern sweet-vetch, lorthern hedysarum)		51, M	1	M-G,D-2,D, C,N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Leguminosae (Cont'd)	Lupinus arcticus Wats.	[Arctic lupine, Broadleaf lupine)		S, M	1	M-G,D-2,D,N C
	L. kuchei Eastw.	[Yukon lupine, Kuchei's lupine)		Ri,H,D,Sl		D-2,D,N,C
	L. nootkatensis Donn	(Nootka lupine)		S1		N,C
	Oxytropis arctica R. Br.			R	10	M,D-2,N
	O. arctica R. Br. var. arctica			M, T, A	25,26	D-D,D-2
	O. campestris (L.) DC.	(Field oxytrope, Field crazyweed)		O,H,A,S,Me, S1		D-2 ,C
	O. campestris (L.) DC. var. dispar (Nels.) Barneby			S,A,Me,H,Sl	27	D-D
	O. campestris (L.) DC. var. gracilis (Nels.) Barneby	[Field oxytrope, Field crazyweed)		O,H,A,S,Me, S1		N,D,C
	O. deflexa (Pall.) DC. var. deflexa	(Deflexed oxytrope ?endantpod crazy-weed)		Me,Ri,O,D		D-2,C
	O. deflexa (Pall.) DC. var foliosa (Hook.) Barneby	[Deflexed oxytrope, ?endantpod crazyweed)		Me,Ri,O,D		D-2,D,N,C
	O. deflexa var. seriaca T. & G.	[Deflexed oxxytrope, ?endantpod crazyweed)		Me,Ri,O,D		D-2, N
	O. leucantha (Pall.) Pers. var. depressa (Rydb.) Boivin	Stemless locoweed		S1	20	M2
	O. leucantha (Pall.) Pers. var. leucantha	stemless locoweed			20	M2,D-2,N,C
	O. maydelliana Trautv.	Maydell oxytrope			20	M2,D-2,N,C
	O. nigrescens (Pall.) Fisch.	stemless locoweed		Mi, R, Sl	1,20	M-G,M2,D-2, N
	O. nigrescens (Pall.) Fisch. var. bryophila (Greene) Lepage	stemless locoweed		Mi, R, Sl		
	O. nigrescens (Pall.) Fisch var. pygmaea (Pall.) Cham.			S1		N

APPENDIX 8.1: The Vascular Plant **Species of Kluane** national Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Leguminosae (Cont'd)	Oxytropis sericea **Nutt.**	stemless locoweed		),S,Me,Sl		N
	O. aplendens **Dougl.**			Me,Ri		D-2, N
	Trifolium hybridum L.	Alsike clover		I, D		D-2, N
	T. pratense L.	Red clover		)		D-2, N
	T. **repens L.**	White clover		I, D		N
Linaceaa (**Flax** family)	**Linum** perenne **L.**	Parennial flax, (Wild blue flax)		)		D-2, C
	L. perenne L. var. **lewisii (Pursh)** Eat. & Wright	Perennial flax, (Wild flax, Wild blue flax)		)		D, N, C
Geraniaceae (Geranium family)	Geranium **bicknellii** Britt.	Wild geranium		I, Me, D		N
	G. erianthum DC.	[Northern geranium)		Me,S,A,H,	2,23,28,29	D-D,D-2,C
Callitrichaceae (Water-starwort family)	Callitriche anceps Fern	Water-starwort		Aq		N
	C. hermaphroditica L.	Water-starwort		Aq		D-2, N
	C. verna **L.**	Water-staruort		Aq		D-2, N
Empetraceae (Crowberry Family)	Empetrum nigrum L.	Black crowberry, Curlewberry		I	1	M-G,D-2,D,C, N
	E. nigrum L. f. nigrum	Black crowberry, Curlewberry				

APPENDIX 8.1: **The** Vascular Plant **Species** of **Kluane National Park Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	References[6]
'iolaceae (Cont'd)	Viola adunca Sm.	(Western dog violoet)		Me,H,M,O	1	M-G,D-2,D,N
	V. epipsila Ledeb.	violet		Me, Ri		N
	V. langedorfii (Regel) Fisch.	(Alaska violet)		Me, C		D-2, N,C
	V. palustris L.	Alpine marsh violet		Me, Ri		D-2
	V. renifolia Gray	White violet		M,H,Sl,Ri	23	D-D,N,D-2,C
:laeagnaceae (Oleaster family)	Eleaagnus commutata Bernh.	Silverberry (Wolfwillow)		Ri, O		D-2,D,N,C
	Shepherdia canadeneis (L.) Nutt.	Soapberry, (Buffaloberry)		M,H,Ri	1,20	M2,M-G,D-2, D,N,C
)nagraceae (Evening Primrose family)	Epilobium alpinum L.	(Alpine willow-herb)		Me,Ri,Sl		C
	E. alpinum L. var. alpinum	(Alpine willow-herb)		Me,Ri,Sl		N,D-2,C
	E. alpinum L. var. lactiflorum (Haussk.) Hitchc.	willow-herb		Me,Ri,Sl		N,D-2
	E. alpinum L. var. nutans (Hornem.) Hook.			Me,Ri,Sl		N,D-2
	E. angustifolium L.	Fireweed, Great willow-herb		M,H,D,Ri	1	M-G,D-2,D,C,
	E. angustifolium L. asp. angustifolium	Fireweed, Great willow-herb		M,H,D,Ri		N
	E. qlandulosum Lehm.	(Glandular willow-herb)		Me,Ri		D-2,N.C
	E. latifolium L.	River beauty (Dwarf Fireweed)		Ri,Sl	20	M2,D-2,D,N,C
	E. leptophyllum Raf.	aillow-herb	R	Ri,Me		N
	E. palustre L.	rillcw-herb		Ri,Me		D-2,N
	E. watsonii Barbey	willow-herb		Me,Ri		N

APPENDIX 8.1: The Vascular Plant **Species** of **Kluar- National** Park **Reserve**.

Family Name	Scientific Name[1]	**Common Name**[2]	**Status**[3]	**Habitat**[4]	**)ocumented)ccurrences**[5]	**References**[6]
laloragaceae (Water-milfoil family)	**Myriophyllum** spicatum L.	dater-milfoil		**Aq,Ri,M**	**30**	**D-D,D-2,N**
Iippuridaceae (Mare's Tail **family)**	Hippuris montana Ledeb.	**nare's** tail		**Ri,Aq,Me**		**N**
	H. vulgaris L.	**nare's** tail		**Ri,Aq**		**D-2,N**
raliaceae **(Ginseng** family)	Oplopanax **horridus** (Sm.) **Miq.**			**H,S,R**	**2**	**N,D-D**
mbelliferae (Parsley family)	**Angelica lucida** L.	**angelica**		**S,Me,H,R**	**2**	**)-D,D-2,N**
	Rupleurum ranunculoides L.			**Aq,Ri,Me**		**I**
	Cicuta douglasii (DC.) C. 6 R.	rater-hemlock		**Ri,Aq,Me**		a
	C. mackenzieana Raup	rater-hemlock		**Me,Ri**		**)-2**
	Cnidium cnidiifolium **(Turcz.)** Schischk.	**:usson**		**Ri,Me,Sl**		**I,D-2,C**
	Heracleum lanatum **Michx.**	**:ow-parsnip**		**Ri,Aq,Me,H**		**)-2,D,N**
	Osmorhiza chilensie H. & A.	**weet cicely**		**H**		**)-2,N**
:ornaceae (Dogwood family)	**Cornus** canadensis L.	Bunchberry, Dwarf **cornel**		**M,H,Me**	**1**	**M-G,D-2,N,C**
	C. canadensis **L.** var. intermedia **Farr.**			**H,Me**		**N**
	C. stolonifera Michx.	Red **osier** dogwood		**H,Me,Ri**		**D-2,N**

APPENDIX 8.17: **The Vascular Plant** Species **of Kluane** National Park **Reserve.**

Family Name	Scientific Name'	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Pyrolaceaeae (Wintergreen family)	Moneses uniflora (L.) Gray	One-flowered pyrola, (Single delight, Wax-flower)		C,M	1	M-G,D-2,D,N,C
	Pyrola asarifolia Michx.	Pink pyrola, (Liverleaf wintergreen, Leafless pyrola)		C,H,M	1	M-G,D-2,D,C
	P. asarifolia var. purpurea	Arctic pyrola		C,H		N
	P. grandiflora Radius	(Large-flower wintergreen)		Sl	20	M2,D-2,N,C
	P. grandiflora Radius var. gormanii (Rydb.) Porsild	Arctic pyrola		Sl		M2
	P. minor L.	Wintergreen		C,H		D-2,N
	P. secunda L.	One-sided wintergreen, (Sidebells pyrola)		C,H,M	1	M-G,D,C
	P. secunda L. var. obtusata Turcsz.	One-sided wintergreen		C,H		N
	P. secunda L. var. secunda	One-sided wintergreen		C,H		D-2,N,C
	P. virens Schweigger	Wintergreen		C		N,D-2
Ericaceae (Heath family)	Andromeda polifolia L.	Bog rosemary		M,C	1	M-G,D-2,N,C
	Arctostaphylos alpina (L.) Spreng. ssp. rubra (Rehd. & Wils.) Hult.	Alpine bearberry		Sl,M	1,20	M2,M-G,D-2,D,N,C
	A. uva-ursi (L.) Spreng.	Common bearberry, Kinnikinnick Sandberry		N,O	1,20	M2,M-G,D-2,D,C,N
	Cassiope stelleriana (Pall.) DC.	Moss-heather (Alaska moss heath)		A,Me,C		D-2,D.N
	C. tetragona (L.) Don	Arctic white heather, Four-angle mountain heather, Lapland cassiope)		M,O,Sl	1,20	M2,M-G,D-2,D,N,C

APPENDIX 8.1: The **Vascular** Plant Species of **Kluane** National park **Reserve** **(Continued)**.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Ericacea (Cont'd)	Cassiope tetragona (L.) D. Don var. saximontana (Small) Hitchc.	Arctic white heather, (Four-angle mountain heather, Lapland cassiope)		M, O, Sl		N,C
	Chamaedaphne calyculata (L.) Moench	Leather-leaf, Cassandra		C, Ri		D-2
	Kalmia polifolia Wang. var. microphylla (Hook.) Rehd.	Pale, Bog or Swamp laurel		ne, c		D-2,C
	K. polifolia Wang. var. polifolia	Pale, Bog or Swamp laurel		Me, C		N
	Ledum groenlandica Oeder	Labrador-tea, (Bog labrador tea)		C, M	1	N,M-G,D-2,D,C
	Loiseleuria procumbens (L.) Desv.	Alpine azalea		Sl, c		D-2.C
	Oxycoccus microcarpus Turz	(Swamp cranberry)		C, M	1	M-G,D-2,D,N,C
	Phyllodoce aleutica (Spreng.) Heller ssp. glandulifera (Hook.) Hult.	Yellow mountain heather		R, Sl		D-2,N
	P. empertriformis (Sw.) Don	Pink mountain heather		Sl		D-2 ,D,N,C
	Rhododendron lappondicum (L.) Wahl	Lapland rosebay		R, H, S		D-2,N,C
	Vaccinium caespitosum Michx.	Dwarf bilberry or huckleberry (Dwarf blueberry)		Ri, R, H, Me		D-2,D.N.C
	V. ovalifolium Sm.	Tall huckleberry (Early huckleberry)		M, C, S, H	2,31,32	D-D.D-2.C
	V. uliginosum L.	Alpine bilberry, Bog huckleberry		C, R	20	M2,D-2,C
	V. uliginosum L. ssp. gaultherioides (Bigel.) Young --	Alpine bilberry, Bog huckleberry		M, C, R	1	M-G,N

APPENDIX 8.1: **The** Vascular Plant **Species of Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	**Status[3]**	Habitat[4]	Documented Occurrences[5]	References[6]
Ericacea (Cont'd)	**Vaccinium uliginosum L.** ssp. **pubescens (Wormsk.)** Young	**Bog** blueberry, Alpine bilberry		**M, C, R**	1	I-G,N,D,C
	V. vitis-idaee L.	**Mountain** cranberry, **Lingon-berry**		**M**	1	I-G,D-2,N,D,C
Primulaceae (Primose family)	**Androsace alaskana** Cov. **&** Standl.	**Androsace**	RI **E**	**M, A, T**	**6,18,19**	**[illegible]-D,D-2,N,C**
	A. chamaejasme Host.	**Androsace**		**R, Sl**		**D-2,N,C**
	A. septentrionalis L.	(**Northern** androsace)		**R, Sl**	**20**	**12,D-2,N,C**
	Dodecatheon frigidum C. **& S.**	(Northern shooting star)		Me		**D-2,N,C**
	D. jeffreyi van Houtte	**Tall mountain** shooting star		Me, **Ri**		D
	Douglasia arctica Hook	**Douglasia**		**R**		**D-2,N,C**
	Primula **borealis** Duby	**Primrose,** cowslip		**Ri**		
	P. cuneifolia Ledeb.	**Primrose**		Me		**D-2**
	P. egalikensis Wormsk.	**Greenland primrose**		**Ca**, Me, **Ri**		
	P. incanna Jones	(Silvery primrose)		Me, **Ri**		**D-2,N,C**
	P. **sibirica Jacq.**	(Siberian primrose)		**Ri, Me**		**D-2,D,N**
	P. **stricta Hornem.**	**Primrose**		**Ri,** Me		**D-2,D,N**
	Trientalis europaea L.	**European** star-flower		**C,M,H,S,Me, D-2,C**	1	I-G,D,N,

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Gentianaceae (Gentian family)	Gentiana algida Pallas	gentian		Me, Sl, R		D-2, N
	G. crinita (Froel.) Don ssp. procera (Holm) Gillett	Fringed gentian		He, Ri		N, C
	G. glauca Pallas	(Glaucous gentian)		A-No		D-2, N, C
	G. nivalis L.	Snow gentian		O, R		
	G. prostrata Haenke	Moss gentian		R, Ri	20	M2, D-2, N
	Gentianella amarella (L.) Börner	(Northern gentian)		Ri, N, Ma	1	M-G,D-2,N,C
	G. detonsa (Rottb.) Don ssp. yukonensis Gillett	Fringed gentian		Me, C, Ri		D-2
	G. propinqua (Richards.) Gillett	(gentianella, Four-parted gentian)		Ri, R	20	M2, C
	G. tenella (Rottb.) Börner	gentianella		Me	20	M2,D-2,N,C
	Lomatogonium rotatum (L.) E. Fries	Stargentian, Marsh felwort		He, C, Ri		D-2
	Menyanthes trifoliata L.	Buckbean, Bogbean		C, Ri, Aq		N
	Swertia perennis L.			S, A, Me, Ri		D-2, N
Polemoniaceae (Polemonium family)						
	Phlox hoodii Richards.	Moss pink (Moss phlox)		O		D-2, N, C
	P. sibirica L.	(Siberian phlox)		R	20	M2,D-2,C,N
	Polemonium boreale Adams	(Northern jacob's ladder)		Me, Ad, Sl	20	M2,N,D-2,D
	P. boreale Adams var. villosissimum Hult.	Jacob's ladder		S, R, Ca, Me	14	M
	P. caeruleum L.	Jacob's ladder		Me, Ca		D-2
	P. caeruleum L. ssp. villosum (Rud.) Brand	(Blue- jacob's ladder)		Me, Ca	20	M2,N,D-2,C
	P. pulcherrimum Hook.	(Pretty jacob's ladder)		R, Ri, Me		D-2,D,N,C

APPENDIX 8.1: The Vascular Plant Species of **Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Hydrophyllaceae (Water-leaf family)	Phacelia franklinii (R. Br.) Gray	Scorpion-weed		Me, D		D-2, N
Boraginaceae (Borage family)	Amsinckia lycopsoides Lehm.	Fiddle-neck		O, 51, D		N
	A. menziesii (Lehm.) Nels. & Nacbr.	Fiddle-neck		Sl, O		N
	Eritrichium nanum (Vill.) Schrad.			M, Sl		N
	E. rupestre (Pall.) Bunge			R		D-2
	Lappula myosotia Moench.	(Stickseed, Bristly stickseed)		I, D		D-2,D,N,C
	L. redowskii (Hornem.) Greene			O, D		N
	Mertinsia paniculata (Ait.) Don	Lungwort, bluebells		M, Me, H	1	M-G,D-2,D
	M. paniculata (Ait.) Don var. borealis (Macbr.) Williams	(Tall bluebell)		H, Me		C
	M. paniculata (Ait.) Don var. paniculata	Lungwort, bluebells		H, Me		C, N
	Myosotis scorpioides L.	Forget-me-not		Aq, Ri		
	M. sylvatica Hoffm. var. alpestris (Schm.) Koch f. alpestris	Forget-me-not		D, Me, Sl	20	M2,N,C,D-2
Labiatae (Mint family)	Dracocephalum nuttalii Britt.	False dragonhead		H, Me, Ri		D-2
	Mentha arvensis L.	Common mint		Me, Ri		N
	Prunella vulgaris L.	Heal-all, carpenter-weed		O, D		D-2

APPENDIX 8.1: The **Vascular** Plant **Species** of **Kluane National** Part **Reserve** **(Continued).**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Scrophulariaceae (Figwort family)	Castilleja **chrymactis Pennell**	Lndian paint-brush		R, O		3-2
	C. fulva **Pennell**	Lndian paint-brush				D-2
	C. hyperborra **Pennell**	[Northern indian paintbrush)		D, M	1, 20	I-G, **M2,** D-2 N, C, D
	C. **pallida (L.)** Spreng. asp. **candata Pennell**	Lndian paint-brush		R, O		N, D-2
	C. **pallida (L.)** Spreng. ssp. septentrionalis **(Lindl.)** Scoggan	Lndian paint-brush		R, cl		D-2
	C. **parviflora** Song.	(**Castilleja)**		S, A, **Me,** T	29	D-D, D-2, C
	C. **raupii Pennell**	Indian paint-brush		Me		D-2, N
	C. unalaschensie **(C. & S.)**	(**Unalaska** indian paintbrush)		M, **Me, S**	1	M-G, D-2, N, C
	C. **yukonis Pennell**					j-3, D-2, MD
	Euphrasia arctica Lange	(**Arctic** eyebright)		D		D-2, **N,** C
	Lagotis glauca Gaertn.	**Lagotis)**		R		I, D-2, C
	Pedicularis capitata Adams.	Capitate lousewort)		Sa, **M, Sl**	1, 20	I-2, M-G, D-2, **N,** C
	P. labradorica **Wirsing**	Labrador lousewort)		il, **R**	20	12, D-2, D, I, C
	P. lanata C. **& S.**	Wooly lousewort		Sl, **R**		12, **N,** D-2,
	1. langsdorfii **Fisch.**	Langsdorf lousewort)		Me, R, Sl		I, D-2, C

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Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Scrophulariaceae (Figwort family)	Pedicularis oederi Vahl	(Oeder lousewort)		Me, R, Sl	20	M2, D-2, N,C
	P. parviflora Sm.	lousewort		Me, Ri		N
	P. sudetica Willd.	louseuort		Me, Sl, R		M2, c
	P. sudetica Willd. ssp. interior Hult.			MI, Me, Sl, I	1	U-G, D-2, D, N
	P. verticillata L.	Whor led lousewort		Ri, Me, Sl	20	M2, D-2, N, C
	Penstemon gormani Greene	(Gorman beardtongue, Gorman's penstemon)		Sl		D-2, D, N, C
	P. proceras Dougl.	Beardtongue, Small-flowered Penstemon		O, Sl, H		D-2, D, N, C
	Rhinanthus crista-galli L.	Common yellow rattle, (Rattlebox)		Me, R, I. D	26, 33	D-D, D-2, C
	Synthyris borealis Pennell	(Kittentails, Alaska synthyris		R	20	M2, D-2, N,C
	Veronica alpina var. alternfflora Fern.	Alpine speedwell				D, N, D-2, C
	V. americana Schwein.	American brooklime		Ri, Aq, Me		D-2, N
	V. arvensis L.	Corn-speedwell		I, O, D		D-2, N
	V. peregrina L. var. xalapensis (HBK.) St. John & Warren	Neckweed, Purslane-speedwell		Ri, Me		N
	V. scutellata L.	Marsh speedwell		Ai, Me		D-2, N
	V. serpyllifolia L.	Thyme-leaved speedwell		O, Me, D		D-2

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Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Orobanchaceae (Broomrape family)	Boschniakia rossica C. & S. Fedtsch.	(Ground-cane, Poque)		C-P		D-2, N, C
	Orobanche fasciculata Nutt.	clustered broom-rape		P		N
Lentibulariaceae (Bladderwort family)	Pinguicula villosa L.	buttarwort				N, D-2
	P. vulgaris L.	Common butterwort				D-2, N
	Utricularia intermedia Hayne	bladderwort		Aq, Ri		D-2, N
	U. minor L.	bladderwort		Aq, Ri		N
	U. vulgaria L.	Common bladderwort		Aq, Ri		D-2, N
Plantaginaceae (Plantain family)	Plantago canescens Adams	plantain		Sl, Me		D-2, N
	P. eriopoda Torr.	plantain				N
	P. major L. var. major	Common plantain, Whiteman's-foot		D		D-2, N
	P. maritima L.	Seaside plantain		Me		D-2, D
Rubiaceae (Madder family)	Galium boreale L.	Northern bedstraw		I, O, M, Ri, Me	1	M-G, D-2, D, N, C
	G. trifidum L. var. trifidum			Ri, Me		N
	G. triflorum Michx.	Sweet-scented bedstraw		S, H	31	D-D, D-2, N, C

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Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Caprifoliaceae (Honey-sucke family)	Linnaea borealis L.	Twinflower		4, C, H	1	4-G
	L. borealis L. var. borealis	Twinflower		C, H		D-2, D, N
	Sambucus racemosa L.	Red-berried or Stinking elder		4, Me		D-2
	S. racemosa L. var. arboreecene (T. & G.) Gray	Red-berried or Stinking elder		4, Me, S	22	D-D
	Viburnum edule (Michx.) Raf.	High bush cranberry		1	1	4-G, D-2, D, N, C
Adoxaceae (Moschatel family)	Adoxa moschatellina L.	Moschatel		4, Ri, C		D-2, N
Valerianaceae (Valerian family)	Valeriana capitata Pallas	(Capitata valerian)		Sl, Me		D-2, N, C
	V. sitchensis Bong.	(Sitka valerian)		), H, Me		D-2, N, C
Campanulaceae	Cempanula lasciocarpa Cham.	(Mountain harebell)		Me		j-2, C, N
	C. rotundifolia L.	Harebell, Bluebell		Ii, Sl, Me		D-2, D, C
	C. uniflora L.	Harebell		l, Me	20	12, D-2, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Compositae (Asteraceae)	Achillea millefolium L.	Common yarrow		M	1	M-G, D-2, D, C
	A. millefolium L. var. borealis (Bong.) Farw. f. borealis	Common yarrow		Me, Ri, Sl		N
	A. millefolium L. var. lanuloea (Nutt.) Piper f. lanuloea	Common yarrow		Me, Ri, Sl		N, C
	A. millefolium L. var. borealis (Bong.) Farw. f. borealis	Common yarrow		Me, Ri, Sl		N
	A. sibirica Ledeb.	(Siberian yarrow)		H, Me		D-2, C
	Agoseris auriantiaca (Hook.) Greene	(Mountain dandelion)		Me, H		D-2, N, C
	A. glauca (Pursh) Raf.	(Short-beaked wheatgrass)		Me, O		D-2, D
	Antennaria angustata Greene	pussytoes		R	20	M2, D-2, C
	A. friesiana Trautv. Ekman	pussytoes		Me, Rl		N
	F. friesiana (Trautv.) Ekman ssp. alaskana (Malte) Hult.	pussytoes		Me, Rl		N
	A. friesiana (Trautv.) Ekman ssp. compacta (Malte) Hult.	pussytoes		Me, Sl		N
	A. friesiana (Trautv.) Ekman ssp. friesiana	pussytoes		Me, Sl		N
	A. media Greene	pussytoes		Me, Sl		N
	A. pulcherrima (Hook.) Greene	pussytoes		Me, Sl		D-2, N, C
	A. rosea Greene	(Pink pussytoes)		M	1	N, M-G, D, C M

APPENDIX 8.1: The Vascular Plant Species **of Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Compositae (Asteraceae) (Cont'd.)						
	Antennaria rosea **Greene** var. **nitida** (Greene) **Breitung**	(Pink pussytoes)		N	20	ł, M2
	A. rosseauii Porsild	pussytoes		R		)-2, c
	A. umbrinella Rydb.	**Umber pussytoes**		R		)-2, D, C,
	Arnica alpina **(L.)** Olin **ssp.** angustifolia **(Vahl)** Maguire	(Alpine **arnica)**		R	20	ł2, N, C
	A. alpina **(L.) Olin** var. attenuata	(Alpine **arnica)**		R	20	ł2,D-2,N,C,),D-D
	A. amplexicaulis **Nutt.**			Ri, Ii		1, D-2
	A. chamissonis Less. ssp. **chamissonis**	(Meadow **arnica)**		Me, **Ri**		)-2, N. C
	A. chamissonis Less. ssp. **foliosa** **(Nutt.) Haguire**	arnica		He, **Ri**		B-2
	A. chamissonis Less. ssp. **foliosa** **(Nutt.)** Haguire var. incana (Gray) **Hult.**	(Meadow arnica)		**Me, Ri**		b-2, D, **N,**
	A. chamissonis Less. ssp. incana (Gray) **Hult.**	arnica		Ye, **Ri**		I-2
	A. cordifolia Hook.	**(Heart** leaf arnica)		**M,** Me, **H**	1	I-G, D-2, I ł, C
	A. latifolia Bong. var. gracilis **(Rydb.) Cronq.**	arnica		**H,** Me		I-2, c

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	References[6]
ompositae (Cont'd.)	Arnica latifolia Bong. var. latifolia	rnica		H, Me		Ci-2, C
	A. lessingii Greene	rnica		A, S, Me	20	M2, D-2, C,I
	A. lonchophylla Greene	Alpine arnica)		O, Ca, R		CI-2, D, N, (CI-D
	A. louiseana Farr. ssp. frigida (Hey.) Maguire	rnica		T, Sl, R		CI-2, c
	A. louiseana Farr. ssp. louiseana	rnica		T. Sl, R		N
	A. mollis Hook.	rnica		S, Me, H, R	29, 34, 35	D-D, D-2, C
	A. parryi Gray	rnica		H, Me, Sl		D-2
	Artemisia arctica Less. ssp. arctica	Norwegian sagewort, Boreal ormwood)		M	20, 1	MI-G, D, C, D-2, N, M2
	A. campestris L. ssp. borealis (Pall.) Hall & Clements	agewort, wormwood		O, Sl		D-2
	A. campestris L. ssp. canadensis (Michx.) Scoggan	agewort, wormwood		O, Sl		N
	A. dracunculus L.	arragon		O, R, Sl		D-2, N
	A. frigida Willd.	rairie sagewort	E	M, S, D, O, A, Ca	7, 36, 37, 8, 39	D-2, D-D, D, N
	A. furcata Bieb.	agewort, wormwood		R, Sl	20	M2, D-2, N, D. C
	A. tilesii Ledeb. var. elatior T. & G.	Mountain wormwood)		O		N, D-2, D, C
	A. tilesii Ledeb. var. tilesii	Mountain wormwood)		O, R		D-2, N, C

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Compositae (Cont'd.)	Aster alpinus L.	Alpine aster, Boreal aster)		Sl, Me		D-2, D, N,
	A. borealis T. & G. Provancher	ısterq		Me, Ca, Ri		D-2, N
	A. ericoides L. var. commutatus (T. & G.) Boivin	leath aster		O		D-2, C
	A. laurentianus Fern.	ıster		D-2		
	A. modestus Lindl.	ıster		Me, H		N
	A. sibiricus L.	Arctic aster)		O, R, Ne	20	M12, N
	A. sibiricus L. var. meritus (Nels.) -up	Arctic aster)		O, R, Me		D
	A. sibiricus L. var. sibiricus	Arctic aster)		O, R, Me		D-2
	A. subspicatus Nees	ıster		H, Me		D-2
	A. yukonensis Cronq.	Yukon aster)	E	Ri	40, 41	D-D, D-2, I N, C
	Cirsium foliosum (Hook.) DC.	Leafy thistle)		Me, Ri		[l-2, N, C
	Crepis elegans Hook.	Elegant Hawk's-beard)		Ri, O		D-2, N, C
	C. nana Richards.	lawk's-beard		T, R		N, D-2
	C. nana Richards. var. lyratifolia (Turcz.) Hult.	ıawk-beard		T, R	20	M12
	C. tectorum L.	ıawk's-beard	R	I, D		D-2, N

APPENDIX 8.1: The Vascular Plant **Species** of **Kluane National** Park **Reserve.**

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences	References
Compositae (Cont'd.)	Erigeron acris L.	[Northern daisy)		H, Ri, Me		D-2, D
	E. acris L. var. asteroides (Andrz.)DC.	Fleabane		H, Me, Ri		N, C, D-2
	E. acris L. var. debilis Gray	[Northern daisy, fleabane)		H, Me, Ri		N, C, D-2
	acris L. var. elatus (Hook.) Cronq	Fleabane		H, Me, Ri		N, D-2
	caespitosus Nutt.	(Gray daisy, fleabane1		R, O		D-2, D, N,
	E. compositus Pureh	[Dwarf mountain fleabane)		Ca, R		D, C
	E. compositus Pursh var. discoideus Gray	Fleabane		Ca, R		N
	compositus Pursh var. compositus	Fleabane		Ca, R		N
	compositus Pursh var. qlabratus Macoun	(Dwarf mountain fleabane)		Ca, E		D-2, N, C
	. qlabellus Nutt. var. pubescens Hook.	Fleabane		Me, Ri		D-2
	. qrandiflorus Hook.	Fleabane		O	20	12, D-2, C,
	. lonchophyllus Hook.	Fleabane		Ca, Me, Ri		D-2, N, C
	pereqrinus (Pursh) Greene ssp. pereqrinus	Coastal-fleabane)		Me, Ri		D-2, N, C
	. pumilis Nutt.	Fleabane		O, Sl		D-2
	. pumilis Nutt. ssp. intermedius Cronq.	Fleabane		O, Sl		
	. purpuratus Greene	Fleabane			20	12, D-2, N,
	. uniflorus L. var. eriocephalus (Vahl) Boivin	Fleabane		Me, T, Sl, Ca		12, N,

APPENDIX 8.11 The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Compositae (Cont'd.)	Erigeron uniflorus L. var. unalaschkensie (DC.) Boivin	fleabane		ie, T, Sl, :a	20	12,D-2,N,C
	E. yukonensis Rydb.	(Yukon fleabane)				
	Gaillardia aristata Pureh	gaillardia		I, Me		)-2
	Hieracium triste Willd.	(Slender hawkweed)		ie, R		)-2, N, C
	Matricaria matricarioides (Less.) Porter	Pineapple-weed		I, D		)-2, N
	Petasites frigidus (L.) Fries	(Arctic sweet coltsfoot)		Ri, H		), D-2, N,C
	P. eagittatus (Banks) Gray			4, Me	1	)-2, H-G. N
	P. vitifolius Greene	sweet coltsfoot		Ri, H		N
	Saussurea americana Eat.	(American saussurea)		S, Me, Sl	2, 29, 34	)-D, D-2, N,
	S. angustifolia (Willd.) DC.	saussurea		)		)-2, C, N
	S. visida Hult.			)	20	12, N
	Senecio atropurpureus (Ledeb.) Fedtsch.	groundsel, ragwort		)		)-2, C
	S. atropurpureus (Ledeb.) Pedtsch. ssp. atropurpureus	groundsel, ragwort		)		

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve.

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	Documented Occurrences[5]	References[6]
Compositae (Cont'd.)	S. atropurpureus (Ledeb.) Fedtsch. ssp. frigidus (Richards.) Hult.	groundeel, ragwort		0		N
	S. atropurpureus (Ledeb.) Fedtsch. ssp. tomentosus (Kjellm.) Hult.			0	20	M2, N
	S. congestus (R. Br.) DC.	marsh fleabane		Ri, Me		D-2, N, C
	S. indecorus Greene	groundsel, ragwort		Ca, R, Sl		D-2
	S. integerrimus Nutt. var. lugene (Richards.) Boivin	groundsel, ragwort		O, H, M	1, 20	M2, M-G, D-: D, N, C
	S. lindstroemii (Ostenf.) Porsild			Me, Sl	20	D-2, N, M2,(
	S. nuda Ledeb.	groundscl, ragwort		Ri, Ne, Sl		D-2
	S. pauciflorus Pursh	groundsel, ragwort		R, S, A Me		D-2, N, C
	S. pauperculus Michx.	(Butterweed)		Ca, C, R		D-2, D, N, (
	S. resedifolius Less.	groundsel, ragwort		R, S, A	20	M2, D-2, N,(
	S. scheldonensis A.E. Porsild	(Sheldon groundsel)		S-Me		D-2, N, C
	S. streptanthifolius Greene	(Cleft-leaf groundsal)		0, n		D-2, D, N, (
	S. triangularis Nook.	(Arrowleaf)		Me, 0		D-2, D, N, (
	S. yukonensis A.E. Porsild	(Yukon groundsel)		0		D-2, C
	Solidago canadensis L. var. canadensis	Canada goldenrod		H, Me, D		N
	S. multiradiata Ait.	(Northern goldenrod)		Me, R	20	M2, D-2, C
	S. multiradiata Ait. var. multiradiata	goldenrod		Me, R, M	1	M-G, N
	S. multiradiata Ait. var. sco ulorum Gray	goldenrod		Me, R		D, N

APPENDIX 8.1: The Vascular Plant Species of Kluane National Park Reserve (Concluded).

Family Name	Scientific Name[1]	Common Name[2]	Status[3]	Habitat[4]	ocumented ccurrences[5]	eferences[6]
ompositae (Cont'd.)	olidago spathulata DC.	goldenrod		Me, R, M		I-2, c
	. spathulata DC. ssp. spathulata var. neomexicana (Gray)	goldenrod		Me, R, M	1	I-G, D, N, (
	ionchus arvensis L.	Fieldsow thistle		[, D		-2
	. uliginosus Bieb.	sowthistle		[, D		-2
	'araxacum ceratophorum (Ledeb.) DC.	(Horned dandelion)		Me, R, Ca		-2, N. C
	. glabrum DC.	dandelion				
	. lacerum Greene	dandelion		Me, Ri		, N
	. laevigatum (Willd.) DC.	ted-seeded dandelion		[, D		-2
	. lapponicum Kihlm.	dandelion		Me, Ri, Sl		
	. lyratum (Ledeb.) DC.	dandelion		[, D		-2
	. officinale Weber	Common dandelion		[, D		-2, N, C
	'ownsendia exscapa (Richards.) porter			)		-2, N
	. hookeri Beaman					-3

Footnotes: Appendix 8.1:: **The vascular plant species of Kluane National P...**

1. Scientific **Names**
   Standarized according to Scoggan (1978).

2. Common **Names**
   Standarized according to Budd (1979). Names in parentheses are fro.. Scoggan (1978) .

3. Status
   R - Rare
   E - Endemic

   NOTE: Status of the vascular plants of Kluane has not been documents an authoritative manner.

4. Habitat

   A - Alpine
   S - Sub-alpine
   M - Montane
   R - Rock outcrops, ridges, etc. (dry)
   Sl - Slopes (well-drained, rocky)
   Me - Marshes, wet and dry meadows
   T - Talus slopes and fellfields
   Ri - Riparian (along stream banks, lakeshores, wet areas etc.)
   Aq - Aquatic (not in rivers or creeks)
   SC - **Scree** (wet **or dry)**
   C - Coniferous (*Picea glauca*)
   H - Hardwood (*Populus*) (mixed wood, forest, moist thickets: lightly-wooded areas).
   Ca - Calcareous meadows or loess deposits
   D - Disturbed or dry, denuded areas (may be natural disturbances)
   0 - Open areas (dry, moist, sandy, gravelly, tundra, turfy)
   V - Variety of **areas.**

5. Documented Occurrences (Figure 8.2)

   1. Kathleen Lake campground
   2. Lower Alsek River
   3. Small pond between Mush and Bates lakes
   4. Goatherd Mtn. (bottom of ephemeral lake bed)
   5. Junction of Kaskawulsh and Dezadeash rivers
   6. Marble Creek
   7. Chalcedony Mountain
   8. Guerin Glacier (60°37'N 141°05'W)
   9. Sheep Glacier (60°42'N 141°39'W)
   10. Observation Mountain (60°48'N 138°43'W)
   11. Duke River headwaters
   12. Bighorn Creek

13. Hoge Creek
14. St. Elias Mountain - general area
15. Hoge Mountain
16. Sheep - Bullion creeks plateau
17. Rainbow Mountain (68°68'N 145°37'W)
18. Outpost Mountain (60°56'N 138°22'W)
19. South end of Kluane Lake (61°01'N 138°38'W)
20. Steele Glacier - general area
21. Russell Glacier terminus
22. Fisher Glacier area
23. Bates Lake
24. Wade Mountain
25. Kathleen Lake
26. Lower Dezadeash River
27. Sugden Creek
28. Profile Mountain
29. Onion Lake
30. Mush Lake
31. Mush Creek
32. Wolverine Creek
33. Mile 1022 Alaska Hwy.
34. Cottonwood Creek Headwaters
35. Auriol Range
36. Sheep Mountain
37. Vulcan Mountain
38. Donjek Creek
39. Jarvis River
40. Slims River Delta
41. Kaskawulsh River

6. References (see Section 8.13 Literature Cited)

C - Cretien (1981)
N - Neily (1974)
D - Douglas (1974b)
D-2 - Douglas (1980)
D-3 - Douglas et al (1981)
M-G - Mackenzie - Grieve (1974)
M - Murray (1971a)
D-D - Douglas and Douglas (1978)
M-2 - Murray (1968)
M-D - Murray and Douglas (1980)

7. Although Picea mariana (black spruce) and Larix laricina (tamarack) occur throughout the southern Yukon, neither species has been recorded in the Park proper.

APPENDIX 8.2 Mosses of the Kluane National Park area[1].

Scientific Name[2]	Habitat
Aloina brevirostris (Hook. & Grev.) Kindb.	Infrequent in montane zone on damp calcareous soil.
Amblyodon dealbatus (Hedw.) B.S.G.	Rare on exposed banks in montane zone.
Andreaea rupestris (Hedw.)	Rare on exposed rocks in alpine zone.
Aulacomnium acuminatum (Lindb. & Arnell) Kindb.	Frequent in alpine tundra.
A. palustre (Hedw.) Schwaegr.	Widespread in moist montane Picea glauca forests and fens; less common in moist subalpine or alpine communities.
A. turgidum (Wahlenb.) Schwaegr.	Common in montane fens and bogs.
*Barbula acuta (Brid.) Brid.	Frequent at lower elevation: on calcareous soils in Artemisia frigida-Agropyron yukonense and Dryas drummondii communities.
*B. fallax (Hedw.)	Rare in montane bogs.
B. icmadophila Schimp. ex C. Muell	Rare in montane zone.
Bartramia ithyphylla Brid.	Frequent on vegetation stripes & rock outcrops in the alpine zone.
B. pomiformis (Hedw.)	Rare in montane Picea glauca forest.
Blindia acuta (Hedw.) B.S.G.	Rare in the subalpine zone.
Brachythecium cf. albicans (Hedw.) B.S.G.	Common from the montane zone to the alpine zone.
B. calcareum Kindb.	Rare in the alpine zone.
B. collinum (Schleich. ex C. Muell.) B.S.G.	Rare on forest floor in Picea glauca stand;
B. cf. frigidum (C.Muell) Besch.	Common in Picea glauca forests, infrequent . . the montane Salix glauca community.
B. salebrosum (Web.& Mohr) B.S.G.	Frequent on forest floor in Populus balsamifera and Salix scouleriana forests.
B. turgidum (C.J. Hartm.) Kindb.	Infrequent in moist alpine tundra.
Bryobrittonia pellucida Williams.	Rare on sandy silt banks in montane zone.
Bryoerythrophyllum recurvirostrum (Hedw.) Chen.	Common on exposed, calcareoas soil, particularly on over-hanging banks in semi-shad situations in montane zone.

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APPENDIX 8.2 **Mosses** of the **Kluane** National **Park area**'.

Scientific Name[2]	Habitat
Bryum **algovicum** Sendtn. ex **C. Muell.**	Rare in the alpine zone.
B. argenteum (Hedw.)	Common on disturbed sites or or along creeks in the **montane** zone.
B. ceaspiticium (Hedw.)	Rare on **montane** granite rock outcrop.
B. creberrimum Tayl.	Rare in the alpine zone.
B. cryophilum Mart.	**Rare** in the alpine zone.
B. pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.	Rare in **montane** Picea glauca fens, common **on rock** outcrops and along creeks in alpine zone.
Calliergon cordifolium **(Hedw.)** Kindb.	Rare in montane zone.
C. giganteum **(Schimp.)** Kindb.	Infrequent in montane ponds and Picea glauca fens.
C. richardsonii (Mitt) Kindb. ex Warnst.	Rare in Picea glauca fen.
C. **sarmentosum (Wahlenb.)** Kindb.	Rare in the alpine zone.
C. **stramineum (Brid.) Kindb.**	Rare in the alpine zone.
Campylium chrysophyllum **(Brid.)** J. Lange.	Rare on calcareous soils in **Picea glauca/Arcto-** staphylos community.

Scientific Name[2]	Habitat
C. polygamum (B.S.G.) C. Jens.	Infrequent in **montane** zone.
C. **stellatum (Hedw.)** C. Jens	Common in Picea glauca fens and P. **glauca/Salix** glauca forests.
Catoscopium nigritum **(Hedw.)** Brid.	Frequent in fens, less common on calcareous soils in Picea **glauca/** Arctostaphylos stands and on saline soils **of** Slims R. floodplain; infrequent in alpine tundra.
Ceratodon purpureus **(Hedw.)** Brid.	Extremely common in all but wettest habitats in montane zone.
Cinclidium stygium Sw.	Frequent in rich fens.
C. subrotundum Lindb.	Rare **in** rich fen.
Cirriphyllum cirrosum (Schwaegr. ex Schultes) **Grout.**	Frequent on rock outcrops and along creeks from montane to alpine zones.
Climacium dendroides **(Hedw.)** Web. 6 Mohr.	Infrequent along **streams** and in **moist** tundra in the alpine zone.
Conostomum tetragonum **(Hedw.) Lindb.**	Rare on soil in the alpine zone.

APPENDIX 8.2 Mosses of the Kluane National Park area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat.
● Cratoneuron commutatum (Hedw.) Roth var. commutatum	Infrequent in fens at lower elevations.	Dichodontium pellucidum (Hedw.) Schimp.	Infrequent on sand near river.
C. commutatum var. falcatum (Brid.) Moenk.	Rare in montane bog.	Dicranella crispa (Hedw.) Schimp.	Rare in montane bog.
C. filicinum (Hedw.) spruce.	Common in moist Picea glauc forests and bogs in the montane zone.	● D. grevilleana (Brid.) Schimp.	Rare in montane bog.
C. williamsii Grout.	Rare in montane fen.	D. subulata (Hedw.) Schimp.	Rare on disturbed soil.
Cyrtomnium hymenophylloidea (Hueb.) Kop.	Bare in the alpine zone.	D. varia (Hedw.) Schimp.	Rare in montane bog.
C. hymenophyllum (B.S.G.) Holmen	Infrequent in moist protected microhabitats in alpine tundra, often in and around rock outcrops.	Dicranoweisia crispula (Hedw.) Lindb. ex Milde.	Extremely common in moist to dry alpine habitats.
Desmatodon cernuus (Hueb.) B.S.C.	Infrequent on saline soils.	Dicranum acutifolium (Lindb. & Arnell) C. Jens ex Weinm.	very common throughout montane zone.
● D. heimii (Hedw.) Mitt.	Rare in open, dry Picea glauca forest.	D. angustum Lindb.	Infrequent in lowland shrub and forest communities.
D. latifolius (Hedw.) Brid.	Rare in alpine tundra.	D. elongatum Schleich. ex Schwaegr.	Rare in alpine zone and along small creek In Picea glauca stand.
D. leucostoma (R.Br.) Berggr.	Rare on calcareous soil in alpine tundra.	D. majus Sm. var. orthophyllum A. Braun ex Milde.	Infrequent in Picea glauca/Salix glauca and S. glauca stands.
D. systylius Schimp.	Rare on exposed soil in the alpine zone.	*D. muehlenbeckii B.S.G. var cirratum (Schimp) Lindb.	Frequent in shrub and forest communities in montane and subalpine zones.

APPENDIX **B.2 Mosses** of the **Kluane** National **Park area**[1].

Scientific Name[2]	Habitat
Dicranum muehlenbeckii var. muehlenbeckii	Frequent and widespread in **montane** zone, rare in alpine Empetrum **nigrum** stands.
D. **scoparium (Hedw.)**	Infrequent in Picea **glauca/** Betula **glandulosa** and and Betula **glandulosa** **Festuca** altaica communities, rare on **snowbed** sites in alpine zone.
D. undulatum Brid.	**Rare** on forest floor in Picea **glauca/Betula glandulosa and** Populus tremuloides stands.
Didymodon **asperifolius** (Mitt.) **Crum, Steere &** Anderson.	Rare on montane rock outcrop.
D. **johansenii** (Williams) **Crum.**	Rare on soil in Picea glauca forest.
Distichium capillaceum (Hedw.) B.S.G.	Common and widespread from montane to the alpine zones.
D. inclinatum (Hedw.) B.S.G.	Infrequent in rich fens and calcareous mudflats.
Ditrichum **flexicaule (Schwaegr.) Hampe.**	Common and widespread in **montane zone, less** frequent on rocky alpine ridges.
Drepanocladus aduncus (Hedw.) Warnst.	Rare in Picea **glauca** fen.
D. badius (C.J. Hartm.) Roth.	Infrequent in rich **montane** fens.
D. exannulatus (B.S.G.) Warnst.	Infrequent in pools in rich **montane** fens.
D. revolvens (Sw.) Warnst.	Frequent in rich **fens** in **montane** zone and moist **calcareous** tundra at higher elevations.
D. sendtneri (Schimp.) Warnst.	Rare on the bottom of ephemeral pond.
D. uncinatus (Hedw.) Warnst.	Common in deciduous and coniferous forests, less frequent in **Salix** glauca and fen **communities** in montane **zone;** also frequent **throughout** subalpine and alpine zones.
D. **vernicosus (Lindb. ex C. Hartm.)** Warnst.	Rare in wet **Salix community**
Encalypta affinis R. **Hedw.**	Infrequent in Picea glauca forests.
E. **alpina** Sm.	Frequent on soil in alpine zone.
E. procera **Bruch.**	Rare on shady, rocky slopes and rock crevices **above** creek in montane and alpine zones.

APPENDIX 8.2 Mosses of the Kluane National Park area[1].

Scientific Name[2]	Habitat
Encalypta rhaptocarpa Schwaegr.	Rare in moist montane meadows.
E. vulgaris Hedw.	Rare on rocky Alpine And montane soil banks.
Entodo" concinnus (DeNot. Par.	Rare in moist Picea glauca forest.
Eurhynchium pulchellum (Hedw.) Jen".	Infrequent on soil And humus in Picea glauca forest.
Fissidens bryoides Hedw.	Rare on soil on moist sites from montane to the Alpine zones.
Funaria hygrometrica Hedw	Infrequent from montane to alpine zone.
Grimmia affinis Hoppe & Hornsch. ex Hornsch.	Rare on rocks in Alpine zone.
G. alpicola Hedw.	Rare in montane zone.
G. anodon B.S.G.	Rare on montane granite outcrop.
G. apocarpa Hedw. var. apocarpa.	Rare on dry, montane cliff.
Grimmia apocarpa var. stricta (Turn.) Hook & Tayl.	Rare in montane zone.
Gymnostomum recurvirostrum Hedw.	Frequent on calcareous And saline soils.
● HeteroclAdium dimorphum (Brid.) B.S.G.	Rare in dry montane meadow.
Hygrohypnum luridum (Hedw.) Jenn.	Infrequent in small montane streams.
Hylocomium splendens (Hedw.) B.S.G.	Common And widespread throughout montane zone.
Hypnum bambergeri Schimp.	Frequent on rocky, Alpine slopes and in mesic Alpine tundra.
H. cupressiforme Hedw.	Infrequent in moist Picea glauca forest.
H. lindbergii Mitt.	Infrequent on moist sites i montane zone, often on sandy soils beside small streams.
H. plicatulum (Lindb.) Jaeg. & Sauerb.	Rare on rotton log in Picea glauca-Populus tremuloides stand.
H. procerrimum Mol.	Rare in Picea glauca forest and on moist alpine tundra.
H. revolutum (Mitt.) Lindb.	Extremely common and wide-spread on mesic to dry sites from montane to alpine zones.
H. vaucheri Lesq.	Infrequent on dry, rocky sites at lower elevations.

APPENDIX 0.2 Mosses of the Kluane National Park area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
Isopterygium pulchellum (Hedw.) Jaeg. & Sauerb	Infrequent in Picea glauca/Salix glauca stands in montane zone and on rocky alpine ridges.	Oncophorus virens (Hedw.) Brid.	Rare in montane and sub-alpine Salix glauca community.
		O. wahlenbergii Brid.	Infrequent in fens at lower elevations.
Leptobryum pyriforme (Hedw.) Wils.	Infrequent in Betula glandulosa/Festuca altaica stands and disturbed soil banks in montane zone.	Orthothecium chryseum (Schwaegr. ex Schultes) B.S.G.	Frequent in calcareous seepages in alpine zone.
		orthotrichum anomalum Hedw	Rare in montane Picea mariana bog.
Heesia triquetra (Richt.) Anqstr.	Rare in rich Picea glauca fens and wet, calcareous sites.	O. jamesianum Sull. ex James.	Rare in montane zone.
M. uliginosa Hedw.	Frequent on wet sites in Picea glauca rich fens and on moist, organic soil in alpine zone.	O. laevigatum Zett. fo. macounii (Aust.) Lawton & Vitt ex Lawton.	Frequent on exposed rock in alpine zone.
		O. obtusifolium Brid.	Frequent on Picea glauca branches and on fallen Alnus branches.
Mnium arizonicum Amann.	Infrequent beneath trees in montane and subalpine zones.	O. pulchellum Brunt. ex Winch & Gateh.	Rare on fallen branches of Alnus in dense Picea glauca forest.
M. blyttii B.S.G.	Infrequent on ridges and rock outcrops in alpine zone.	O. pylaisii Brid.	Rare on rocks in alpine zone.
M. thompsonii Schimp.	Infrequent in Picea glauca forests.	O. speciosum Nees ex Sturm var. elegans (Schwaegr. ex Hook. & Grev.) Warnst.	Rare on Populus trunks.
Myurella julacea (Schwaegr.) B.S.G.	Frequent and often inter-mixed with mosses on calcareous soil in alpine zone.		
M. tenerrima (Brid.) Lindb	Infrequent in same habitats as M. julacea.		

APPENDIX 8.2 **Mosses** of the **Kluane National** Park **area**[1].

Scientific Name[2]	Habitat
Orthotrichum speciosum var. speciosum	Frequent on Picea glauca branches and fallen Alnus branches.
Paludella squarrosa (Hedw.) Brid.	Infrequent in montane rich fens.
Philonotis fontana (Hedw.) Brid. var. fontana.	Infrequent in fens at lower elevations and in calcareous seepages in montane and alpine zones.
P. fontana var. pumila (Turn.) Brid.	Infrequent aiong small streams in alpine zone.
Plagiobryum demissum (Hook.) Lindb.	Rare in alpine zone.
P. zierii (Hedw.) Lindb.	Rare in alpine zone.
Plagiomnium ellipticum (Brid.) Kop.	Infrequent in montane zone.
Plagiopus oederiana (Sw.) Limpr.	Infrequent on cliff faces and ledges in montane and alpine zones.
Pleurozium schreberi (Brid.) Mitt.	Common in Picea glauca forests, infrequent in montane meadows.
Pogonatum urnigerum (Hedw.) P. - Beauv.	Rare in alpine zone.
Pohlia annotina (Hedw.) Lindb.	Infrequent on sandy soil near river.
P. atropurpurea (Wahlenb.) H. Lindb.	Infrequent on sandy soil near river.
● P. bulbifera (Warnst.) Warnst.	Rare in alpine zone.
P. cruda (Hedw.) Lindb.	Common and widespread from montane to alpine zones.
P. nutans (Hedw.) Lindb.	Common throughout montane zone.
P. proligera (Kindb. ex Limpr.) Lindb.	Infrequent in dry Picea glauca forests.
P. rothii (Corr. ex Limpr. Broth.	Rare in alpine zone.
P. wahlenbergii (Web. 6 Mohr) Andr.	Rare in alpine zone.
Polytrichastrum alpinum (Hedw.) G.L. Smith.	Common throughout alpine zone on rocky slopes and ridges.
Polytrichum commune Hedw.	Infrequent in Picea glauca/ Betula glandulosa stands.
P. juniperinum Hedw.	Common and widespread from montane to alpine zones.
P. piliferum Hedw.	Infrequent in Picea glauca forests, more common on dry subalpine 6 alpine slopes and ridges.

APPENDIX 8.2 Mosses of the Kluane national Park area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
Polystrichum sexangulare arid.	Infrequent in alpine vegetation stripes and on rocky alpine ridges.	R. heterostichum (Hedw.) Brid. var sudeticum (Funck) Dix. ex Bauer.	Rare on alpine talus slopes.
P. strictum Brid.	Infrequent on logs in mixed Picea glauca-Populus tremuloides stand and fens.	R. lanuginosum (Hedw.) Brid.	Infrequent on alpine talus slopes.
		Rhizomnium gracile Kop.	Rare in open Picea glauca stand. --
● Pseudoleskea radicosa (Mitt.) Macoun & Lindb. var. compacta Best.	Rare on alpine rock outcrop	Rhytidium rugosum (Hedw.) Kindb.	Common in montane and alpine zones.
		Saelania glaucescens (Hedw.) Bomanss. & Broth.	Rare in alpine zone.
Pterygoneurum ovatum (Hedw.) Dix.	Infrequent in montane Picea glauca forests and in alpine zone.		
P. subsessile (Brid.) Jur	Rare in alpine zone.	Scorpidium scorpioides (Hedw.) Limpr.	Infrequent in rich fens.
Ptilium crista-castrensis (Hedw.) DeNot.	Rare, on a log in mixed Picea glauca-Populus tremuloides stand.	S. turgescens (T.Jens.) Loeske.	Frequent in depressions and in pools in rich fens in montane zone as well as in pools in alpine tundra.
Pylaisiella polyantha (Hedw.) Grout.	Rare in Picea glauca forest,		
*Rhacomitrium canescens (Hedw.) Brid. var. ericoides (Hedw.) Hampe.	Infrequent but widespread from montane to alpine zones.	Seligeria subimmersa Lindb	Rare on calcareous rock in alpine zone.
		Sphagnum fuscum (Schimp.) Klinggr.	Infrequent in Picea glauca fens.
		S. girgensohnii Russ.	Rare on a N-facing bank in montane zone.
		S. warnstorfii Russ.	Infrequent in Picea glauca fens.

APPENDIX 8.2 **Mosses** of the **Kluane** National Park area'.

Scientific Name[2]	Habitat
Splachnum luteum Hedw. var. luteum.	Rare on wist sites in montane zone.
• S. luteum var. melanocaulon Wahlenb.	Rare on dung in moist depression in Picea glauca forest. --
S. sphaericum Hedw.	Infrequent on wist sites in montane zone.
Stegonia latifolia (Schwaegr. ex Schultes) Vent ex Broth. var. latifolia.	Infrequent on exposed soil in alpine zone.
S. latifolia var. pilifera (Brid.) Broth.	Infrequent in alpine zone, often intermixed with var. latifolia.
Tayloria lingulata (Dicks.) Lindb.	Rare in alpine zone.
Tetraplodon angustatus (Hedw.) B.S.G.	Rare in wntane zone.
T. mnioides (Hedw.) B.S.G. var. cavifolius Schimp.	Rare in alpine zone.
T. mnioides var. mnioides.	Rare in Picea glauca stand.
Thuidium abietinum (Hedw.) B.S.G.	Common in Picea glauca forests and often a dominant cover in northern part of region.
T. delicatulum (Hedw.) B.S.G. var. radicans (Kindb.) Crum, Steere & Anderson.	Rare in Picea glauca stand.
T. recognitum (Hedw.) Lindb.	Rare in wntane zone.
Timmia austriaca Hedw.	Infrequent in Picea glauca forests. --
T. megapolitana Hedw. var. bavarica (Hessl.) Brid.	Infrequent in Picea glauca forests. --
Tomenthypnum nitens (Hedw.) Loeske.	Common in wntane and alpine fens and on moist sites in Picea glauca forests
Tortella arctica (Arnell) Crundu. & Nyh.	Infrequent in alpine zone.
T. fraqilis (Drumm.) Limpr.	Infrequent on dry gravelly sites in montane zone.
*T. inclinata (R.Hedw.) Limpr.	Rare in wntane zone.
T. tortuosa (Hedw.) Limpr.	Infrequent in alpine zone.
Tortula mucronifolia Schwaegr.	Infrequent on disturbed soil in alpine and montane zones, rare in Picea mariana bog.
T. norvegica (Web.) Wahlenb. ex Lindb.	Frequent in vegetation stripas and rock outcrops in alpine zone.

APPENDIX 8.2 Mosses of the Kluane National Park area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
Tortula ruralis (Hedw. Gaertn., Meyer & Scherb.	Extremely common on dry sites throughout montane zone.		
Trematodon brevicollis Hoppe & Hornsch. ex Hornsch.	Rare in alpine zone.		
*Weissia controversa Hedw.	Rare on exposed calcareous soil in alpine zone.		

Footnotes:

*species newly reported for the Kluane area.

1. Source: Douglas & Vitt 1976. Includes some species identified outside Park boundaries.

2. Nomenclature, authorities, and synonymy are based on Crum et al 1973.

APPENDIX 8.3 Lichens of the Kluane National Park area'.

Scientific Name[2]	Habitat
Acarospora chlorophana (Wahlenb. ex Ach.) Mass.	Common on rocks in alpine zone.
*A. glaucocarpa (Wahlenb. ex Ach.) Körb.	Rare on soil in alpine zone.
A. oxytona (Ach.) Mass.	On igneous rock in alpine zone.
A. cf. veronensis Mass.	Rare on rock on rocky alpine ridge.
*Alectoria lanestris (Ach.) Gyeln.	Common on branches of Picea glauca in southern half of region, less frequent on rock in alpine zone.
'A. nigricans (Ach.) Nyl.	Infrequent in alpine fell-fields and rock outcrops.
A. ochroleuca (Hoffm.) Mass.	common on soil on exposed alpine ridges and rock outcrops often with A. nigricans.
*A. pubescens (L.) R. H. Howe.	Frequent on rocks on alpine talus slopes and rock outcrops.
● Arthrorhaphis citrinella (Ach.) Poelt var. alpina (Schaer.) Poelt.	Infrequent on Populus balsamifera bark.

Scientific Name[2]	Habitat
Bacidia obscurata (Somm.) Zahlbr.	Rare on soil in subalpine Salix planifolia stand.
B. sphaeroides (Dicks.) Zahlbr.	Infrequent on soil in Populus balsamifera stand.
Buellia epigaea (Hoffm.) Tuck.-----	On soil on dry, montane site (Hoefs 6 Thomson, 1972).
B. insignis Th. Fr.	Frequent on rock in alpine zone.
● B. papillata (Somm.) Tuck.	Frequent on rock and soil i alpine zone.
B. stellulata (Tayl.) Mudd.	On metamorphic rocks in montane zone (Hoefs 6 Thomson, 1972).
*B. triphragmioides Anzi.	Rare on bark of Populus balsamifera.
*B. zahlbruckneri J. Stein	Common on rotton logs in deciduous forests; rare on bark of Alnus crispa var. lacinata.
● Caloplaca cinnamomea (Th. Fr.) Oliv.	Rare on soil in montane Dryas drummondii stands.
C. cirrochroa (Ach.) Th. [illegible]	On soil on dry, montane site (Hoefs & Thomson, 1972).

APPENDIX 8.3 **Lichens** of **the Kluane** National **Perk area**[1].

Scientific Name[2]	Habitat
***Caloplaca** fraudnas **(Th.Fr.) Oliv.**	Rare on rock on alpine **scree** slope.
C. holocarpa (Hoffm.) Wade.	Rare on **Populus balsamifera** bark.
C. **jungermanniae (Vahl)** Th. Fr.	Frequent and widespread from montane zone to alpine zones.
***C. stillicidiorum (Vahl)** Lynge.	Rare on soil on alpine ridge.
***C. tetraspora (Nyl.) Oliv.**	Rare on soil in **montane Salix** glauca stand.
● Candelariella aurella (Hoffm.) Zahlbr.	Rare on soil in montane Artemisia frigida-Poa glauca **stand.**
[illegible] **terrigena** Ras.	Rare on soil on alpine ridge.
C. vitellina (Ehrh.) Mull. Arg.	Rare on soil on alpine rock outcrop.
Cetraria **commixta (Nyl.)** Th. Fr.	Rare on rock on alpine **talus** slope. .
C. **cucullata** (Bell.) Ach.	Extremely common on soil on alpine slopes and ridges; less frequent but widespread in montane and subalpine zones.

Scientific Name[2]	Habitat
● s. delisei **(Bory ex Schaer.) Th.Fr.**	Infrequent on soil in alpine Cassiope tetragona and-Salix **reticulata communities.**
C. ericetorum Opiz.	Common and widespread on soil from **montane** zone to alpine zones.
C. hepatiron (Ach.) Vain.	Frequent on rock in alpine zone.
C. islandica (L.) Ach.	Common and widespread on soil from **montane** to alpine zones.
C. laevigata Rass.	Infrequent on soil in alpine zone,
C. nivalis **(L.)** Ach.	Common on soil on alpine slopes and ridges. On the driest, exposed ridges, where snow rarely accumulates, this species is often the dominant plant. **Less** frequent but widespread in montane and subalpine zones.
C. pinastri **(Scop.)S.** Gray.	**Common** on tree **trunks,shrubs** and dead logs in southern half of region.
C. **richardsonii** Hook.	On **soil** in alpine zone from Slims **R.** region northward **(Hoefs &** Thomson, **1972).**

APPENDIX 8.3 Lichens of the Kluane National Park area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
• Candelariella subalpine Imsh.	On soil in snowbed communities dominated by cassiope stelleriana or Salix polaris in southern half of region	C. cariosa (Ach.) Spreng.	Frequent on soil in Picea glauca and Salix communities.
		C. carneola (Fr) Fr.	Infrequent in Picea glauca/ Salix glauca community.
C. tilesii Ach.	Common and widespread on dry sites from montane to alpine zones.	C. cenotea (Ach) Schaer.	Rare on rotten log in Salix glauca stand.
		'C. chlorophaea (Flörke ex Somm.) Sprenq.	Rare on soil in Salix glauca stand.
Cladina alpestris (L.) Harm.	Infrequent in alpine Cassiope tetragona and Dryas octopetala communities.	C. coccifera (L.) Willd.	Frequent on soil in Picea glauca/Betula glandulosa and Betula glandulosa/Festuca altaica communities.
C. arbuscula (Wallr.) Hale & W. Culb.	Common throughout montane zone, less frequent in subalpine and alpine zones.	C. cornuta (L.) Hoffm.	Common throughout montane zone.
		C. cf. cyanipes (Somm.) Nyl.	Rare in subalpine Salix planifolia stand.
C. mitis (Sandst.) Hale & W. Culb.	Common throughout montane zone, less frequent in subalpine and alpine zones.	• C. ecmocyna (Ach.) Nyl.	Common throughout montane zone, infrequent in subalpine and alpine zones.
C. rangiferina (L.) Harm.	Rare in Betula glandulosa/ Festuca altaica stand.	C. fimbriata (L.) Fr.	Common on litter and dead logs in deciduous and coniferous forests.
• Cladonia acuminata (Ach.) Norrl.	Rare in Picea glauca-Alnus stand.	C. furcata (Huds.) Schrad.	Rare on forest floor in Picea glauca/Salix glauca stand.
C. amaurocraea (Flörke) Schaer.	On decaying wood in Picea glauca forest.		
• C. botrytes (Hag.) Willd.	Infrequent on rotten logs in Picea glauca and Salix communities.		

APPENDIX 8.3 Lichens of the Kluane National Park area[1].

Scientific Name[2]	Habitat
Cladonia gonecha (Ach.) Asah.	Common rotten logs in coniferous and deciduous forests.
C. gracilis (L.) Willd., sens. lat.	Extremely common throughout montane zone, less frequent in subalpine and alpine zones.
C. lepidota Nyl.	In moist Picea glauca forest.
*C. macrophyllodes Nyl.	Rare in subalpine Empetrum nigrum stand.
*C. major (Hag.) Sand-at.	Rare in alpine Salix reticulata stand.
C. multiformis Merr. fo. multiformis.	Frequent from montane to alpine zones.
*C. multiformis fo. subascypha (Vain.) Evans	Rare in montane Festuca altaica stand.
C. cf. norrlinii Vain.	Rare in Picea mariana fen.
*C. phyllophora Hoffm.	Infrequent in Picea glauca forests and Festuca altaica meadows.
C. pityrea (Flörke) Fr.	Rare on log in Populus balsamifera stand.
C. pocillum (Ach.) O.Rich.	Frequent from montane zone to alpine zones.
C. pyxidata (L.) Hoffm.	Infrequent in Picea glauca forests. - -
*C. squamosa (Scop.) Hoffm.	Rare in montane Feetuca altaica stand.
C. subcervicornis (Vain.) Kernst.	Rare in mesic, herbaceous meadow.
C. uncialis (L.) Wigg.	Infrequent in montane meadows and on alpine slopes.
C. verticillata (Hoffm.) Schaer.	Common throughout montane zone, rare in sub-alpine Festuca altaica stands.
Collema coccophorum Tuck.	Rare on dry, S-facing montane slope (Hoefs 6 Thomson, 1972).
Cornicularia aculeata (Schreb.) Ach.	Infrequent but widespread i montane and subalpine zones, more common on dry sites in alpine zone.
c. divergens Ach.	Rare in alpine Dryas octopetala stand.
Dactylina arctica (Hook.) Nyl.	Common and widespread in subalpine and alpine zones, rare in montane zone.
D. madreporiformis (Wulf.) Tuck.	Infrequent on dry sites fro montane to alpine zone.

APPENDIX 8.3 **Lichens** of **the Kluane National** Park **area**[1].

Scientific **Name**[2]	Habitat	Scientific **Name**[2]	Habitat
Dactylina ramulosa (Hook.) Tuck.	common on dry alpine ridges and rock outcrops.	Hypogymnia physodes (L.) **W.** Wats.	Rare **on Picea** glauca twigs.
Dermatocarpon fluviatile (G. web.) Th.Fr.	Infrequent in small creeks in alpine zone.	Icmadophila ericetorum **(L.)** Zahlbr.	Rare on rotten log in **montane** zone.
D. hepaticum (Ach.) Th.Fr.	Infrequent, but locally common in open **montane** areas.	**Lecanora atra (Huds.)** Ach.	Infrequent on rock on alpine rock outcrop.
Diploschistes scruposus (Schreb.) Norm.	Infrequent on calcareous soils from **montane** to alpine zones.	**L. caesiocinerea Nyl.**	Infrequent on rock on **montane** to alpine rock outcrops.
Evernia divaricata (I..)	On dead Picea glauca **branches.**	**L. candida (Anzi)** Nyl.	On igneous rock in alpine zone.
E. esorediosa **(Müll.** Arg.) **DuRietz.**	On soil in dry open Picea glauca forest.	L. **cenisia** Ach.	Rare on rock on alpine rock outcrop.
E. perfragilis Llano.	Infrequent on soil from **montane** to alpine zones.	**L.** chrysoleuca (Sm.) Ach.	Infrequent on rock on dry sites in **montane** zone.
Fulgensia bracteata (Hoffm.) **Räs.**	Common on calcareous soils in **montane** zone, rare in alpine zone.	**L.** epibryon **(Ach.)** Ach.	**Common** and widespread on soil in dry habitats from **montane** to alpine zones.
● Haematomma **lapponicum** Ras.	Rare on rock on alpine ridge.	**L. frustulosa (Dicks.)** Ach.	Infrequent on rock in lower alpine zone.
● Hypogymnia atrofusca **(Schaer.) Räs.**	Rare on alpine rock outcrop.	● L. **hageni (Ach.)** Ach.	Rare on bark of **Populus** balsamifera in P. **balsamifera** staid.
H. austerodes **(Nyl.) Räs.**	Common on dead logs, twigs & tree trunks in coniferous 6 deciduous forests in southern half of region.	**L. melanophthalma** (Ram.) Ram.	Frequent on rock in alpine zone.

APPENDIX 8.3 Lichens of the Kluane Rational Park area[1].

Scientific Name[2]	Habitat
*Lecanora muralis (Schreb.) Rabenh.	Infrequent on rock on alpin rock outcrops and in alpine fellfields.
*L. polytropa (Ehrh.) Rabenh.	Infrequent on rock in dry alpine fellfields.
• L. rupicola (L.) Zahlbr.	Common on rock on alpine rock outcrops and in alpine fellfields.
• L. verrucosa Ach.	Infrequent from montane to alpine zones.
• L. wisconsinensis Magn.	Rare on Alnus crispa var. lacinata bark in sub-alpine zone.
*Lecidea armeniaca (DC.)Fr.	Infrequent on rock in alpin zone.
*L. atrobrunnea (Ram.) Schaer.	Common on rock on alpine rock outcrops and in alpine fellfields.
L. atromarginata Magn.	Infrequent on rock in alpin zone.
• L. berengeriana (Mass.) [illegible]	Frequent on forest floor in Picea glauca stands.
L. cuprea Somm.	On soil over igneous rocks in alpine zone.
L. decipiens (Hedw.) Ach.	Common on soil in dry habitats from montane zone to alpine zone.
• L. flavocaerulescene Hornem.	Rare in alpine fellfield.
• &. glomerulosa (DC.) Steud.	Infrequent on Populus balsamifera bark in montane zone, rare on dead twigs in alpine zone
L. granulosa (Ehrh.) Ach.	Infrequent on soil from montane to alpine zones.
• k. lapicida (Ach.) Ach.	Frequent on rock in alpine sone.
Lecidea marginata Schaer.	On igneous rock in alpine zone.
• L. pantherina (Hoffm.) Th.Fr.	Rare on alpine rock out-crops.
L. rubiformis (Wahlenb. ex Ach.) Wahlenb.	Common on soil in dry, montane habitats, rare in alpine zone.
*L. subsoredira Lynge.	Rare on rock in alpine zone
L. tessellata (Ach.) Flörke.	Infrequent on rock from montane to alpine zones.
• Lecidella stigmatea (Ach.) Hert. 6 Leuck.	Rare on rock on rocky alpin ridges.
• Lepraria neglecta (Nyl.) Lett.	Common on soil from montane zone to alpine zone.

APPENDIX 8.3 Lichens of **the Kluane National Park** area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
Lobaria linita (Ach.) Rabenh.	Infrequent throughout **montane** zone, rare in alpine zone.	***P.** exasperatula Nyl.	Infrequent on rotten logs and Populus balsamifera bark in **P.** balsamifera stands.
Nephroma **arcticum (L.) Torss.**	Infrequent in subalpine zone.	● P. fraudans Nyl.	Rare on **rock** on alpine rock outcrop.
N. expallidum **(Nyl.)** Nyl.	Frequent in **montane** Picea **glauca/Betula** glandulosa and Betula **glandulosa/Festuca** altaica communities.	● p. infumata Nyl.	Rare on Picea **glauca** twig in **P. glauca stand.**
● Ochrolechia **frigida** (Sw.) Lynge.	Frequent in alpine Salix **reticulata** and Cetraria nivalis communities.	**P.** stygia **(L.)** Ach.	Rare **on rock on** alpine **talus** slope.
'0. **upsaliensis (L.)** Mass.	Extremely common throughout alpine **zone.**	**P.** sulcata Tayl.	Infrequent **on Picea** glauca twigs in **P. glauca** forests.
Pannaria **pezizoides (G.Web.) Trev.**	**Rare on mist sites** in sub-alpine and alpine zones	**P.** taractica Kremp.	Infrequent on soil in dry habitats from **montane** to alpine zones.
***Parmelia alpicola** Th.Fr.	Rare on alpine rock outcrop.	**Parmeliopsis ambigua (Wulf.)** Nyl.	Common on dead twigs and logs in Picea glauca forests.--
P. centrifuya **(L.)** Ach.	Rare on **rock** in alpine fellfield.	Peltigera aphthosa **(L.) Willd.** var. aphthosa.	Common throughout **montane &** subalpine zones, less frequent in alpine zone
***P.** chlorochroa Tuck	Rare on calcareous soil in wntane Artemisia Frigida-Agropyron yukonense stand.	P. aphthosa var. leucophlebia Nyl.	In **moist** Alnus thicket.
● P. elegantula **(Zahlbr.) Szat.**	Rare on **bark** of Populus balsamifera.	P. **canina (L.) Willd.**	Extremely common throughout **montane** zone.
		*P. elisabethae Gyeln.	Rare on forest floor in **Pop**-ulus tremuloides stand-

APPENDIX 8.3 Lichens of the Kluane National Park area[1].

Scientific Name[2]	Habitat
*Peltigera horizontalis (Huds.) Baumg.	Rare on soil beside river.
• P. malacea (Ach.) Funck.	Infrequent in montane zone.
P. rufescens (Weis.) Humb.	Common throughout montane *one, less frequent in subalpine and alpine zones.
P. scabrosa Th.Fr.	Rare in alpine zone.
P. spuria (Ach.) DC.	Infrequent in Picea glauca/Betula glandulosa stands, less common in subalpine zone.
P. venosa (L.) Baumg.	Rare on moist, but well-drained, gravelly sites from montane to alpine zones.
• Pertusaria alpina Hepp.	Rare on moist, but well drained, gravelly sites from montane to alpine zones.
P. dactylina (Ach.) Nyl.	Frequent throughout alpine zone.
• Physcia adscendens (Th.Fr) Oliv.	Rare on bark of Populus balsamifera.
• P. aipolia (Ehrh.) Hampe.	Rare on bark of Populus balsamifera.
P. caesia (Hoffm.) Hampe.	Rare on bark of Populus balsamifera.
• P. intermedia Vain.	Rare on rock on alpine rock outcrop.
P. sciastra (Ach.) DuRietz	Rare on soil on alpine rock outcrop.
P. wainioi Räs.	Rare on rock in alpine zone.
Physconia muscigena (Ach.) Poelt. fo. alpina Nadw.	Rare on soil in Artemisia frigida/Agropyron vukonense stand.
P. muscigena fo. muscigena	Common on dry sites throughout montane, subalpine and alpine zones.
• Protoblastenia rupestris (Scop.) J.Stein	Rare on an alpine scree slope.
Psoroma hypnorum (Vahl) S.Gray.	Frequent throughout alpine zone, rare in montane Picea glauca forests.
Ramalina roesleri (Hochst. Nyl.	Infrequent on dead Picea glauca branches.
• Rhizocarpon disporum (Naeg. ex Hepp.) Müll. Arg.	Infrequent on rock on alpina rock outcrops or in alpine, fellfields.
R. geographicum (L.) DC.	Frequent on rock in alpine zone.
'R. macrosporum Räs.	Rare on rock in alpine zone.
*R. sphaerosporum Räs.	Rare on rock in alpine zone.

APPENDIX 8.3 Lichens of the Kluane National Park area[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
• Rinodina mniaraea (Ach.) Körb.	Frequent on soil from montane to alpine zones.	S. rivulorum Magn.	In moist Picea glauca forest.-
• R. nimbosa (Fr.) Th.Fr.	Infrequent on soil on alpine rock outcrops.	S. tomentosum Fr.	Frequent in montane zone.
• R. roscida (Somm.) Arn.	Infrequent on dead material from montane to alpine zones.	Thamnolia subuliformis (Ehrh.) W.Culb.	Common and widespread from montane zone to alpine zone.
R. turfacea (Wahlenb.) Körb.	Bare on rotten log in Salix scouleriana stand.	T. vermicularis (Sw.) Ach. ex Schaer.	Infrequent from montane zone to alpine zones.
Solorina crocea (L.) Ach.	Common in moist habitats throughout alpine zone.	Toninia caeruleonigrican (Lightf.) Th.Fr.	Infrequent on calcareous soils in montane, sub-alpine and alpine zones
*S. octospora Arn.	Rare on soil in alpine zone.		
S. saccata (L.) Ach.	Frequent in moist habitats throughout alpine zone.	• Umbilicaria cylindrica (L.) Del.	Bare on rock on alpine talus slope.
S. spongiosa (Sm.) Anzi.	On soil in alpine zone.	*U. deusta (L.) Baumg.	Bare on dead Picea glauca twig in P. glauca forest.
• Sporastatia testudinea	Rare on rock on alpine rock outcrops.	U. havaaaii Llano.	On igneous rock in alpine *one.
Squamarina lentigera (G.Web.) Poelt.	Common on dry, calcareous Soils in montane zone.	U. hyperborea (Ach.) Ach.	Common on rock on alpine rock outcrops and talus slopes.
Stereocaulon alpinum Laur.	Frequent from the montane to alpine zones.	U. proboscidea (L.) Schrad.	Common on rock on alpine rock outcrops and talus slopes.
S. glareosum (Sav.) Magn.	On mesic N-facing alpine slopes.		
'S. grande (Magn.) Magn.	Infrequent in montane 6 sub-alpine Festuca altaica stands.-	• Usnea glabrata (Ach.) Vain	Frequent on branches of Picea glauca in southern part of region.

APPENDIX 8.3 Lichens of the **Kluane** National Park **area**[1].

Scientific Name[2]	Habitat	Scientific Name[2]	Habitat
● IJsnea **glabrescens** (Nyl. **ex** Vain.) Vain. ssp. glabrella Mot.	Frequent on branches of **Picea** glauca in **southern part of region.**		
● Xanthoria candelaria **(L.)** Th.Fr.	Rare on bark of Populus balsamifera.		
X. elegans (Link) **Th.Fr.**	Frequent on rocks in **montane** subalpine and alpine **zones.**		
● X. polycarpa **(Ehrh.) Oliv.**	Rare on bark of Populus balsamifera.		

Footnotes:

1. Source: Douglas 6 Vitt 1976. Includes some species identified outside Park boundaries.

2. Nomenclature, authorities, and synonymy are based **on** **Hale** and Culberson 1970.

CHAPTER 9

Wildlife of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

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Date of preparation: March 1985.

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9.1 Introduction[1]

Kluane National Park has been described as one of the richest wildlife areas in the Canadian north (Hoefs 1980). A national park reserve and the Kluane Game Sanctuary were designated in 1942 and 1943 , respectively in recognition of the area's diversity and density of large mammal species and the need to protect these populations from indiscriminant hunting as a result of easy access along the Alaska Highway. The Park Reserve was not formally proclaimed until 1972 and, prior to that time, protection for wildlife was afforded only by Game Sanctuary status, under the administration of the Yukon Game Branch. Yukon regulations prohibited all hunting and trapping in the Game Sanctuary but, in 1950, trapping by Indians at Burwash Landing.'was allowed by special consent. In the last 2 or 3 years, these regulations have again been modified to allow native hunting in the Game Sanctuary. Since 1972, the Park Reserve has been administered under the National parks Act and all hunting and trapping are prohibited within Reserve boundaries. The Park and Sanctuary boundaries are shown in Map 1.1.

Poaching was the major threat to Kluane's wildlife from 1942 to the early 1970's. At the time of Park establishment, initial reconnaissance revealed 21 active airstrips in the Greenbelt areas of the Park, utilized mainly by American outfitters hunting illegally in the Park and Sanctuary. Since then concerted international efforts by Park and American enforcement personnel have brought this activity under control. Incidents do still occur but they are now considered rare.

In the face of continuing pressure on wilderness areas in the south, the value of Kluane's environment as a wildlife sanctuary is increasing every year. This is particularly true for species such as Grizzly bear, Dall's sheep, and Mountain goats which are sensitive to human intrusion of their range. Preservation of the Park's wilderness character and its wildlife populations and their habitat are two of the prime objectives of Resource Conservation in Kluane. These objectives are carried out in the face of external pressures on species which move across Park boundaries, the need to counter and eliminate organized international poaching of trophy specimens, increasing demands for development of visitor facilities within the Park, and increasing backcountry use.

9.2 Data Sources and Limitations - Mammals and Raptors

9.2.1 General

To carry out the mandate to preserve naturally regulated wildlife populations in Kluane, it was first necessary to enumerate the

---

[1] Sections on Avifauna, Amphibians, and Insects to be completed at a future date.

dynamics, and provides a basis for management decisions and future planning in areas of Dall's sheep habitat throughout Kluane.

9.2.3 Current Wildlife Monitoring

The current wildlife monitoring program in Kluane has evolved over the last 13 years to the point where the size of the populations is known, the basic influences on them are understood although many are not proven scientifically, and the survey schedules and boundaries have been adjusted to achieve the most representative count of the population, given increasingly limited financial resources.

The program began in 1972 when the Kluane National Park Reserve was formally proclaimed. As part of the Basic Resource Inventory, a contract was let to M. Hoefs through the Canadian Wildlife Service to report on the abundance and distribution of important wildlife species, their critical habitats, and migration routes in and near the new Kluane National Park. This report (Hoefs 1973) was a reconnaissance survey of 8165 km^2 in the Front Ranges and Greenbelt areas, including 1300 km^2 outside but adjacent to the Park. It estimated total populations and mapped total range for Dall's sheep, Mountain goats, Moose and Caribou.

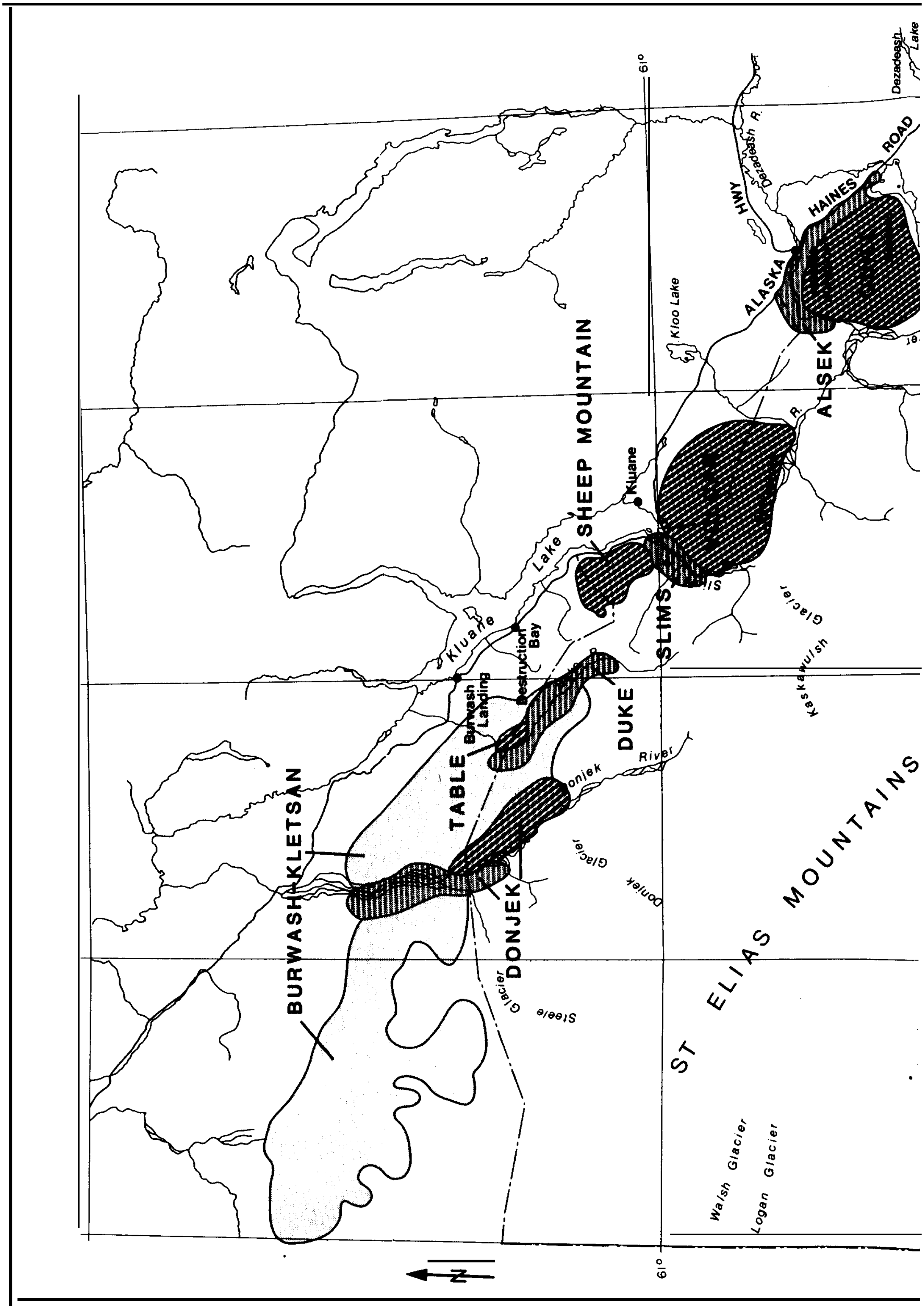
In 1973 and 1974, the Warden Service assumed responsibility for wildlife investigations and undertook two major surveys to obtain more population data and to delineate winter and summer ungulate range more precisely. Hoefs (1974*, 1975) continued his work, concentrating on the Dall's sheep population on Sheep Mountain.

In 1976, meetings were held with the Canadian Wildlife Service to formulate a long range plan for wildlife monitoring (schedules, areas, data to be collected), data storage and handling, and reporting. The survey program which resulted was designed to meet two objectives:

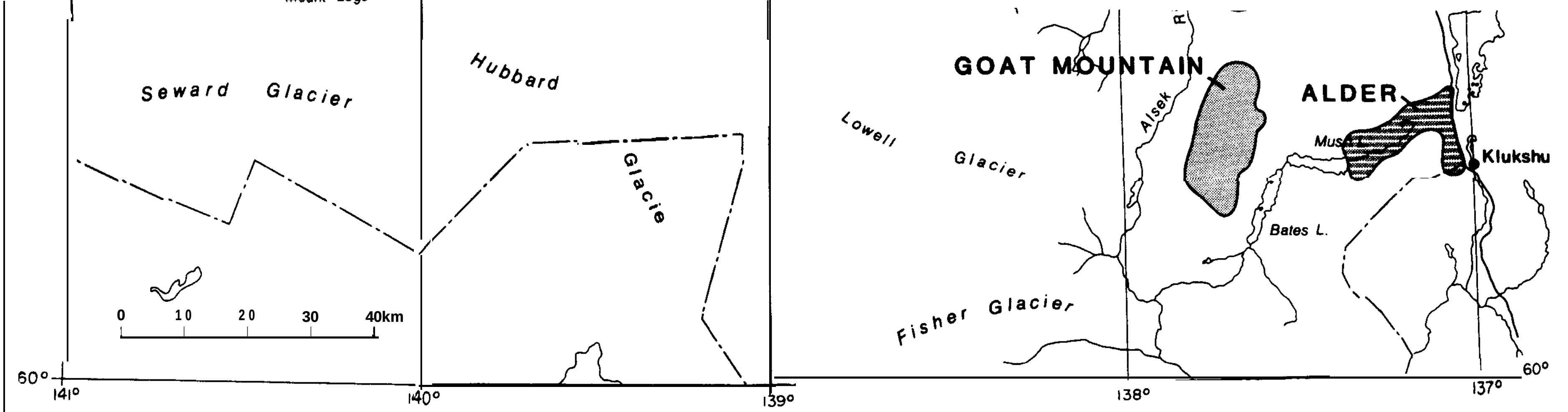
1. collection of baseline inventory data on seasonal abundance and distribution correlated to landforms, vegetation communities, and habitat; and

2. determine trends in abundance and distribution of certain species through periodic surveys of the entire park area.

The survey areas chosen are shown in Figure 9.1 and the schedule of surveys is described in Table 9.1. Habitat type, elevation, and exposure were recorded with all observations. Incidental observations of grizzly and black bears, wolves, gyrfalcons, bald and golden eagles were also recorded. The data were transferred to computerized storage on the CanSIS system to develop an easily accessed and manipulated data base. A report of each survey was prepared, followed by a consolidated annual report of all wildlife monitoring activities. All Warden Service reports from this and



SHEEP MOUNTAIN
Kluane
Kluane Lake
Destruction Bay
Burwash Landing
SLIMS
DUKE
TABLE
BURWASH-KLETSAN
DONJEK
ALSEK
ALASKA HAINES HWY ROAD
Dezadeash R.
Dezadeash Lake
Kloo Lake
Donjek River
Donjek Glacier
Steele Glacier
Kaskawulsh Glacier
Walsh Glacier
Logan Glacier
ST ELIAS MOUNTAINS
61°
N



KLUANE NATIONAL PARK RESERVE

Figure 9.1 Wildlife survey areas- Kluane National Park, 1976.

- ~~Caribou (Burwash - Kletsan)~~
- Goat (Goat Mountain)
- Moose (Alder, Slims, Duke, Donjek, Alsek)
- **Sheep (Quill, Vulcan, Sheep Mtn., Table, Donjek, Logan)**

Table 9.1 The 1976 wildlife monitoring program - Kluane National Park.

Species	Timing	Areas	Type of Survey	Comments
all's sheep	.) once/3 years	total Park area	aerial	' total count of sheep in all known and suspected range.
	›) biannually in fall (late Aug. - early Sept.) and spring (late April)	Sheep Mt., Donjek, Vulcan, Quill Ck., Table Mt., Logan	aerial & ground	. total count in sample areas . ground surveys to produce age-sex structure data.
lountain goat	ı) once/3 years	total Park area	aerial	
	›) at same time as sheep surveys	same areas as sheep surveys	aerial	• goat observations to be made during sheep surveys
loose	. biannually for 2 years; fall - Nov. winter - Feb. - early March.	Donjek, Slims, Alder, Duke & Alsek	aerial	fall census provides age-sex structure data, correlates numbers & distribution to habitat type, elevation, and exposure - winter census reveals change in distribution in response to weather.
:aribou	1976-1978 4 surveys/year	Burwash-Kletsan	aerial	- flown to determine numbers, seasonal distribution, and migration patterns of the populatio which moves across the Park boundary.

subsequent monitoring programs are listed in Appendix 9.1. The Park-wide survey scheduled at **3-year** intervals (called Biophysical survey in Appendix 9.1 and Figure 9.25) was attempted only once - in 1978. The large area involved necessitated an extended period of good weather and a large block of helicopter time to ensure that the survey **was** done in **as short** a period of time as possible. Financial resources have not been made available for repeat surveys on this **scale**.

Since 1976, the program has evolved as the Warden Service has become more familiar with mammal distributions and as financial resources and helicopter time have been reduced.

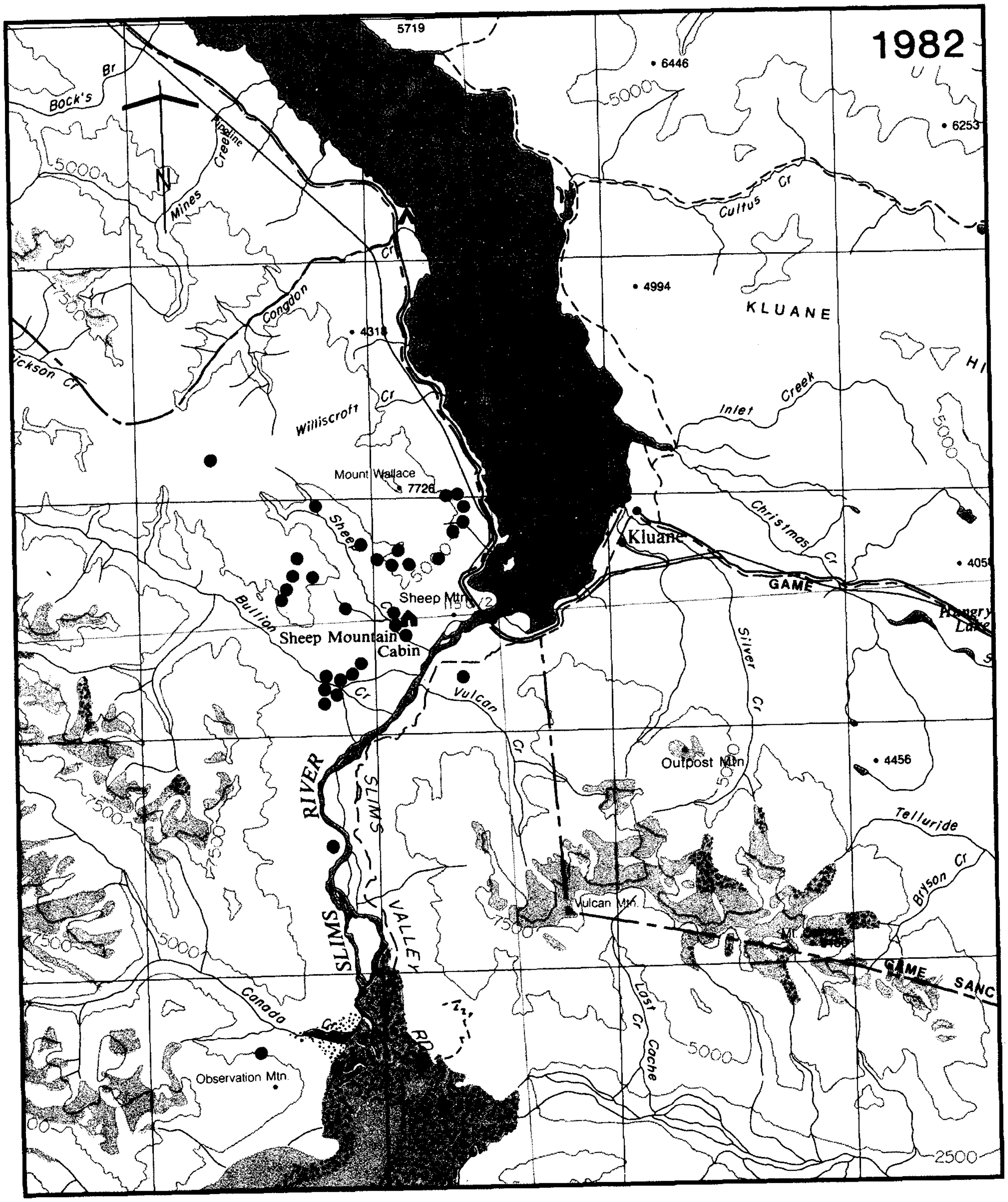
Theberge and Gauthier (1978) reported on **a** study of raptors in the slims River Valley and, as a result of their work, raptor monitoring was added to the overall program in 1979. This was extended to include surveys of a raptor nesting area in the Donjek Valley in 1980, providing **data on a population** in an isolated area to compare with the **relatively heavily** used Slims Valley. The 1984 program is outlined in Table 9.2 and the current survey **areas are** shown in Figure 9.2.

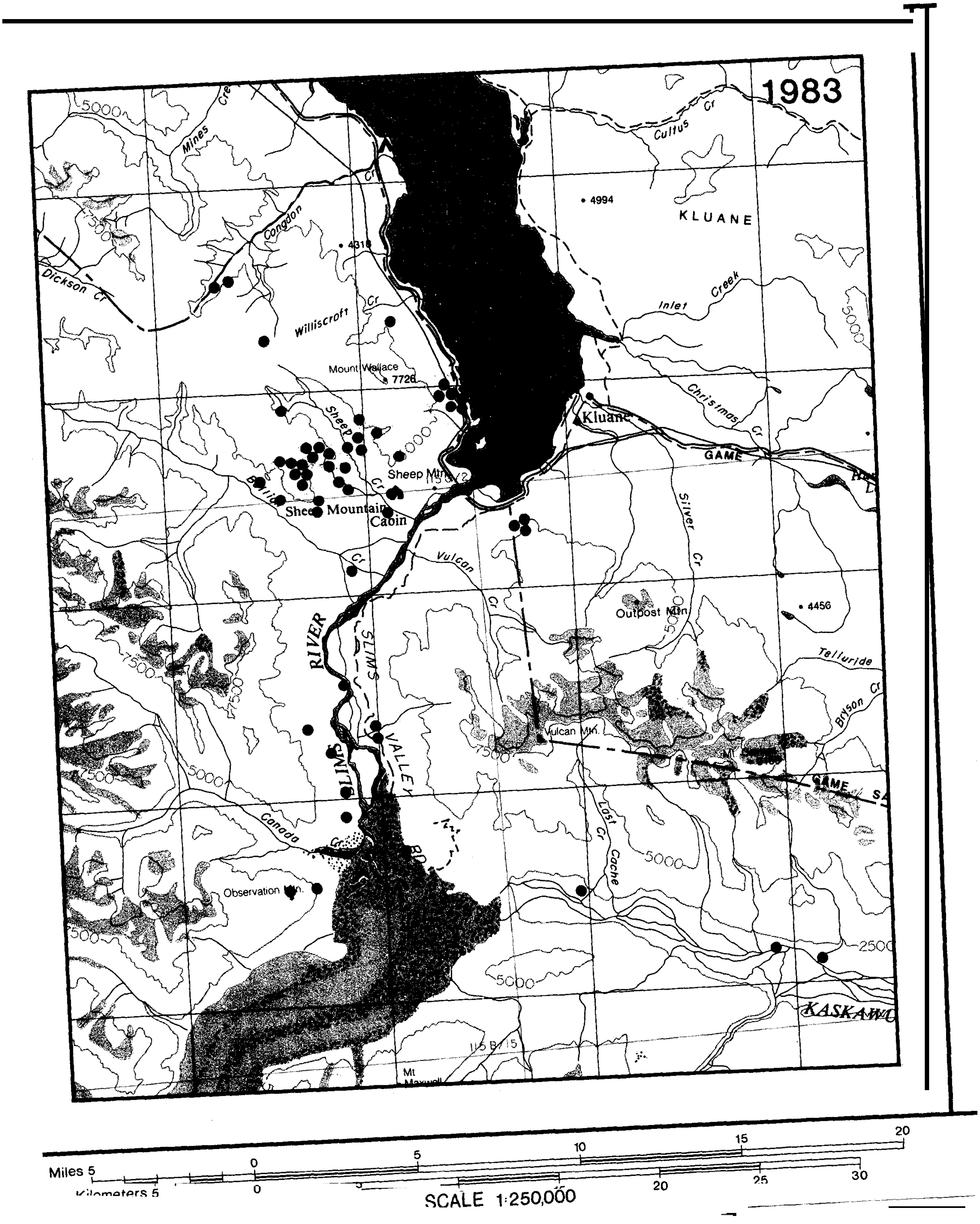
Aerial surveys are flown using **a** Bell 206 Jet Ranger helicopter, two observers, and one recorder. Total counts are made within the study areas, flying at about 100 m and 100-130 km/hour. Sheep surveys are conducted in late spring about two weeks after lambing when the lambs are strong enough to stand the disturbance and when it is still possible to differentiate yearlings and lambs. A pre-lambing survey was eliminated to reduce stress on the animals.

The goat survey is done in June when most snow has melted from the Goatherd Mountain area **and** before dispersal to summer range. Moose are surveyed in fall, after the rut and after a complete snow cover has formed but before the moose disperse from their post-rut congregations in the subalpine. Bulls, yearling bulls, and calves can be distinguished at this time on the basis of **antler** size. Golden eagle nests in the Donjek and Slims **valleys are** monitored by helicopter twice during the spring and summer. The first survey takes place in late May when attachment of the adults to the nests is believed to be strongest to yield nest occupation information. The second survey is in early July just before the young have fledged to **assess** productivity.

Opportunistic monitoring of Grizzly bears, Mountain lions, Mule deer, Peregrine falcons, and Gyrfalcons, and any other unusual or unique occurrences continues throughout the year. The rare or shy nature of these species makes incidental observation the most effective way of monitoring their distribution. Mule deer and Mountain lions are recent immigrants to the southwest Yukon and their distribution is still uncertain.

Figure 9.6 Locations of grizzly bear sightings - Slims River valley, 1980-I 984. (concluded).





1983
Mines Cr
Congdon Cr
Dickson Cr
Williscroft Cr
Mount Wallace
7726
4318
4994
KLUANE
Cultus Cr
Inlet Creek
Christmas Cr
Kluane
GAME
Sheep Cr
Sheep Mtn
Sheep Mountain
Cabin
Vulcan Cr
Silver Cr
Outpost Mtn
4456
Telluride
Bryson Cr
RIVER
SLIMS
SLIMS VALLEY
Vulcan Mtn.
Last Cr
Cache
Canada Cr
Observation Mtn.
KASKAWU
115 B/15
Mt Maxwell
5000
7500
2500

Miles 5 0 5 10 15 20
Kilometers 5 0 5 10 15 20 25 30
SCALE 1:250,000

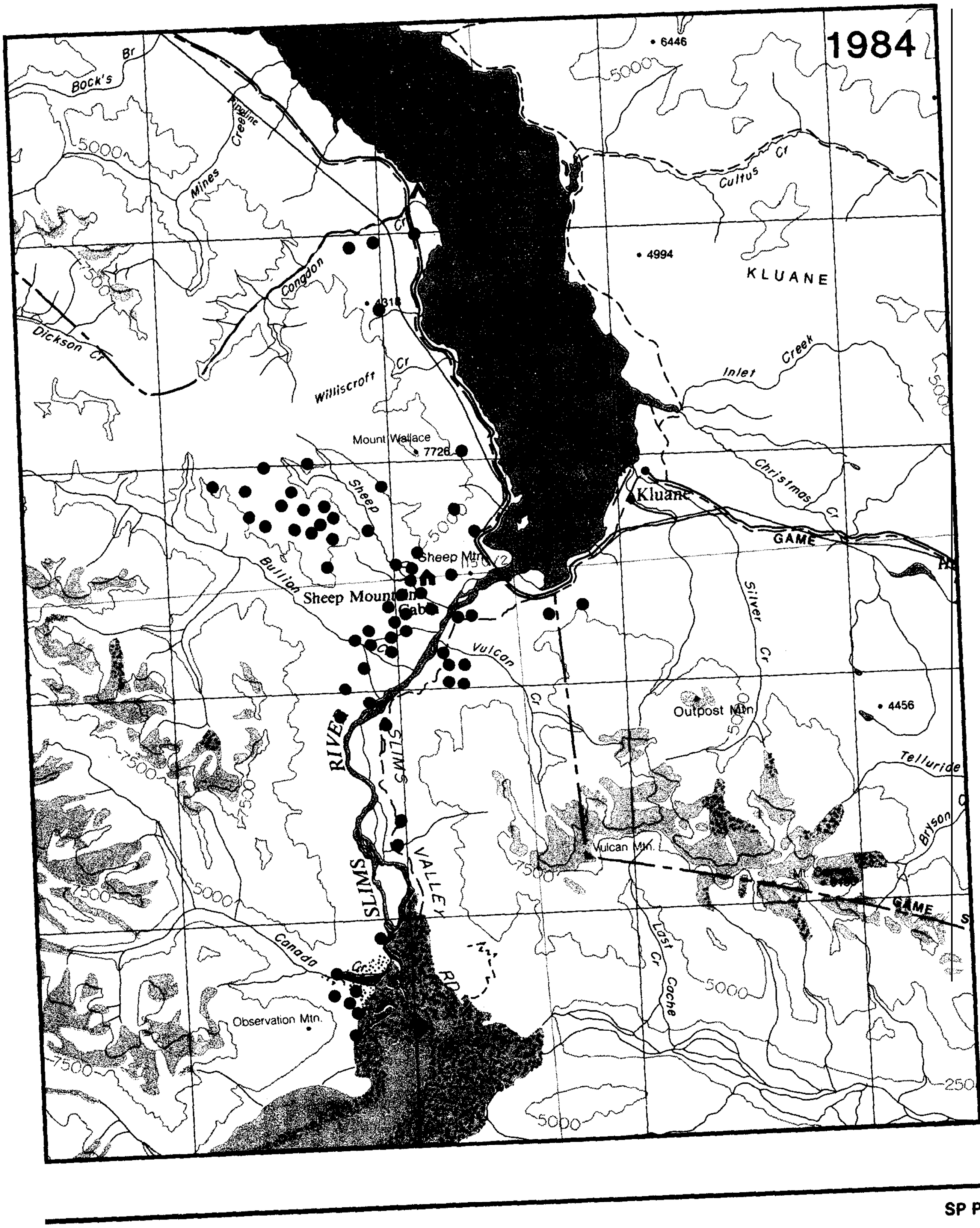
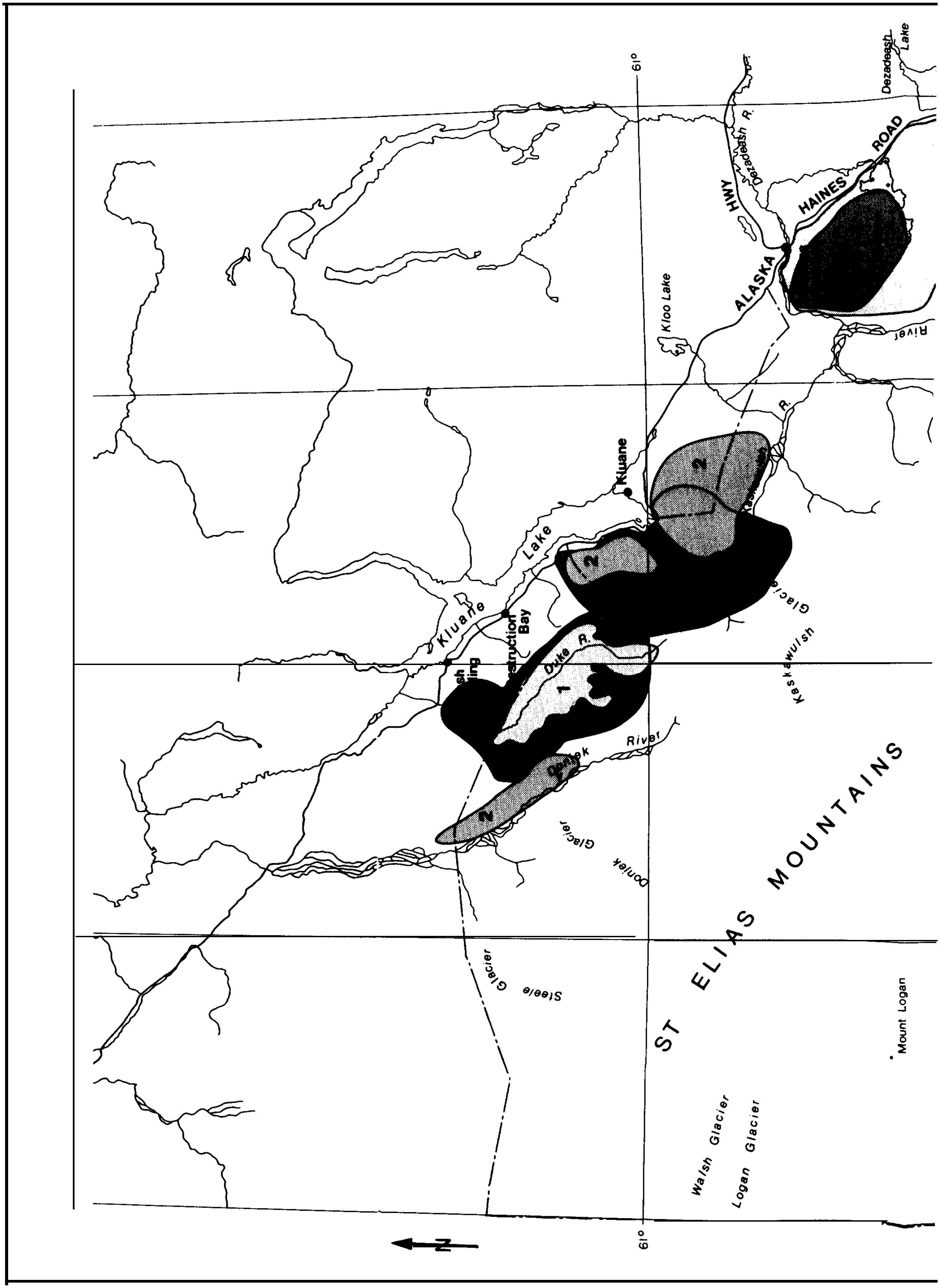
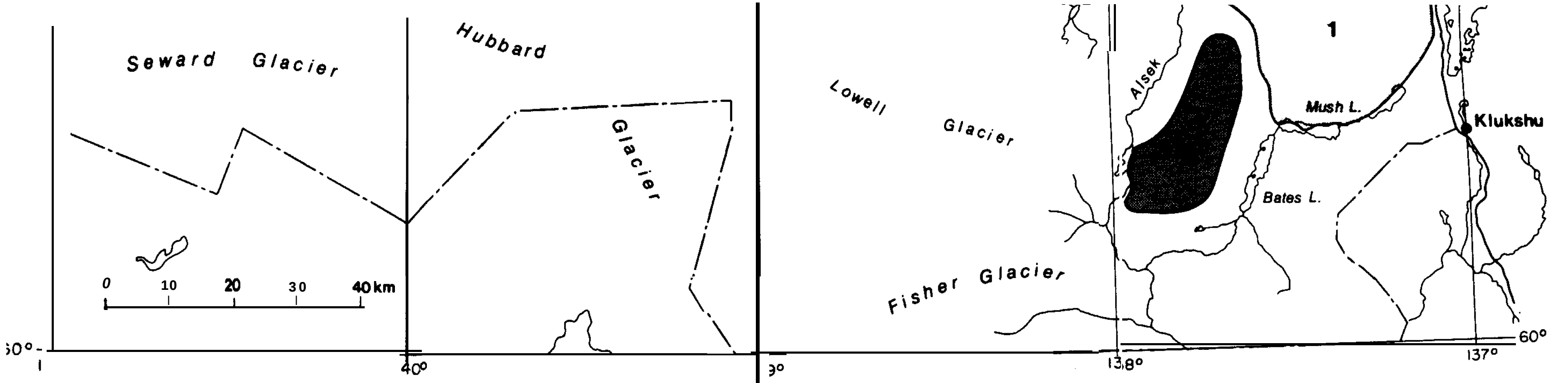

1984
6446
Bock's
Br
5000
Mines
Creek
Cultus
Cr
4994
KLUANE
Congdon
4318
Dickson Cr
Williscroft
Cr
Inlet
Creek
Mount Wallace
7726
Christmas
Cr
Kluane
Sheep
GAME
Sheep Mtn.
Bullion
Sheep Mountain Cabin
Silver
Cr
Vulcan
Outpost Mtn.
4456
RIVER
SLIMS
Telluride
Vulcan Mtn.
Bryson
VALLEY
GAME
Canada
Lost
Cr
Cache
Observation Mtn.
7500
5000
2500

Table 9.2 The 1984 wildlife monitoring program - Kluane National Park.

Species	Timing	Areas	Type of Survey	Comments
ball's sheep	annual - early June	Sheep Mt., Donjek, Vulcan, Auriol	aerial	• early June survey allows distinction between YOLY and YOY.
Mountain goat	annual - early July	Goatherd	aerial	• earlier assumption that sheep and goats used the same habitat was false. • incidental observations of goats during other surveys continues.
Moose	annual - early November	Duke, Alder	aerial	• Slims dropped as it was not moose habitat. Alsek used only in winter and spring and anticipated native harvest did not materialize. Moose have abandoned Donjek habitat possibly because of horse competition or vegetation success ion.
Golden eagle	biannual - early May & early July	Donjek & Slims valleys	aerial	
Grizzly bear	annual report of summer sightings	Slims valley & south Kluane Lake area	ground	• collated from incidental warden and visitor obser- vations.


Dezadeash Lake
Dezadeash R.
HAINES ROAD
ALASKA HWY
Kloo Lake
River
Kluane
Kluane Lake
Duke R.
Donjek River
Donjek Glacier
Kaskawulsh Glacier
ST ELIAS MOUNTAINS
Steele Glacier
Mount Logan
Walsh Glacier
Logan Glacier
61°
N
1
2



KLUANE NATIONAL PARK RESERVE

Figure 9.2 Wildlife survey areas- Kluane National Park, 1983.

- 1 Moose
- 2 Sheep
- Goat
- Golden Eagle

The prime difficulty with aerial survey data in Kluane is lack of comparability from year to year. Survey areas are not topographically isolated and the number of animals using the areas can vary with in and out-migration. Over time, survey boundaries have been altered to give better topographic control and, on the basis of past experience, to give a more representative count of the total population. However, every time the boundary is changed, the data becomes not directly comparable with previous years,

Weather can also introduce sources of error by delaying the survey past the scheduled time or by advancing or retarding the movements of the animals themselves. The survey schedule must be flexible to account for these natural variations though experience and discretion on the part of the warden service in deciding when to survey can accommodate many of these differences. Changes in weather during the survey can prevent successful total counts and limited resources may preclude a repeat of the survey.

In the Dall's sheep surveys, consistent overestimation of ewes has occurred because of the difficulty of distinguishing 2-year old rams from mature ewes. This is most easily remedied by using 'Nursery sheep' to describe ewes, some 2-year old rams, and yearlings, but it has resulted in introduction of a bias to the data which is hard to remove.

Many of these limitations prevent statistically significant analyses of the data necessary for example to document population trends, or the influence of external factors, such as weather, on the population. However for some purposes, the data gaps can be filled by the extensive knowledge of the Warden staff themselves who, after long observation, can describe the patterns of movement, approximate range boundaries, and seasonal habits of most of these species.

In many instances, this type of information provides the only 'analyzed' view of the large mammal resources of the Park available at the present time. The following descriptions of these resources are based on published study results where available, aerial survey data presented in raw form, survey reports, and the personal observations of the Warden Service staff.

9.2.4 Outside Data Sources

During planning for the Alaska Highway Gas Pipeline, Foothills Pipe Lines (Yukon) Ltd. and their consultants conducted corridor studies along the proposed pipeline route, which while not of direct application as the route was outside the Park except for a short section on the west side of Kluane Lake provide additional regional information on raptors and large mammals. Raptor studies were also done in conjunction with the Shakwak Highway Project.

Oosenbrug (1976) and Gauthier (1980) undertook studies of the Burwash caribou herd which ranges along the northern Park boundary in the Burwash Uplands. Foothills Pipe Lines (Yukon) Ltd. (Beak 1981) continued Gauthier's studies of the herd and monitored movements of radiocollared animals through the Quill Creek Test Site, a 6 km long full scale facility for testing pipeline design and construction modes and reclamation techniques. This facility and the proposed pipeline route bisect the caribou range and migration route as they move from the Burwash Uplands across the Shakwak Trench to another upland area north of Brooks Arm on Kluane Lake.

Krebs and Wingate (1974) surveyed the small mammals of the Park and Krebs' students from UBC have continued to study small mammal populations in the area (Green 1977) Cottrell (1975) studied wolf predator-prey relationships in Kluane.

The Yukon Game Branch continues to monitor wildlife populations throughout Yukon, and, in cooperation with the Warden Service, in areas adjacent to the Park where animals regularly cross the Park boundary.

9.3 Characteristics of the Mammalian Fauna

9.3.1 Zoogeographic Origins

The southwest Yukon has been described as a zoogeographic tension zone - an area in which species of different environmental affiliations mix, some reaching limits of their ranges. In Kluane,. species occur which are associated with the boreal forest-subarctic biome (Moose, Black bear, caribou, Red squirrel), with high mountain environments (goats, sheep, Cougar, Grizzly bear, marmot, Pika), and with the grassland forest edge (Mule deer, Least chipmunk). This diversity is due in part to the diversity of landforms and biological niches available in the Park and in part to the complex glacial history of the area.

Table 9.3 contains the mammal species list for Kluane based on Banfield (1974), Youngman (1975), Krebs & Wingate (1976), and additional observations and comments by the Kluane Wardens staff. Forty-six species are present, from 15 families and 6 orders. The distribution and status of many species, particularly small mammals, is not confirmed and exact identification to subspecies has not been verified in Kluane. Subspecies are listed only on the basis of Youngman (1975).

Youngman (1975) considers that the mammalian fauna of the Yukon originated from two refugia following the Wisconsin glaciation - Beringia, and the main unglaciated part of North America, south of the continental ice margin. Table 9.4 lists the species by their assumed refugial origin, and indicates those with extensive and limited ranges in Yukon.

Table 9.3 List and status of mammals in Kluane National Park.

Scientific Name'	Common Name'	Status	Miscellaneous records and notes
Order Insectivora			
Family Soricidae			
Sorex cinereus Kerr	Short-tailed shrew	P	
Sorex obscurus Merriam	Dusky shrew	P	
Sorex palustris Richards	Water shrew	EXP	• collected from Dezadeash Lake
Microsorex hoyi Baird	Pygmy shrew	EXP	• collected just outside Park boundary near Dezadeash Lake.
Order Chiroptera			
Family Vespertilionidae			
Myotis lucifugus (Le Conte)	Little brown bat	P	• known from Kathleen and Mush aree
Order Lagomorpha			
Family Ochotonidae			
Ochotona princeps (Nelson)	Pika	C	
Family Leporidae			
Lepus americanus Erxleben	Varying hare	C	• subject to cyclic population fluctuations.
Order Rodentia			
Family Sciuridae			
Eutamias minimus (Bachman)	Least chipmunk	P	• near northwest limit of their range.
Marmota monax (Linnaeus)	Woodchuck	R	• Youngman (1975) reports spotty distribution but remains of an animal presumed to be a woodchuck were found in the Park and specimen sent to National Museum for further identification.
Marmota caligata (Eschscholtz)	Hoary marmot	C	• seen Mt. Vulcan area, head of Halfbreed Ck, Donjek Valley.
Spermophilus parryii (Richards)	Arctic ground squirrel	C	
Tamiasciurus hudsonicus (Erxleben]	Red squirrel	C	
Glaucomys sabrinus (Shaw)	Northern flying squirrel	R	• specimens collected from Kathleen River area. Believed to be rare in the Park.

Table 9.3: List and status of mammals in Kluane National park. (Continued)

Scientific Name'	Common Name'	Status	Miscellaneous records and notes
Family Castoridae			
Castor canadensis Kuhl	Beaver	C	- Alder Creek fen.
Family Cricetidae			
Peromyscus maniculatus (Wagner)	Deer mouse	P	
Neotoma cinerea (Ord)	Bushy-tailed wood rat	EXP	- not collected in KNP but Youngman (1975) states one was collected on Kluane Lake.
Clethrionomys rutilus (Pallas)	Red-backed vole	P	
Phenacomys intermedius Merriam	Heather vole	R	
Microtus pennsylvanicus (Ord)	Meadow vole	C	
Microtus oeconomus (Pallas)	Northern vole	C	
Microtus longicaudus (Merriam)	Long-tailed vole	C	
Microtus miurus Anderson	Singing vole	P	- southern range limit in Kluane National Park.
Ondatra zibethicus (Linnaeus)	Muskrat	EXP	
Lemmus sibiricus (Richardson)	Siberian lemming	?	
Synaptomys borealis (Richardson)	Northern bog lemming	P	
Family Dipodidae			
Zapus hudsonius (Zimmermann)	Meadow jumping mouse	P	
Family Erethizontidae			
Erethizon dorsatum (Linnaeus)	Porcupine	C	
Order Carnivora			
Family Canidae			
Canis latrans Say	Coyote	C	
Canis lupus Linnaeus	Wolf	C	
Vulpes vulpes (Linnaeus)	Red fox	C	
Family Ursidae			
Ursus americanus (Pallas)	Black bear	F	
Ursus arctos (Ord)	Grizzly bear	C	
Ursus arctos			

Table 9.3: List and status of mammals in Kluane National Park. (Continued)

Scientific Name'	Common Name'	Status	Miscellaneous records and notes
Family Mustelidae			
Martes americana (Turton)	Marten	P	
Mustela erminea (Linnaeus)	Ermine	P	
Mustela nivalis Linnaeus	Least weasel	P	
Mustela vison Schreber	Mink	P	
Gulo gulo (Linnaeus)	Wolverine	C	
Lontra canadensis (Schreber)	River otter	P	- seen at Alder Ck., Jarvis, Christmas Ck.
Family Felidae			
Felis concolor Linnaeus	Cougar	VR	- cougar have been observed in the Park and near Haines Junction since Youngman (1975).
Lynx lynx (Linnaeus)	Lynx	C	- abundance related to varying hare cycle - common in 1982-83.
Order Artiodactyla			
Family Cervidae			
Odocoileus hemionus (Rafinesque)	Mule deer	P	- Mule deer appear to be expanding their range into the KNP area. They are frequently observed between Whitehorse and Haines Junction, and have been recorded in the Kluane Lake area, Cultus Bay area and Vulcan Fan.
Alces alces Miller	Moose	C	
Rangifer tarandus caribou (Gmelin)	Woodland caribou		
Family Bovidae			
Oreamnos americanus (de Blainville)	Mountain goat	C	- reach their northern limit in Kluane.
Ovis dalli dalli (Nelson)	Dall's sheep		

Table 9.3: List and status of mammals in Kluane National Park. (Concluded)

Scientific Name[1]	Common Name[1]	Status	Miscellaneous records and notes
		C	- Common
		U	- Uncommon
		O	- Occasional
		R	- Rare
		EXP	- Expected
		?	- Uncertain presence
		P	- Present but abundance unknown

[1] Nomenclature follows Banfield (1974).

Table 9.4 Probable refugial origins of Recent Yukon terrestrial mammals:

Beringian Refugium	Southern Immigrants
Ochotona princeps collaris	Sorex cinereus cinereus
Castor canadensis	Sorex obscurus
Clethtionomys rutilis dawsoni	Sorex wlustris *
Microtus miurus	Microsorex hoyi +
Microtus oeconomus	Myotis lucifugus
Lemmus sibiricus trimucronatus	Lepus americanus +
Ursus arctos horribilis	Eutamias minimus *
Mustela erminea arctica	Marmota monax
Mustela nivalis eskimo	Elarmota caligata
Mustela vison ingens	Spermophilus parryii plesius
Gulo gulo	Tamiasciurus hudsonicus +
Alces alces gigas	Glaucomys sabrinus
Ovis nivicola dalli	Peromyscus maniculatus •
Canis lupus	Neotoma cinerea *
	Phenacomys intermedius *
	Microtus pennsylvanicus +
	Microtus lonsicaudus
	Ondatra zibethicus +
	Zapus hudsonius
Rocky Mountain Refugium	Erethizon dorsatum +
	Canis latrans +
Lemmus sibiricus helvolus	Vulpes vulpes +
	Ursus americanus +
	Martes americana +
	Felis concolor *
	Felis canadensis +
	Odocoileus hemionus *
	Rangifer tarandus caribou
	Oreamnos americanus

Footnotes:

Source: Youngman 1975.

[1] subspecific names are used where a species is thought to have been isolated in more than one refugium.
+ Species with extensive ranges in Yukon.
* Species with northern range limits in southern Yukon.

During the last glacial maximum, the Bering Land Bridge was open linking North America and Asia and an ice-free area existed in Alaska and central Yukon. This vast contiguous area cf northeastern Asia and northwestern North America is referred to as Beringia and is assumed to have acted as a refuge for plants, animals, and man during the glacial periods, and as a source cf stock for recolonization after deglaciation. The zone cf convergence between the continental and Cordilleran ice sheets also occurred in Yukon and extended southward through Alberta. Current work indicates that this zone may actually have been an ice-free corridor through much of the Wisconsin glaciation (Rutter 1980), thus perhaps allowing more north-south movement than previously thought.

During most of the late Pleistocene, a steppe-tundra environment, rich in sages, sedges, and grasses, quite unlike that of today, existed in Beringia (Matthews 1982). Large herds of grazing animals (bison, elk, caribou, and some now extinct Pleistocene species) exploited this environment and it is postulated that some of them moved into the southwest Yukon as the grassland habitat expanded following deglaciation about 10,000 years ago. Controversy continues in the scientific community of the nature of the vegetation and fauna of Beringia and Hopkins et al (1982) provide an excellent overview of current research and theory. Little work has been done in south Yukon from this perspective. Extensive glaciation and the lack of archaeological and palynological sites and fossil remains has made it an area of marginal interest.

About 3000 years ago, the climate began to cool from its relative postglacial warmth (the Hypsithermal Period) and spruce forests began to replace the grassland environment in southwest Yukon (Morlan and Workman 1980). The large herbivores were also replaced by boreal species (moose, Black bear) as forest niches became available and the fauna of the area acquired the species composition which characterizes it today. Much of the diversity of habitat and species now seen in the area arose at this time. Workman (1980) sees this diversity making the southwest Yukon a particularly attractive environment for early man with boreal forest, relict grassland, upland tundra (and their associated wildlife species) as well as salmon rivers and other similar resources.

Youngman (1975) believes that in early postglacial time the Kluane area was populated by species of Beringian origin. Later boreal forest species from southern central North America migrated northward along the ice-free corridor (see reference to Rutter (1980) above), and even later species from the southern Cordillera expanded into the southwest Yukon. Youngman (1975) suggests that many factors such as sequence of occupancy, availability of species to the corridor, plant succession, climatic influences, competition, and others influence the expansion of range and limit its extent.

The range of some southern immigrants (see Table 9.4*) seems to coincide with the -4°C isotherm or the southern limit of widespread discontinuous permafrost (Youngman 1975). Youngman (1975) implies that some species originally ranged throughout the continent and were subsequently isolated into two populations which survived the glacial periods in separate refugia. This resulted in differentiation of many populations at the subspecies level. The subspecific populations of two such species, Ochotona princips (Pika) and Mustela nivalis (Least weasel), have not rejoined. In some instances, Beringian and boreal subspecies met in direct intraspecific competition when they reoccupied the south Yukon e.g. Sorex cinereus, Spermophilus parryii, Lemmus sibiricus, Mustela erminea, Canis lupus sp., Rangifer tarandus, Alces alces, Ovis dalli. Some of these species have intergraded broadly with their Beringian counterparts (Canis lupus, Ovis dalli) and others maintain only a narrow area of range overlap (Lemmus sibiricus, spermophilus parryii, Mustela erminea) (Youngman 1975).

Porsild (1966) suggests that several small high altitude (1500-1800 m) unglaciated refugia may have existed in the St. Elias Mountains in the late Wisconsin and Youngman (1975) postulates that these may have been the sites of subspeciation of Microtus miurus cantator (singing vole).

Recently mule deer have expanded their range into southwestern Yukon from areas further east but sightings in the Park are still too infrequent to determine an actual distribution. Two species, Bison bison and Cervus elaphus canadensis (Wapiti or Elk) have been introduced to the southern Yukon. Five bison were released in the Braeburn Lake area in 1951 and ranged widely, remaining for some time in the Nisling Valley. According to Youngman (1975) none have been seen since 1963. Wapiti were also released in 1951 and again in 1954 and have been more successful, particularly in the Takhini valley near Whitehorse. Neither species occurs in Kluane National Park.

9.4 Fauna1 Descriptions

9.4.1 Introduction

There is considerable variation in the level of detailed information available for fauna1 species in Kluane National Park. The larger mammals and high profile species such as Dall's sheep are quite well known. Smaller mammals have not been intensively studied and only general statements on their habits can be made inferred from work in other areas. There is little information on the broader ecological interrelationships between mammals and vegetation, food habits, and predator-prey relationships.

The following description of the major fauna1 families and species of Kluane reflects these data limitations. Table 9.3 lists the mammals present to species, according to Banfield (1974).

9.4.2 Small Mammals

The habits of most small mammals in Kluane are not well known. General descriptions are provided here from Banfield (1974). Where identification and range units are relatively clear, subspecies are indicated according to Youngman (1975). Where these relationships are not clear, the animals have been described only to species.

Krebs and Wingate (1974, 1976) have done the only detailed study of small mammal communities in Kluane. Their work was conducted over two summers at sites in the northern, central and southern areas of the Park. They report a relatively high species diversity among small rodents, probably indicative of the nature of the area as a zoogeographic tension zone. Most habitats sampled contained 3 to 4 species of cricetid rodents and a marsh along Dezadeash River contained 6 species, the highest of all areas sampled. There was little habitat overlap among the eight common cricetids. Only Peromyscus maniculatus and Chlethrionomys rutilis showed significant overlap and this was markedly reduced in the second year of the survey. Krebs and Wingate (1976, p 384) concluded that "most of these rodent species exploited the range of available habitats in different ways so that they did not usually overlap greatly. This result should reduce the possibility of intraspecific competition.".

Their study also showed the following general species-habitat associations:

Habitat	Dominant Species
Subalpine-alpine zones	Clethrionomys rutilis Microtus oeconomus
Dense spruce forest	Clethrionomys rutilis
Open spruce forest	Peromyscus maniculatus Clethrionomys rutilis
Beach ridges Dryas drummondii areas Balsam poplar-buffaloberry	Peromyscus maniculatus
Marshes, shrub birch	Yicrotus pennsylvanicus

Most small mammal populations are subject to cyclical population variations often on a 3 to 4-year cycle (Krebs & Myers 1974) and, in the case of Lepus americanus, a 10-year cycle. Although Krebs and Wingate's (1974) study was not long enough to document these variations they did report significant variation in abundance, and non-synchronous changes between the northern, central, and southern regions.

9.4.2.1 Soricidae - shrews

Short-tailed shrew - Sorex cinereus cinereus Kerr
Dusky shrew - S. obscurus obscurus Merriam
Water shrew- S. palustris navigator (Baird)
Pygmy **shrew** - Microsorex hoyi (Baird)

Four species of Soricidae are present in Kluane. Shrews are small insectivorous mammals which foreage for insects, small vertebrates, and centipedes in debris on the forest floor. S. palustris navigator is adapted to an aquatic habitat and feeds on aquatic life stages of insects, fish eggs, and small fish. It is the largest shrew in the area up to 15 cm in total length and lo-15 g in weight.

Microsorex hoyi is the smallest mammal in the New World (Banfield 1974), averaging about 9 cm in total length and weighing only 4-5 g. All species are voracious insectivores. They occupy a wide range of forest, meadow, and grassland habitats in all life zones. They are prey to weasels, hawks, and owls. Shrews are active throughout the year, moving about in burrows beneath the snow.

All Soricidae in Kluane are presumed to be postglacial immigrants to the southwest Yukon from southern refugia.

9.4.2.2 Vespertilionidae - Smooth-faced bats

Little brown bat - Myotis lucifugus (Le Conte)

Myotis lucifugus is the most common bat in Canada and its range extends across southern Yukon. It is seldom seen in flight however because of the long summer daylight period in Yukon and most observations are of individuals roosting during the day or flying at dusk in late summer. Bats are nocturnal animals, resting in sheltered locations during the day and hunting insects with efficiency through the night. The Little brown bat hibernates or more correctly becomes dormant in caves in winter and during this time its body temperature drops to that of its environment. The caves must therefore be large and deep enough to stay above freezing throughout the witner. Youngman (1975) believes that bats may not overwinter in Yukon because of the severe winter climate and a scarcity of suitable caves, but migration has not been verified and nothing is known of their possible migratory destinations.

Mating occurs in late fall or during dormancy. The sperm remain viable in the female uterus until ovulation in April or May and the young are born from mid-May to early July. They can fly in three weeks and become fully mature over the following winter.

Bats have been sighted in the Kathleen Lake-Mush Lake area (R. Frey, pers. comm.) and Youngman (1975) reports investigating a cache at the Kathleen Lake outlet which he believes contained a breeding colony of several hundred until just a few days prior to his visit.

Bats are prey to few other species. Owls may take a few at night and shrews sometimes kill bats resting near the ground. The Little brown bat is a southern postglacial immigrant to the southwest Yukon.

9.4.2.3 Ochotonidae - pikas

Pika - Ochotona princeps collaris (Nelson)

The Pika is a small stocky tailess mammal inhabiting talus slopes and other rocky areas above treeline in mountain areas throughout Yukon. It is about 19 cm long and weighs about 150 g. The Pika is active throughout the daylight period, feeding on a wide variety of grasses, sedges, and flowering plants and sunning itself on exposed rocky lookouts. It remains active through the winter, feeding on characteristic small haystacks accumulated in a fall harvest. Its nest is grass-lined and hidden in deep rock crevices. It is territorial, marking and defending its home ground and warning trespassers with a shrill cry. Pikas are prey to many carnivores such as ermine, fox, marten, wolverine, lynx, bears and golden eagles. Ermine are particularly successful predators as they are more slender than Pika and can follow it through its maze of rock tunnels.

The Pika is common on rocky talus slopes in the subalpine and alpine throughout Kluane. Murray & Murray (1970) reported them from Observation Mountain, Steele Glacier area, Kaskawulsh Nunatak and from other nunataks in the Icefields. Little is known about the Pika's life cycle or habits in the Kluane area.

Banfield (1974) recognized 10 races, inhabiting widely separated. areas in western Canada. He states that they have a circumpolar distribution with disjunct populations in central Asia, Japan, and western North America and therefore suggests that they are Beringian species. Youngman (1975) concurs.

9.4.2.4 Leporidae - hares and rabbits

Snowshoe hare - Lepus americanus Erxleben

The varying or snowshoe hare is one of the more common mammals in Canada. The western Canadian subspecies L. a. dalli or macfarlani (according to Youngman (1975) or Banfield (1974)) is common throughout forested areas of Yukon. In Kluane, they occur throughout the forested montane zone and have been reported from the lower subalpine shrub zone as well. Hares are active from dusk to dawn eating a wide range of grasses and forbs. In winter they eat buds, bark, and the evergreen leaves of woody plants. The snowshoe hare's summer pelage is rusty or greyish brown; an autumn moult begins the gradual change to its pure white winter colouration with black ear tips and greyish underfur. Nests are grass-lined 'forms' on the ground surface. Females may produce two to four litters per year.

The varying hare is subject to dramatic population fluctuations on a cycle varying from eight to eleven years but averaging about 10 years. With several litters produced each year, the population can build up rapidly. As the population expands over several years, the availability of winter browse becomes critical and limiting, and eventually sends the population into decline through poor overwinter survival and reduced reproduction rates. At the same time, predator populations have been increasing because of abundant food supplies, and continuing heavy predation reduces the hare population to very low levels. Hares are an important link in the food chain and are prey to many carnivores. In Kluane their prime predators are lynx and golden eagles, although wolves, foxes, coyotes, and other raptors also depend on them. Many of these predators also experience population fluctuations that are tied to the hare cycle. There is currently no direct measure of this effect but in areas were trapping occurs reduced numbers of lynx and other species are often recorded following a 'crash' of the hare population (Hoefs & Cowan 1979). Burles (pers. comm.) speculates that high hare populations induce golden eagles which usually migrate to overwinter in the Kluane area.

Historical evidence of this cycle in Yukon is scanty. Clarke (1944) reported hares as rare in 1943 but much more abundant in 1944. In 1949 and 1951 Cameron (1952) and Banfield (1951) respectively said the populations were at or near the low points of their cycle. Youngman (1975) reports peak abundance in 1961 and 1963 followed by another peak in 1971 (Krebs 1980; Hoefs & Cowan (1979); and 1973 (L. Tremblay pers. comm.). Keith and Windberg (1978) cite Alaskan data which show a similar peak in 1971-72. The population peaked again in 1980 (R. Frey, pers. comm.) and Nette et al (1984) report very low populations in the winter of 1981-82.

Populations fluctuations are pronounced in northwestern Canada, averaging a 23:1 ratio between peak and lowest spring densities at a study area in central Alberta where Keith and Windberg (1978) monitored hare populations for 15 years. They noted also that there was general regional synchrony between the study population and trends throughout Alberta:

C. Krebs of UBC has been studying hares in Kluane for several years and has followed the population through one entire cycle. Publication of these results will provide useful information on the hare population in the Park.

9.4.2.5 Sciuridae- squirrels

Six species belonging to this family are found in Kluane:

Least chipmunk - Eutamias minimus (Bachman)
Woodchuck - Marmota monax ochracea Swarth
Hoary marmot - Marmota caligata caligata (Eschsholtz)
Arctic ground squirrel - Spermophilus parryii plesius Osgood
Red squirrel - Tamiasciurus hudsonicus (Erxleben)
Northern flying squirrel - Glaucomys sabrinus (Shaw)

All except the Red squirrel and Northern flying squirrel hibernate. The Least chipmunk is a seed eater occupying a wide range of habitats from coniferous forest to alpine tundra. The Woodchuck, Hoary marmot, and Arctic ground squirrel are grazers, feeding on green vegetation. The Woodchuck is rare in the Kluane area. Only four specimens have been taken in the southwest Yukon and its presence in the Park is only 'expected'. Hoary marmot is common in the alpine zone where it feeds on lush alpine meadow vegetation. Murray & Murray (1970) report them from Observation Mountain.

Arctic ground squirrels are extremely common, forming large colonies in well-drained soils and in some areas influencing microrelief and vegetation succession with their burrows. They occur from the montane to alpine life zones. Murray & Murray (1970) reported a colony on Kaskawulsh nunatak, isolated across at least two kilometres of ice from the nearest known colony. They are an important prey species for a variety of small carnivores, including Red fox and golden eagles. Green (1977) studied two colonies of Arctic ground *squirrels* in the Slims River and Coin Creek areas. His study provides detailed information on the biology and phenoloyy of Arctic ground squirrels in Kluane and on population regulators such as dispersal, predation, and mortality. Briefly, he described the following annual cycle of activity.

- a 7-8 month period of hibernation beginning from late August to the third week in September and ending in the second or third week of April;
- establishment of territory, accompanied by aggressive behaviour by males;
- a short breeding season beginning within three weeks of emergence;
- development and emergence of the young usually in mid-late June;
- restoration of fat deposits:
- establishment of fall territories; and
- entry into hibernation.

Most mortality occurred during the overwintering period. Adult male overwintering survival was much poorer than females and juvenile males fared least well of all. Green suggests that predation by Grizzly bears, hawks, and other carnivores accounted for only 10-15% of the annual loss in the resident population. Dispersing animals moving to new terrain were more liable to predation, and juveniles were more susceptible than adults.

Population densities on the two study areas varied markedly. Sheep Mountain densities were 0.27 - 0.38 per hectare while at the Coin creek site, there were 0.46 - 2.0 animals per hectare. There were empty burrows on Sheep Mountain and none at Coin Creek. Green suggests this may reflect a relative scarcity of food at Sheep Mountain due to competition from other herbivores, predominantly Dall's sheep. Figure 9.3 presents a schematic model of the life cycle of the Arctic ground squirrel in this area showing external influences on the population at various times of the year.

The Red and Northern flying squirrels are arboreal and most often seen in the southern areas of the Park. They eat a wide range of seeds, cones, mushrooms, nuts, as well as insects and bird's eggs. The Northern flying squirrel is rarely seen in the Park and little is known of its habits.

9.4.2.6 Castoridae - beaver

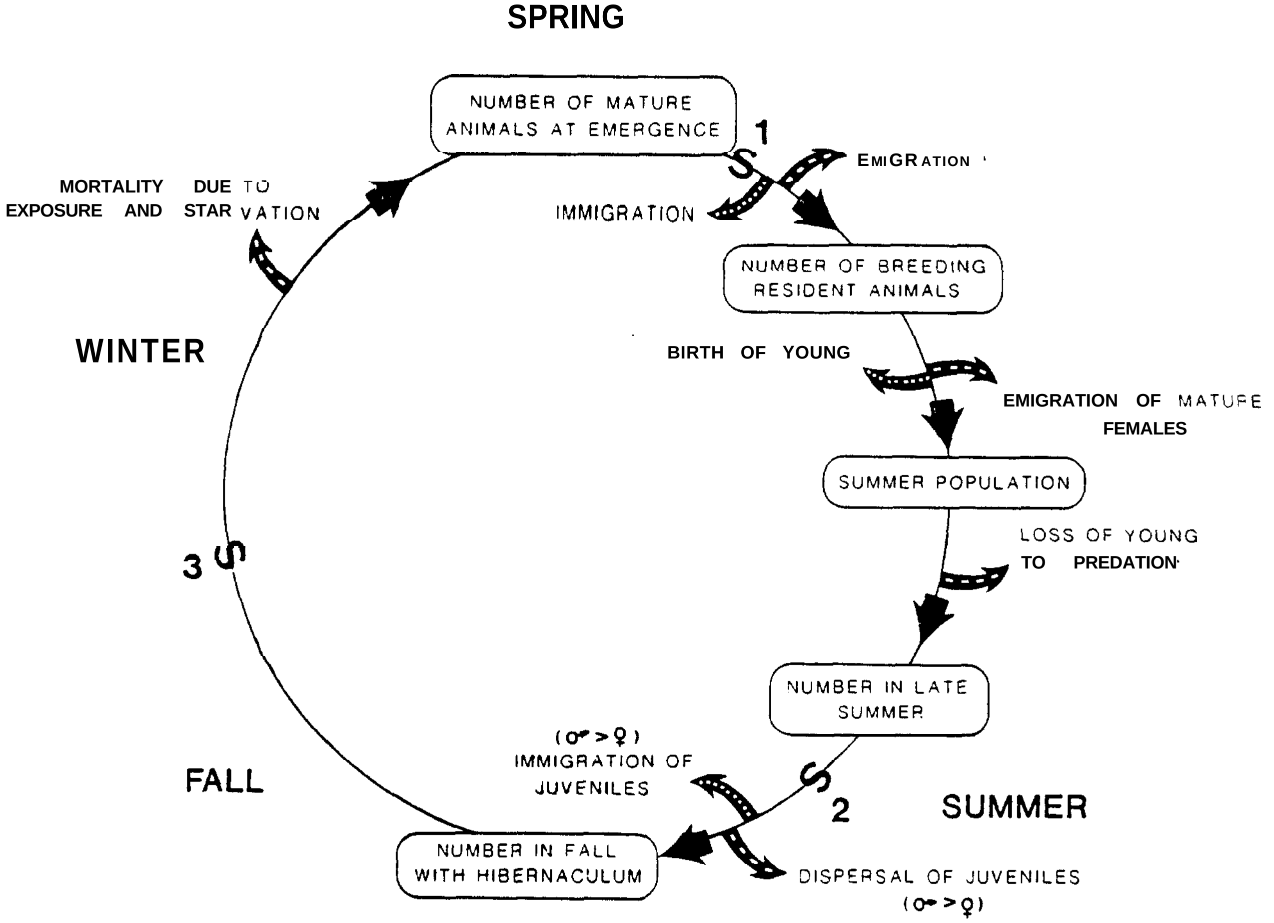
Beaver - Castor canadensis (Kuhl)

Beavers are common throughout Yukon. Their distribution in Kluane is limited by lack of suitable habitat, slow-flowing streams, marshes, and quiet lakes. They occur in the Alder Creek Valley, the Kathleen Lake system, the Dezadeash River system, and in the Dusty River valley where they were trapped by local people prior to the area becoming a game sanctuary.

Beavers remain active through the winter in their lodges and swim about beneath the ice. Dams are built on small streams to create ponds deep enough to provide this overwintering habitat. Beavers are successful manipulators of their habitat and can markedly alter natural flow patterns, and in doing so create habitat for aquatic vegetation, fish, and invertebrates. They feed on tree bark, leaves, twigs, buds, and herbaceous pond vegetation. Preferred species are balsam poplar and willows; coniferous trees are used only if other foods are not available.

Beavers are prey to otter, bear, wolf, coyote and lynx. Only otters which can enter the lodge and move about much as the beaver are particularly successful, and they usually take only young animals.

Youngman (1975) describes the considerable taxonomic confusion surrounding subspeciation in Yukon and no attempt is made here to describe the species to that level. They are presumed to be of Beringian origin.



(after Green 1977)

LEGEND

Graphical model of population regulation in Arctic ground squirrels. The model is described in the text. Recruitment to the population due to birth or immigration is Indicated with dotted lines. Loss from the population due to emigration or other mortality factors is indicated with a dashed line. Waved lines indicate the periods where extrinsic factors may be important to population limitation.

The following extrinsic factors are likely important at:

1. The number of vacant breeding territories.
2. The number of hibernacula.
3. Hibernaculum quality, fat stores, and exposure

Figure 9.3 Schematic model of the life cycle and population regulators of Arctic ground squirrel.

9.4.2.7 Cricetidae - mice, voles, lemmings

Deer mouse - Peromyscus maniculatus algidus Osgood

Krebs and Wingate (1974) found the Deer mouse to be the most common small mammal in the Park. They are mostly nocturnal, primarily seed and insect eaters, and occur in dry habitats in all but the alpine zone. Although Banfield (1974) indicates that they remain active all winter, Krebs (1980) suggests that they may survive the Kluane winter by going into a short period of hibernation. He also states that deer mice in Kluane produce only one litter per season, as compared to about 4 in more temperate conditions. The Deer mouse reaches the northern limit of its range in the Kluane area. It is an important link in many food chains, providing prey for large fish, foxes, ground squirrels, coyotes, wolves, owls, weasels, and mink.

Bushy-tailed wood rat - Neotoma cinerea occidentalis (Baird)

The bushy-tailed wood rat is 'expected' in Kluane. Krebs and Wingate (1974) did not collect it; Youngman (1975) reports a record from the Kluane Lake area. It is the only native rat in Canada. It eats the leaves of trees and shrubs and the seeds and fruits of a variety of flowering plants and ericaceous shrubs. Wood rats are horders, collecting almost anything they can carry in bulky stick dens built in rock crevices. They occur in all life zones preferring rocky habitats such as talus slopes.

Red-backed vole - Clethrionomys rutilis dawsoni (Merriam)

The Red-backed vole was the second most abundant species in Krebs and Wingate's (1974) study of small mammals in Kluane. Its distribution varied over the Park area though and it was more common in the Alsek valley-Haines Road areas than in the central and northern areas in the Slims and Donjek valleys. Krebs and Wingate (1974) suggest that these may represent two subpopulations which undergo independent cyclic population variations.

The Red-backed vole favours open shrub vegetation in the subalpine and montane zones where aspen, alders and willows predominate. It eats the leaves, buds, twigs of these shrubs as well as forbs and occasionally heaths. It appears to remain active through the winter moving about in long tunnels under the snow. Its distribution is Holarctic and it is presumed to be of Beringian origin.

Heather **vole -** Phenacomys intennedius mackenzii Preble

The Heather vole is a boreal Nearctic species which reaches the northwest extent of its range in Kluane. It is a postglacial southern immigrant. Krebs and Wingate (1974) collected it only from the Dezadeash *River* and called it 'rare' in the Park.

Youngman (1975) reports specimens from Kluane Lake and the south end of Dezadeash Lake. It inhabits a wide range of environments but favours open coniferous forest with a willow-heath understory and the shrubby vegetation at forest edges and in mossy meadows. Raptors, weasels and marten are important predators (Banfield 1974).

Meadow vole - Microtus pennsylvanicus (Ord)

The Meadow vole is the ubiquitous Canadian 'field mouse'. It prefers wet meadows but also inhabits a variety of grassland areas, anywhere that grasses or sedges provide a food source and a thick protective carpet to conceal its movements. Krebs and Wingate (1974) collected it in marshy areas along the Dezadeash and Slim; rivers. Youngman (1975) reports it from Kluane Lake, Silver Creek, and Haines Junction. It is active all day and through the winter and it is an important prey species for almost all carnivores from shrews to Grizzly bears. It is a postglacial southern immigrant.

Northern vole - Mircrotus oeconomus macfarlana Merriam

The Northern vole is similar to the Meadow vole in habits and habitat, preferring damp grassy areas. It is common and the dominant species in subalpine and alpine areas in Kluane. Krebs and Wingate (1974) collected it together with M. pennsylvanicus in the Dezadeash and Slims river marshes and found they could not distinguish the two species in the field. Youngman (1975) reports its throughout Yukon and it appears to reach its southern limit near Kluane. It is Holarctic in distribution and of Berinqiar.. origin in southwest Yukon. The Northern vole is an important prey species for owls, raptors, and most small carnivores.

Long-tailed vole - Microtus lonqicaudus vellerosus J.A. Allen

The Long-tailed vole is similar in habits to the Meadow vole and occupies a wide range of habitats from montane to alpine. Krebs and Winqate (1974) called it 'rare' in Kluane and collected it infrequently from subalpine shrub tundra in the Slims Valley and montane spruce-willow forest in the Dezadeash Valley. They report a localized high density near Sockeye Lake in 1973 but did not find it in large numbers anywhere else. Youngman (1975) reports them from the south Kluane Lake area. In Canada, the species is confined to the western Cordilleran area from Yukon to B.C. and is thought to be a southern postglacial immigrant.

Singing vole - Microtus miurus cantator Anderson

The Singing vole occupies alpine tundra areas throughout the southwest Yukon. Its high-pitched trill is distinctive, it lives in colonies in well-drained shrub willow thickets, and is active throughout the day and throughout the winter. In winter it feeds from large hay piles comprised of willow leaves and green vegetation accumulated in late summer.

The Singing vole is subject to marked year to year population variations, the exact causes of which are unknown. They are prey to birds and a number of small carnivores. Clarke (1944) first described the Singing vole during his investigations along the Alaska Righway. Murray & Murray (1970) reported many Singing voles in the Sheep-Bullion plateau area in 1966 and 1967 but none in 1968, and they assumed the population had crashed. Rrebs and Wingate (1974) live-trapped them near Mile 1050 on the Alaska Highway and can find no record of them further south. Youngman (1975) reports them from Sheep Mountain, the Steele Glacier area, and south Kluane Lake.

The Singing vole is presumed to be of Beringian origin, possibly surviving the Wisconsin glaciation in high alpine mountain refugia in southwest Yukon which were not overtopped by ice. Youngman (1975) believes these areas may be the centres of subspeciation of M. m. cantator and M. m. muriei which ranges in the Ogilvie and British Mountains in northern and central Yukon. Banfied (1974) suggests that there are two few reports or specimens available to confidently define their range.

Muskrat - Ondatra zibethicus spatulatus (Osgood)

The muskrat is a southern immigrant widely distributed throughout Yukon and all of Canada. It has not been reported from the Park proper but occurs in areas immediately adjacent. Muskrats are amphibious rodents which spend much of their time underwater. In summer they feed on emergent vegetation, aquatic invertebrates, frogs and small fish. In autumn, as freeze-up begins, the muskrat constructs 'push-ups' or domes of vegetation covering an area of thin ice easily broken through by the muskrat. The vegetation freezes and becomes covered with snow forming an insulated platform from which the animals feed on submerged aquatic vegetation through the winter.

Occurrence of muskrat in Kluane National Park is undoubtedly restricted by the limited extent of wetland habitat in the Park. Hoefs (1973) speculates that the Alder Creek, Mush Lake-Kathleen Lakes area may be suitable but use of these areas has not been confirmed.

Brown lemming - Lemmus sibiricus trimucronatus (Richardson)

The Brown lemming has not been recorded in the Park but Youngman (1975) reports it from eastern and southern Kluane Lake areas and Krebs and Wingate (1974) live-trapped it at Bear Creek Summit. This location is near the western edge of the range for the subspecies as described in Youngman (1975).

The Brown lemming is a small herbivorous rodent inhabiting wet tundra swales rich in grasses and sedges. Suitable habitat is available in the Park, but if it does occur, the animal is likely rare.

In areas where they are abundant, lemmings are important prey species to many raptor and small carnivores. Their populations are subject to cyclic fluctuations and regional abundance, migratory patterns, and population changes in predators such as the Snowy owl have been tied to variations in the lemming population.

Northern bog lemming - Synaptomys borealis (Richardson)

Youngman (197.5) reports the Northern bog lemming from the Steels Glacier area, Burwash Landing and south Kluane Lake. Krebs and Wingate (1974) reported it only from the southern parts of Kluane in a marshy area in the Dezadeash valley and call it 'rare' in tha Park. Its preferred habitat is sphagnum-labrador tea-black spruce bogs which do not occur in the Park, but it also inhabits mossy deep spruce forests and wet subalpine meadows. Populations occur throughout northern Canada and it is a presumed southern postglacial immigrant to the southwest Yukon.

9.4.2.8 Dipodidae - jumping mice

Meadow jumping mouse - Zapus hudsonius hudsonius (Zimmermann)

The Meadow jumping mouse is the only member of the family Zapodidae in Kluane. Krebs and Wingate (1974) collected it from a marsh in the Dezadeash valley and from the subalpine zone in the Kathleen lakes area. They called it 'rare' in the Park. Youngman (1975) reports it from the south Dezadeash Lake area and points further east of the Park.

Z. hudsonius are tiny slender mice with extremely long wirey tails which are used for balance during long leaps. They are seed, fruit, and occasionally insect eaters and prefer grassland habitats. They hibernate in deep burrows in well-drained earth banks or in burrows abandoned by other animals. They are nomadic and populations in an area can vary with in and out migration. Like several other Crecitid species, the Meadow jumping mouse is a good swimmer and it often falls prey to large fish and frogs as well as a variety of small carnivores. They are presumed to be southern postglacial immigrants.

9.4.2.9 Erethizontidae - porcupines

Porcupine - Xrethizon dorsatum myops Merriam

The porcupine is a boreal forest species which probably occurs throughout forested areas of the Park. Krebs and Wingate (1974) report it from Kathleen Lake, Sheep Creek, and near Kluane (outside the Park). Youngman's (1975) nearest record is the south Dezadeash Lake area. Banfield (1961) reported porcupine sign from the Donjek River flats.

Porcupines are primarily nocturnal, resting in trees during the day. They feed on the lush green leaves of a variety of forbs, shrubs, and trees in summer. They also chew bones and antlers for their mineral content. Porcupines are active all winter, eating the cambium and inner bark of spruce and poplar trees. They inhabit both coniferous and deciduous forests and have been reported from the subalpine zone in Kluane in summer.

Porcupines are formidable opponents for predators. Wolverine and fishers are most successful, tackling the porcupine while still in a tree. Wolves, coyotes, and foxes occasionally kill them. Jones and Theberge (1983) report porcupine remains from red fox scats near an alpine den in Kluane. They are postglacial southern immigrants, occurring throughout Yukon and extensively throughout North America.

9.4.3 Large Mammals

Large mammals in Kluane have been the subject of considerable detailed study and their habits are better known.

9.4.3.1 Canidae - dogs

Coyote - Canis latrans Say

Coyotes occur throughout Kluane. They are extremely adaptable and range widely over a variety of habitats from the montane to alpine zones. There is some evidence that they are relatively recent immigrants to the southern Yukon and probably were first seen in the early 1900's (Rand 1945; Cairnes 1909). Clarke (1944) disagrees however and believes they are "ancient inhabitants of the parkland of southwestern Yukon" (in Youngman 1975:125). Youngman notes that there are apparently no known Pleistocene fossils of coyotes.

In Kluane, coyotes are extremely common in the south Kluane Lake area and in the Slims Valley and Delta. Park Wardens report as many as seven animals travelling together in winter near Sheep Mountain. In this area, they are the most common predator of Dall's sheep, particularly ewes and lambs (Hoefs & Cowan 1979). coyotes are also common in the Duke River Valley, Kathleen Lake area, Dezadeash Lake area, and the Alsek Pass near Haines Junction. These areas lie along the periphery of the Park and the animals are subject to hunting and trapping pressure when they range across the Park boundary.

Coyotes prey on a variety of small mammals and carrion. Snowshoe hares are favoured prey and coyote populations are thought to vary with cyclical fluctuations in the hare population (Hoefs 1973). NO attempts have been made to verify or quantify this relationship. The coyote in turn is prey to other larger carnivores such as wolves, Black and Grizzly bears.

In mountainous areas, coyotes tend to move from the alpine zone in summer to sheltered valley ranges in winter, where prey are more readily available. The basic family unit of two adults and pups remain together through the season and is expanded in winter to include others, probably offspring of previous litters (Banfield 1974).

Park Warden staff have not located active dens in the Park but old dens have been found in the Slims and Dezadeash valleys.

Wolf - *Canis lupus* Linnaeus

Wolves are common throughout Kluane. Hoefs (1973) estimated the population at 50, and subsequent observations by Park staff confirm this approximate figure. At least three and perhaps four or five packs use the Park area, but none have their entire range within the Park. Wolves are territorial and establish a range based on prey abundance.

Hoefs (1973) and Hoefs & Cowan (1979) report that wolves are least common in the central peripheral area of the Park (Slims valley - Kluane Lake area) and attibute this to the relatively narrow zone of potential habitat available from the Alaska Highway or Kluane Lake to permanent ice and limited prey diversity in the area. They report a pack of six wolves in this area and state that they probably prey largely on Dall's sheep. Wolves are most abundant in the Dezadeash valley and Kathleen Lakes area. In winter these wolves form packs ranging from 10 to more than 30 individuals. Noose in their principle prey comprising about 50% of their diet (Cottrell 1975). Hoefs (1973) and Cottrell (1975) document numerous observations of this large southern pack by local residents and Park and Territorial government staff. There is less information on wolves in the northern parts of the Park but indirect evidence indicates that the population may be nearly as large as that in the south. Large packs of 40-50 individuals were reported in these northern areas prior to construction of the Alaska Highway (Grace Chambers, aurwash resident, pers. comm. to R. Frey). Hoefs (1973) reports wolf tracks near winter concentrations of caribou in the Burwash Uplands and Dall's sheep in the Donjek Valley. These tracks may represent only one pack or perhaps two which hunt different prey (i.e. caribou and sheep).

Currently, there are no active wolf dens in the Park (R. Frey, pers. comm.). In 1972 and 1973 Cottrell (1975) identified active dens on the Victoria Creek fan near Kathleen and Louise lakes, near Onion Lake, and near the confluence of the Kaskawulsh and Dezadeash rivers. The Kathleen Lake den was at the hub of a system of well-used trails and the ground was well-trampled and littered with food remains and scats. Cottrell (1975) believes this may be a traditional frequently-used den. He suspected there to be an active den near Canada Creek. Wolves have also used dens near Mush Lake and in the Donjek and Duke valleys in the past. Warden Frey believes that habitat in the Park is actually quite marginal compared to that in adjacent areas and the Park dens are used only when prey are abundant and when the predator control programs are in effect in areas outside the Park.

Dens are usually dug in dry earth banks or made by enlarging burrows abandoned by other animals.

Cottrell's (1975) study supports other work indicating that wolves are primarily dependent on large mammals such as moose, sheep, and caribou for prey. Small mammals are used on an opportunistic rather than preferential basis. Use of small mammals may be seasonal as well reflecting the hindering influence of pups on hunting activity in spring.

Table 9.5 lists prey species by percent composition based on scat analysis for wolves in the southern park area and reflects the availability of different species in different locations (Cottrell 1975).

Wolves have been considered a predatory animals in Yukon for years and can be trapped or shot at any time in areas outside the Sanctuary (and the Park). From 1958 to 1971, a bounty was paid on wolves. Winter control programs have been undertaken several times in past years by the Yukon Territorial Government to reduce the wolf population and thereby reduce predation on caribou and moose. Poisoned bait was used in the past but resulted in many non-target species such as fox, coyote, lynx, and wolverine being killed. Scace and Assoc. (1975) report a statement from Fuller (1957) that indicates poisoned bait was routinely dropped in the sanctuary in the mid-1950's. The current wolf control program was started in 1983 following a 20% decline in the moose population. About 20 animals were shot in the Kluane area in 1984 (R. Frey, pers. comm.). The program is continuing in the winter of 1984-85 and the most recent surveys indicate that the moose population appears to have stabilized (R. Frey, pers. comm.).

As all of the wolf packs using the Park area also range outside it, all are subject to these control programs. They are particularly vulnerable when crossing the ice of Kluane or Dezadeash lakes. The effect of depleted predator populations on moose and sheep within the Park has not been quantified. Hoefs (1973) believes wolf control is responsible for some of the very high sheep densities observed in the Park, and in the late 1940's and 1950's for the relatively rapid recovery of the population following overhunting during construction of the Alaska Highway.

Table 9.5 Wolf summer diet composition - southern Kluane National Park.

Species	Kathleen L. den (%)	Onion L. den (%)
Moose	55.7	49.0
Beaver	20.3	4.8
Arctic ground squirrel	0.6	26.0
Mountain goat	8.3	6.3
Snowshoe hare	8.9	0.0
Microtines	4.2	11.1
Dall's sheep	2.6	0.0
others	balance	balance

Source: Cottrell 1975.

Red fox - Vulpes vulpes **(Linnaeus)**

Red fox is common throughout the Greenbelt areas of the Park. It ranges from alpine to **montane** zones and is observed in greatest numbers in the Tatshenshini River area and the Duke and Donjek valleys (park files). Murray and Murray (1970) report them from Observation Mountain, and the north side of the Steele valley.

Dens are usually made in earth banks in sandy knolls or they may be modified from dens abandoned by other animals. The dens are comprised of deep, extensive networks of tunnels often with several entrances. Active dens have been found near Kluane Lake and in the Duke and Donjek valleys.

Foxes are omnivores, eating small mammals, birds, carrion, as well as plants as availability dictates. Debris around an alpine den located above 1500 m in the Donjek Valley indicated Hoary marmot as the principle prey, as well as Ptarmigan and Arctic ground squirrel (park files). Jones and Theberge (1983) studied Red fox summer diet composition in southwest Yukon based on scat analysis and found significant differences in diets in alpine, subalpine, and montane areas, and at den sites and non-den sites. The altitudinal differences are reflected by prominence of snowshoe hare (36%) and Arctic ground squirrel (20%) in the montane, Arctic ground squirrel (64%) in the subalpine, and Arctic ground squirrel (47%) and mice and voles (31%) in the alpine. These data were interpreted as evidence of the opportunistic nature of Red fox predation.

Red foxes are distributed widely throughout North America, Europe, and Asia and are presumed postglacial southern immigrants to southwest Yukon.

9.4.3.2 **Ursidae** -Bears

Black bear - Ursus americanus **(Pallas)**

Black bears are distributed widely throughout the forested areas of Yukon and indeed all of North America. They are most often seen in the southeast part of the Park and one or two Black bear reports are received annually from the Kathleen Lake campground. In 1980, one sow and two cubs were relocated from that area; two immature bears were destroyed in 1983. Hikers at the Dalton Creek primitive campground reported black bear damage to tents and gear in the late summer of 1983.

Black bears are essentially timid by nature. They actively seek out dense cover, seldom venture into the open and avoid areas utilized by their main enemies - Grizzly bears. In natural situations Black bears will avoid people and unless surprised and confronted especially with cubs, will usually run away or can be chased off by aggressive human behaviour. Black bears do, however, become habituated to humans through repeated contact and most *garbage' or problem bears throughout Yukon are blacks (Hoefs 1973).

No studies have been done on black bears in Rluane. Their preference for forest habitat makes aerial surveys impractical. on the basis of habitat availability and characteristic low densities, Hoefs (1973) made a very rough estimate of about 100 bears but this has not been confirmed. Hoefs (1980) suggested there are fewer Black bears than Grizzly bears in the Park.

The adult Black bear stands slightly less than 1 m at the shoulder and is about 1.6 m in length. Males weigh about 110 kg and females about 75 kg. They are considerably smaller than Grizzly bears. Colour varies from black through various shades of brown, cinnamon, and blonde. Black bears are omnivores, in spring eating new green vegetation, berries that have overwintered (soapberry, bearberry, crowberry, blueberry), carrion, moose calves, and invertebrates (Frey 1984*). In summer they feed mostly on green vegetation - horsetails, mountain sorrel, crowberry, grasses, cow parsnip, and moose calves if available (Herrero 1983). In fall ripening berries become the prime food. Black bears do not dig for ground squirrels or Hedysarum roots, both favoured Grizzly bear foods.

Black bears hibernate for 7-8 months *in* dens made at the base of trees, or under windfalls, in places where snow will accumulate. They are more productive than Grizzly bears; females have their first litter at 4 to 5 years of ago. They usually have 2 or 3 cubs and often only 2 years elapses between litters. Bear sign is the most common indirect indicator of numbers and degree of use of an area. Unfortunately, it is not possible to discriminate between Black and Grizzly bears on the basis of scats or rub trees (Herrero 1983). The only positive indicators are footprints, areas where Grizzly bears (but not Blacks) have dug for Arctic ground squirrels or Hedysarum roots, and of course actual sightings.

Grizzly bears - Ursus arctos L.

Kluane National Park is seen as one of the last strongholds of the grizzly bear in North America. Grizzly bears are a reflection of wilderness and the presence and vitality of their populations are increasingly becoming a measure of the 'health' of wilderness and, in Kluane, the successful management of this resource.

Grizzlies are seen throughout the Park but are particularly abundant in the Slims valley, the Alsek and Dezadeash valleys where favoured bear foods are found as pioneer species on the floodplain of former Recent Lake Alsek, and in the Sockeye Lake-Klukshu River area.

Pearson (1975) studied the northern interior Grizzly bear intensively for eight years in the Kaskawulsh-Dezadeash-Alsek confluence area southwest of Haines Junction and his report provides a great deal of our knowledge of bears in the Park. Since

1980, the Warden Service has observed and reported on the activities of Grizzly bears in the Slims valley area (McLaughlin 1980*, 1981*; Burles 1982*, 1983*; Morrison 1984*). Recently, Herrero (1983) discussed bear habitat and management in the Park, particularly in the Mush-Bates and Field Creek-Goatherd Mountain areas. The work since 1980 has been undertaken to gain a better understanding of bear habits and general distribution and to ultimately minimize man-bear encounters in two areas of the Park used increasingly by visitors each year.

The northern interior Grizzly bear is smaller than its infamous. Rocky Mountain relative. Males average about 140 kg and females about 95 kg. The largest weights reported by Pearson (1975) were 240 kg and 125 kg for males and females respectively. These extreme values are about the same as average weights for southern bears.

According to Yukon Territorial Government publications there are between 8000 and 10,000 Grizzly bears in Yukon. Hoefs (1980) estimates 300-400 live in the Kluane area. Pearson (1975) reported a minimum density of 1 bear per 27 km^2 in his study area. In the Slims Valley, density estimates range from 1/14.5 km^2 to 1/19.5 km^2.

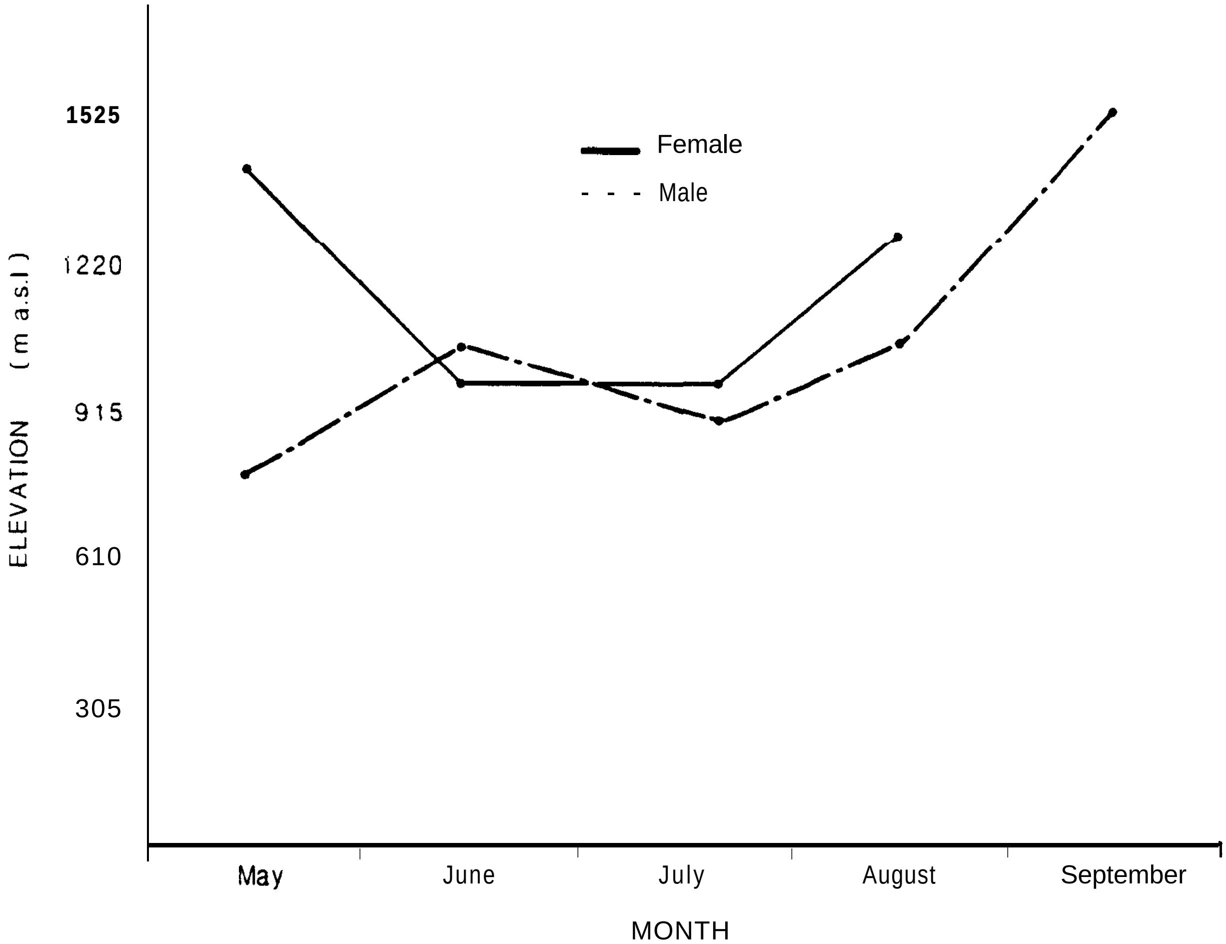
The food habits of Grizzly bears are an important clue to their seasonal movement and likely distribution. Males emerge from hibernation in subalpine zone dens in late April, although there are records of emergence up to one month earlier. These males travel widely on open hillsides, feeding in snowfree areas on roots and grasses. Females appear slightly later, usually in early May and remain in the vicinity of the den for about two weeks. As snowmelt continues, the bears migrate to large alluvial flats in the major valleys were they feed on Hedysarum roots, berries that have overwintered, and carrion when available. In June, they follow the greening vegetation, moving from south to north aspects and then upslope into alpine areas as new vegetation becomes available. Gullies, particularly those containing snowmelt vegetation communities and intermittent streams are favoured travelways to the higher elevations. At this time, they graze extensively on horsetails (Equisetum sp.), mountain sorrel (Oxyria diyyna), cow parsnip (Heracleum lanatum), vetches (Hedysarum sp.; Astralayus sp.), Oxytropis, and grasses. Pearson (1975) reported bears feeding on willow catkins in the subalpine zone at this time. In late July, ripening soapberries (Shepherdia canadensis) become available and the bears move up and downslope following this food source, feeding almost exclusively on these and other berries till fall. They gain weight quickly during this period in preparation for hibernation. Arctic ground squirrels are used opportunistically in the subalpine and alpine zones and Hedysarum roots may be dug again in fall particularly if the berry crop is poor. Marmots provide prey in the alpine zone in areas such as Field Creek (Herrero 1983). In southern areas of the Park, Herrero

(1983) believes moose calves are an important prey, particularly in the Mush-Bates area. Bears in the extreme southern areas take salmon in the Klukshu River in the fall and perhaps in the Sockeye Lake area (Hoefs 1973), and this may actually delay entry into hibernation (Park files). Hoefs (1979) reports grizzly bears feeding on Dall's sheep carcasses in early spring but has never witnessed a kill. He also recounts observations by local residents of Grizzly bears killing mature Dall's sheep rams in the Sheep Mountain area.

Grizzly bears are opportunistic omnivores and make use of whatever is abundant and accessible within a broad range of preferred items. They seek foods high in protein and sugar and are able to extract protein from vegetation with almost the same efficiency as herbivores (Jonkel 1978). Regional variations in food preferences are thus to be expected, reflecting the differing availability of various items. Shepherdia canadensis and Hedysarum are prime foods throughout the Park (McLaughlin 1980*, 1982*; Pearson 1975), and areas with concentrations of these species should be regarded as likely or perhaps preferred habitat.

Figure 9.4 illustrates the general pattern of altitudinal movement through the summer months in grizzlies in the Slims valley, primarily in response to the changing availability of food items. Individual bears tend to move much more randomly than this pattern would suggest (McLaughlin 1981*).

Females enter hibernation about the middle of October and males usually by the end of October. As mentioned previously this may be delayed in the extreme southern areas of the Park by late fall salmon spawning runs. Park files record observations of bears along Klukshu Creek in December. Dens are usually located on 30-40° lee slopes in the subalpine zone between 1100 m and 1350 m in easily dug soils. A coherent surface root mat is necessary to prevent caving in. North-facing slopes at these elevations may contain permafrost and are avoided. Shrubs obscure the den mouth and enhance snow accumulation which insulates the den. Dens usually have a single entrance about 54-58 an high, 91-178 cm long by 126-226 cm wide (Pearson 1975). The bear's body heat can keep these relatively small spaces above freezing without difficulty. Females den with their cubs and yearlings. Dens are sometimes reused but the extent of this practice in Kluane is unknown. The physiological processes associated with hibernation are complex and extremely interesting. Recent studies by Ralph Nelson at the University of Illinois show that bears do not defecate or urinate during this period. Their bodies recycle waste products and have complex means of breaking down and releasing nutrients. Pearson (1975) indicates that bears may lose 28-43% or more of their body weight during hibernation. These recent studies show that while fat is lost, the animals emerge from hibernation in a state of full muscular fitness.



Source: McLaughlin 1981.

Figure 9.4 Average elevations of male and female grizzly observations - Slims River valley.

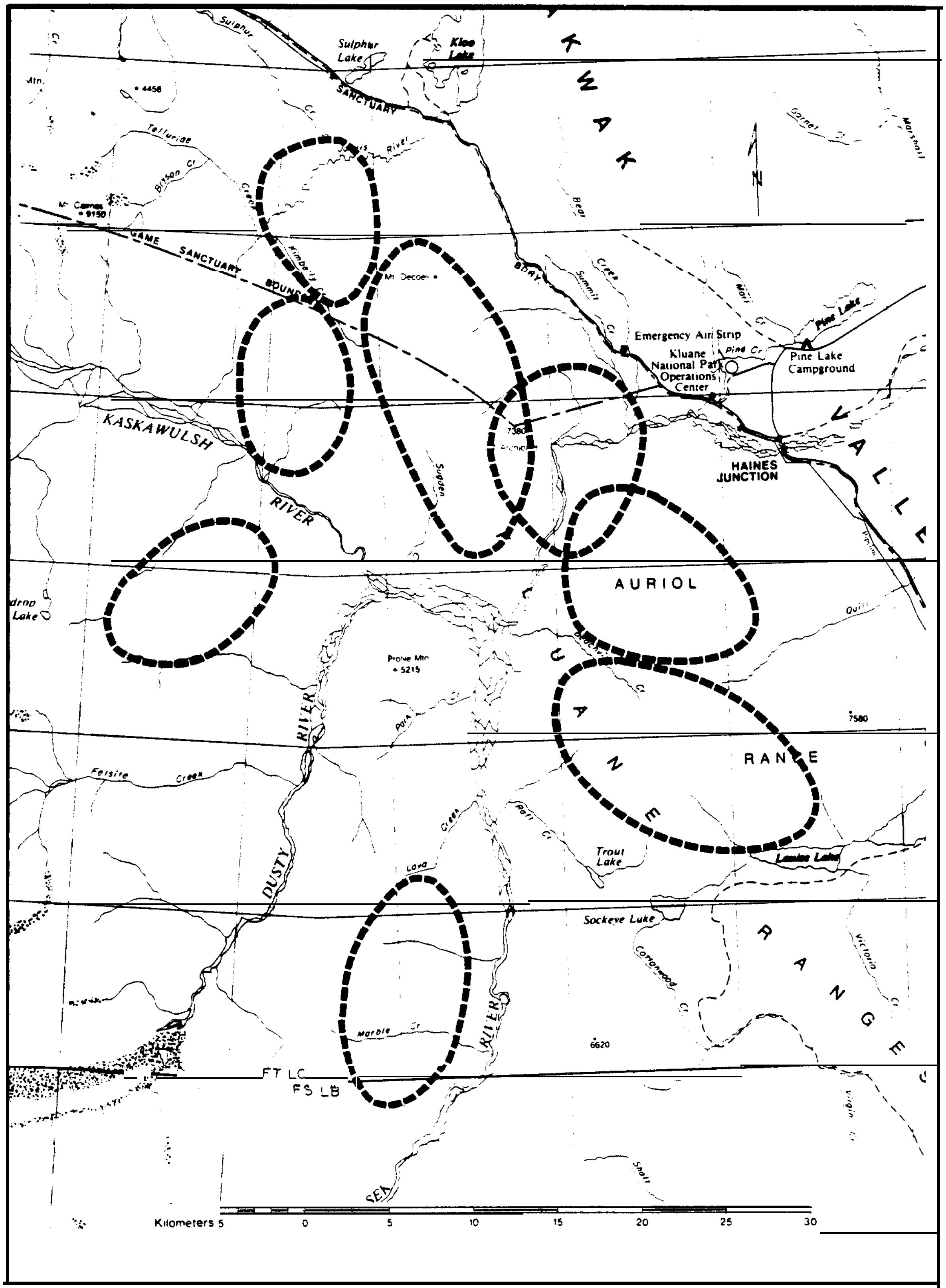
Kluane's Grizzly bears have a particularly low reproductive rate. Females do not breed successfully until 7 or even 8 years of age, average litter size is only 1.6 cubs, and breeding occurs optimally every third year (if the previous litter has survived, less if it has not) but commonly at greater intervals (Pearson 1975). The litter size is the smallest known for North American Grizzly bears (Pearson 1975). The breeding lifetime of female Grizzly bears is unknown. Pearson (1975) reports a 24.5 year old female observed In oestrus after successfully weaning a 2.5 year old cub the same year.

Most breeding takes place in June and early July while the animals are still in the montane zone (Pearson 1975), and are difficult to observe. The Warden Service reports one incident of copulation cn an open alluvial flat along the Kaskawulsh River. Implantation of the fertilized eggs is delayed until the female enters hibernation and young are born in the den in mid-winter, following a gestation period of at least 190 days and probably longer (Pearson 1975). Young remain with their mothers for at least two years. Pearson (1975) reports one litter aged 3.7 years still with its mother and he presumes they denned together for a fourth year.

Pearson (1975) reports that females with cubs seek out remote inaccessible areas in which to rear their young, probably to avoid aggressive encounters with other bears. Yukon Wildlife Branch observations indicate that sows with cubs may occupy discrete ranges in the Ogilvie Mountains and numerous observations of family groups in the Slims Valley may indicate that this area is favoured for rearing (R. Frey, pers. comm.).

Grizzly bears are territorial. Both males and females have home ranges; those of the males are usually considerably larger. Pearson (1975) reports averages of 287 km^2 for males and 86 km^2 for females. Long distance movements, in one instance 145 km, are sometimes recorded for male bears and movements of more than 20 km in a month are not unusual (Pearson 1975). Pearson (1975) believes that ranges contract for females with young of the year (YOY) but expand to normal proportions when the young reached the yearling stage (YLY - young of last year). Figure 9.5 shows the home ranges of eight adult females in Pearson's study area.

Since 1980, the Warden Service has collected data on grizzly bear use of a 400 km^2 area of the Slims River valley. This area is receiving increasing visitor use and in response to the proposed Slims Valley Access Road, efforts were made to collect specific information on bears in this area and to assess the potential for bear-human encounters. The information collected is based on observations by Park Wardens and by visitors who, after sighting a bear(s) during their stay in the area, are asked to complete a data sheet describing the bear, its location, and behaviour.



(after Pearson 1975)

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Figure 9.5 Home range core areas of eight adult female grizzly bears.

Table 9.6 summarizes observations on numbers of bears in the Slim,; area in the last five **years.** Difficulty arose in identifying particular bears or family groups from one year to the next, and in verifying repeated observations of the same bears in any one yea;: as no permanent means of identification has been used. As a result the data have been interpreted conservatively in annual reports and analysis.

The actual locations of sightings are indicated on Figure 9.6 for the five years of data collection. Activity is obviously concentrated in the Sheep-Bullion Plateau, Coin Creek, and Bullion Creek areas. Though not indicated in Table 9.6, observations of sows with YOY **are** infrequent and usually only one or two sows have spring cubs in any one year, supporting the existing information on low reproductive rates.

In May 1983, a sow with three spring cubs **was** seen on the east side of the Slims valley above the Alaska Highway (Burles 1983) but was not seen again that summer. In May 1984, she was sighted in the same area with three yearlings and it is assumed that she denned in the vicinity. As in 1903, no repeat sightings were made through the summer of L984.

On the basis of the five years of early spring and late fall observations and ground investigations, the Warden Service believes dens exist in the following locations:

- on the northeast side of Sheep Mountain above Bayshore Motel - **"a number of bears"** (Burles 1983*) may have denned there;
- east side of Sheep Mountain in the rockslide basin; not used in 1983 (Burles 1983*);
- two dens on the north side of Bullion Creek:
- west side of the Slims Valley near Canada creek;
- east side of the Slims Valley above the Alaska Highway; and
- in the Coin Creek drainage: "used by several bears" (Burles 1983*).

A program of scat collection and analysis has been underway since 1980. Only preliminary results based on a limited number of samples are available at the present time but they support the pattern of seasonal food preferences described previously. Analysis of scats collected in 1981 is presented in Figure 9.7 and illustrates &particularly well the shift to other foods during late summer in what was a poor berry crop year (McLaughlin 1981*).

To date there have been few aggressive encounters with Grizzly bears in Kluane. The only injury incident occurred in August 1984 when two hikers in the Mush-Bates area were treed and one was bitten and scatched. The attack lasted only a short time and was broken off by the bear leaving the vicinity. The Warden Service responded by closing the Alder Creek-Mush Lake road **area** for a month until the berries **in the area** were **done and bears were** no

Table 9.6 Observations of grizzly bears - Slims River valley, 1980- 1984.

Observations	1980	1981	1982	1983	1984
NO. of observations	29	62	48	60	75
NO. of different bears	17	26	21	22	28
Females (cubs)	6 (9)	8 (12)	6 (9)	5 (9)	8 (14)
Males	2	4			2
Unclassified single bears		2	6	8	4
Total estimated population	21	23			
Density (#/km^2)	1/19.4	1/17.5	1/19.0	1/18.5	1/14.5
1st obs. of single bear	24/05	10/05	15/05	23/04	19/05
1st obs. of sow with YLY	19/05	14/05	15/05	26/04	
1st obs. of sow with YOY	24/07	08/07	22/07	24/05	
Last observation	01/09	15/09	17/09	15/10	

** data reflects increased visitor use of the area and the initiation of visitor sighting report collection.

Sources: McLaughlin 1980*, McLaughlin 1981*, Burles 1982*, Burles 1983*, Morrison 1984*.

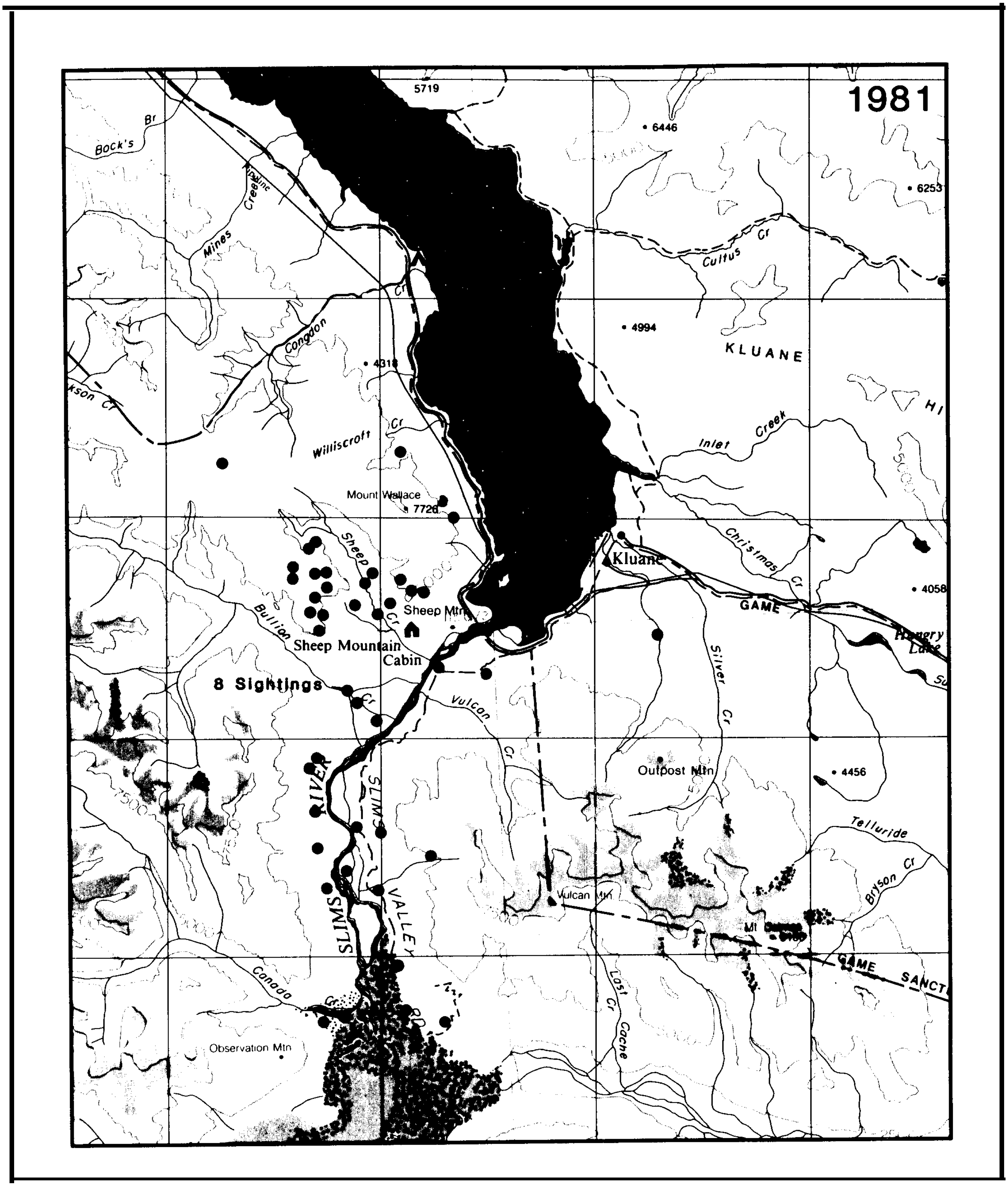

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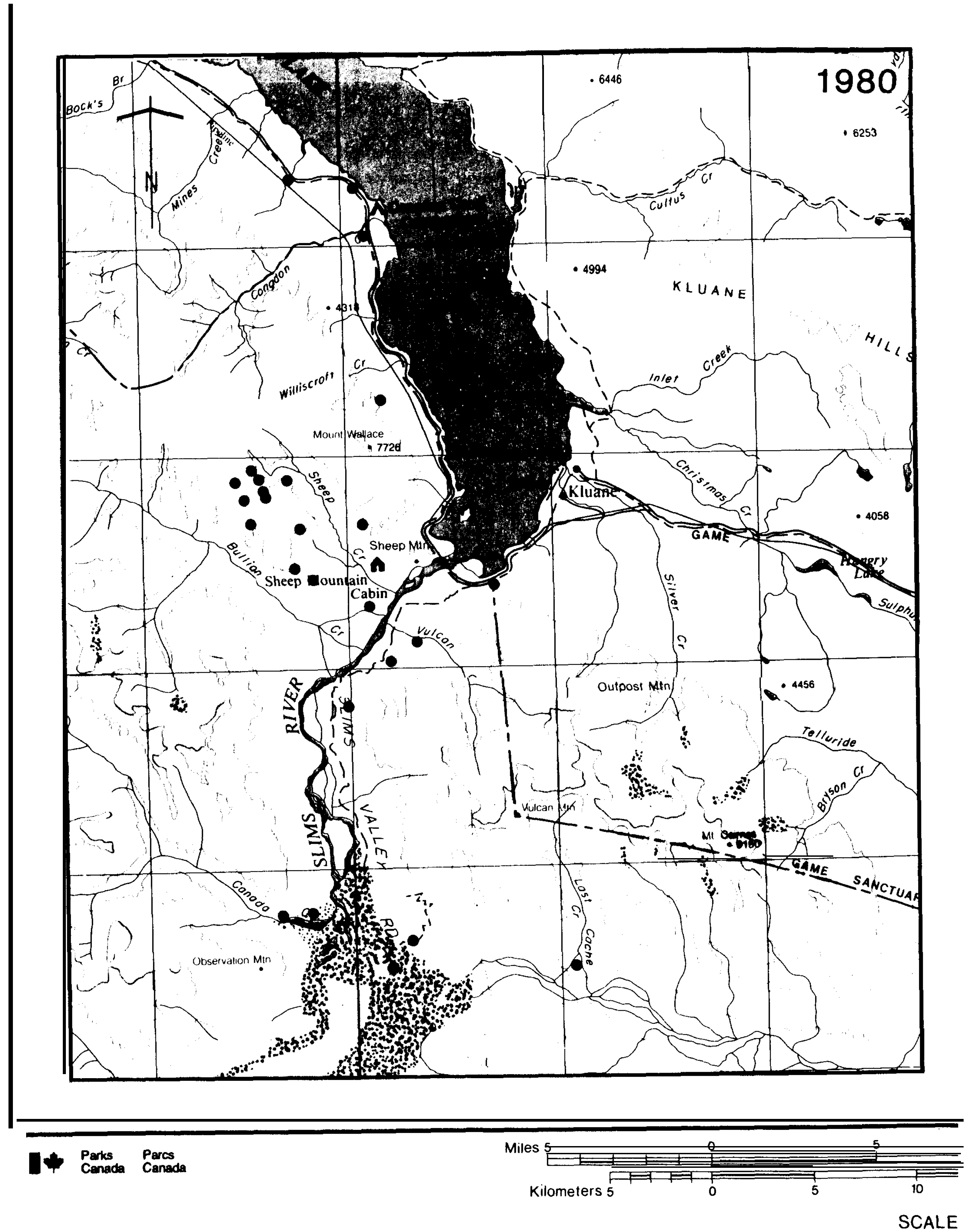
Figure 9.6 Locations of grizzly bear sightings - Slims River valley, 1980-1984.



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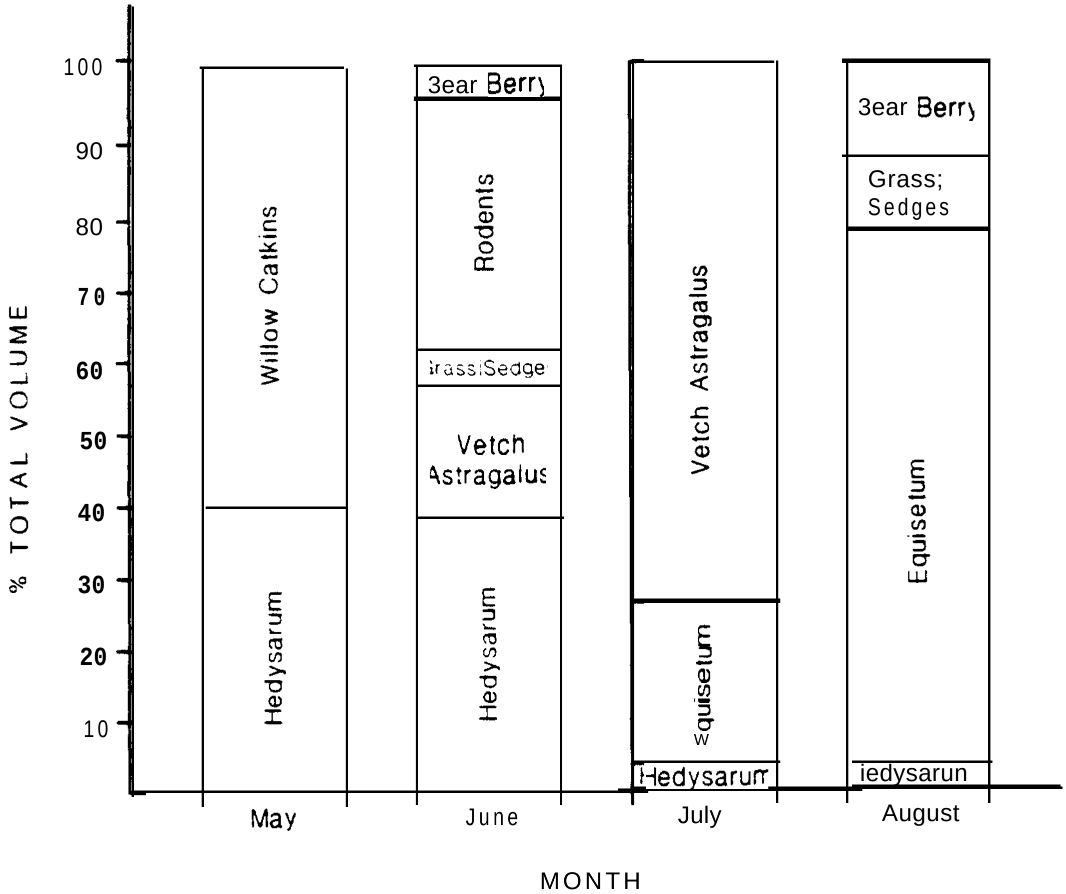


Source: McLaughlin 198 1.

Figure 9.7 Proportional use of food item by grizzly bears - Slims River Valley, 198 1.

longer so strongly attracted. sows with cubs are the most potentially dangerous bears, and the relatively high concentration of family groups in the Slims valley makes this area a zone in which the public should be careful and aware at all time. In 1984, eight females with cubs were known to be in the Slims study area. one sow with two YOY was sighted four times and one of those times charged and chased a person. Another sow with two 2 or 3 year old cubs exhibited aggressive behaviour both times she was sighted by repeatedly advancing and backing off. The potential for encounters is increasing annually as visitor use increases. The development of a Bear Management Plan was identified as a priority in the Park Conservation Plan (Parks Canada 1984) to protect both bears and people. This plan is now in the draft stage (R. Frey, pers. comm.).

9.4.3.3 Mustelidae - Weasels and allies

Six species of Mustelids are present in Kluane. All, except the Least weasel, are trapped for their valuable pelts throughout Yukon where not protected. Mustelids are carnivorous and have a reputation for ferocity. They hunt primarily at night and are active throughout the winter.

Marten - Martes americana (Turton)

The Marten is an arboreal weasel (length 60 cm; weight 1 kg), found in coniferous forest habitat throughout Yukon. Youngman (1975) has no record of them near Kluane; Clarke (1944) and Rand (1945) both report them from southern Yukon, but mention that they were heavily trapped and perhaps extirpated from large parts of the area (Clarke 1944). Banfield (1951) reports 'a few' in the Sanctuary. Archibald and Jessup (1984) reported on a recent study of Marten population dynamics in a late succession white spruce forest in the Nisutlin River area southeast of Whitehorse. The applicability of their findings to Kluane is unknown as their area supported a relatively large population and was surrounded by active registered traplines. Little is known of the present distribution and numbers of Marten in Kluane.

Martens are carnivores, preying largely on mice, voles, squirrels and snowshoe hares. They also eat fruits and carrion. They are southern postglacial immigrants.

Ermine - Mustela erminea (Linnaeus)

Ermine are small ferocious terrestrial carnivores (length 25-30 cm; weight 80 g), found throughout Yukon. Youngman (1975) reports them from the Slims River - Kluane Lake area. Murray and Murray (1970) report a weasel tentatively identified as M. erminea observed eating the remains of a bird on the Seward Nunatak, deep in the Icefields.

Their preferred habitat is coniferous forest but they are also found in tundra areas, meadows, and in riparian habitat. Ermine are present in the Park but suitable habitat is not abundant and their numbers and distribution are not well known. They prey primarily on mice, voles, ground squirrels, and pika, and have been known to attack small hares successfully. Their populations fluctuate with cyclic variations in the mouse population (Banfield 1974). In turn they are prey to many larger carnivores including marten, coyote, and raptors. Their pelage changes colour in winter from rich brown with white undersides to pure white with a black tail tip. Ermine have a Holarctic distribution and are presumed to be of Beringian origin.

Least weasel - Mustela nivalis Linnaeus

The Least weasel is the smallest Mustelid, only 20 cm in total length and weighing about 45 g. Hoefs (1973) indicates that it probably occurs in Kluane in mixed forest habitat but there are no reported observations of it in the Park. It is a southern postglacial immigrant to Yukon.

Mink - Mustela vison Schreber

Mink occur throughout Yukon in lakeshore, swamp, and streambank habitat. Youngman (1975) reports them from the Kluane Lake area. They are carnivores, eating mostly mice and voles but also crustaceans, frogs, fish, and birds. They are secretive in habit and, while present in Kluane, little is known of their numbers or distribution. The Mink is a southern postglacial immigrant.

Wolverine - Gulo gulo

A considerable body of folklore surrounds the purported ferocity and intelligence of the wolverine. It is the largest mustelid, about 1 m in length, 40 cm at the shoulder, and weighing 15 kg. The wolverine is present throughout Kluane but its numbers are unknown. Their preferred habitat is coniferous forest but they range widely from the montane to alpine zones. Youngman (1975) reports them from Kluane Lake, Sheep Mountain, and the Slims River area. Murray and Murray (1970) report sightings from Observation Mountain and Steele Glacier. Wolverine are primarily scavengers, though they also prey on small and large mammals, including moose calves, caribou, sheep, and Mountain goats (Youngman 1975). Hoefs & Cowan (1979) report apparent predation on Dall's sheep near Sheep Mountain. They rob traplines and food caches and as a result were hunted and, for a time, subject to a bounty. Their numbers were also reduced incidentally during the wolf control programs which used poisoned bait. Wolverine will successfully defend their food and their territory against much larger animals. They are solitary animals travelling extremely long distances constantly in search of food. Wolverine fur is used in the north as parka trim because of its unusual ability to resist the formation of frost.

River otter - Lontra canadensis (Schreber)

River otters are amphibious and seek out shoreline habitat near clear lakes, rivers, and large marshes. suitable habitat is not common in Rluane but Park Warden staff have sighted them frequently and believe that at least two family groups are present in the Park, one in the Kathleen River system and another in the Mush-Bates area. Figure 9.8 indicates areas where otter or their tracks are commonly seen. In winter, the tracks in the snow are quite distinctive and travel routes are easily determined.

Otters are carnivores, eating most fish, aquatic invertebrates, amphibians and occasionally small mammals such as muskrats, shrews, voles, and sometimes young beavers (Banfield 1974).

9.4.3.4 Felidae - cats

Cougar - Felis concolor Linnaeus

The Cougar is extremely rare in south Yukon. Murray and Murray (1970) report sightings by IRRP personnel along the Alaska Highway near the south end of Kluane Lake between 1964 and 1966 and at various times by residents along the Highway from Haines Junction to Burwash Landing. Wood (1967) reported one from the Kaskawulsh-Donjek Glacier divide area. L. Tremblay (pers. comm.) reports one at the Experimental Farm at Haines Junction in 1975 and the Warden Service and Youngman (1975) report 'several sightings' from the Kathleen Lake area. The Cougar is not officially confirmed in the Kluane area and these occasional sightings represent northward range extensions from central British Columbia, perhaps in response to northward movement of the Mule deer population (R. Frey, pers. comm.).

Cougar are solitary hunters of large mammals such as deer, moose, and sheep and a variety of smaller mammals. They are most commonly found today in mountainous terrain in Western Canada. Banfield (1974) indicates that they once ranged throughout southern Canada in a variety of habitats but have been largely extirpated fran the central and southern areas of the country.

Lynx - Lynx lynx canadensis Kerr

Lynx are common in Kluane, ranging throughout the forested areas of the Park, and have been seen occasionally well into the Icefields and on the Lowell Glacier (Murray & Murray 1970). Youngman (1975) reports them from Kluane Lake. They are solitary hunters and are rarely seen. Snowshoe hare are their primary prey but they also eat ptarmigan, lambs, moose calves, a variety of small mammals, and eat carrion. Dependence on Snowshoe hare has tied their populations to the lo-year hare cycle, and Lynx tend to reach peak abundance just after the snowshoe population has crashed. This pattern has not been verified in Kluane but Hoefs and Cowan (1979)

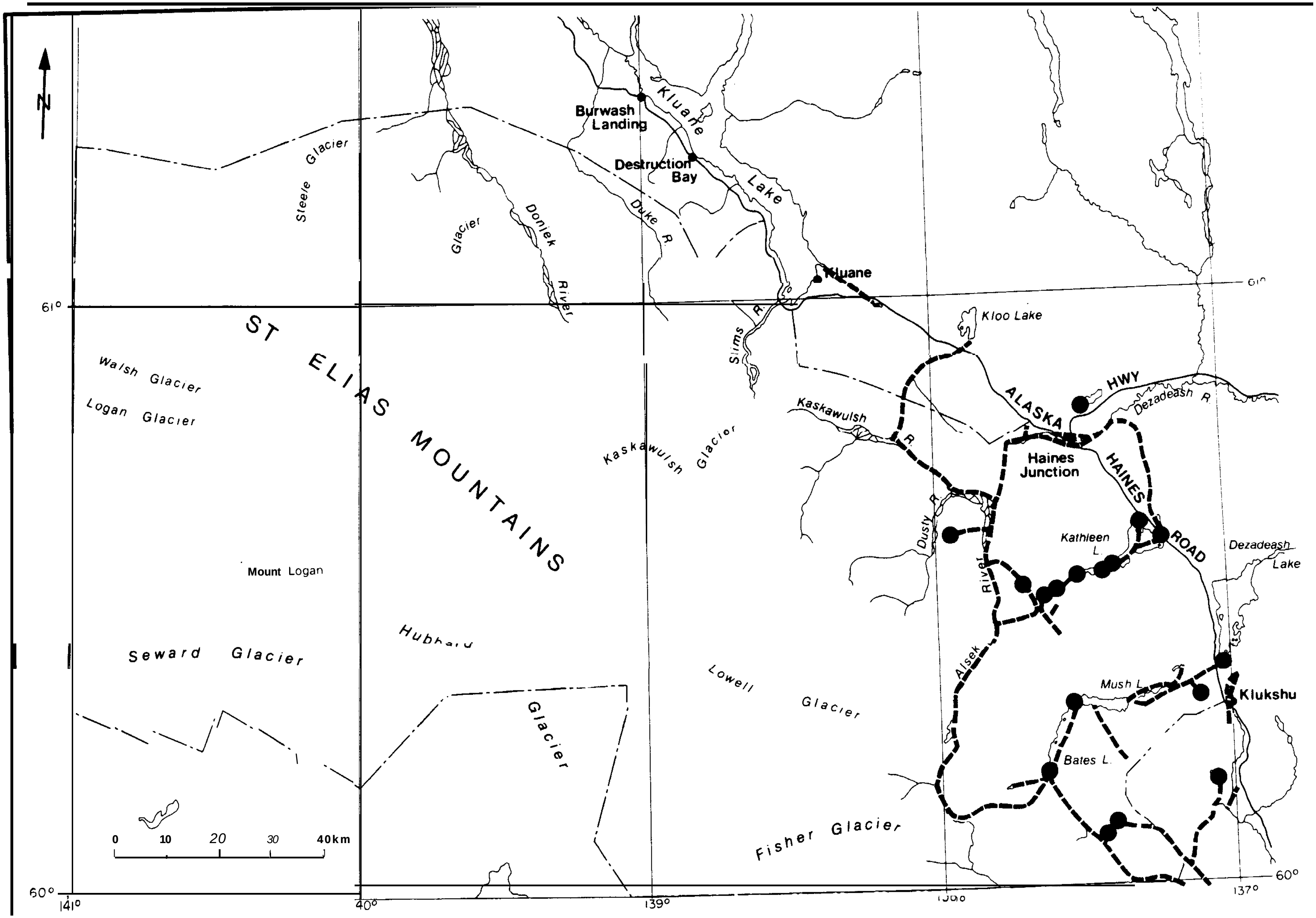

N
Burwash
Landing
Kluane
Destruction
Bay
Lake
Steele
Glacier
Glacier
Donjek
River
Duke R.
Kluane
61°
ST ELIAS MOUNTAINS
Slims R.
Kloo Lake
Walsh Glacier
Logan Glacier
ALASKA HWY
Dezadeash R.
Kaskawulsh
R.
Kaskawulsh Glacier
Haines
Junction
HAINES ROAD
Dusty R.
Kathleen
L.
Dezadeash
Lake
Mount Logan
River
Alsek
Hubbard
Seward Glacier
Lowell
Glacier
Glacier
Mush L.
Klukshu
Bates L.
0
10
20
30
40km
Fisher Glacier
60°
141°
140°
139°
137°

Figure 9.8 Sightings and travel routes of otter in Kluane National Park.

● Areas where otter are frequently seen

▬ ▬ ▬ ▬ Observed travel routes

Source: R. Chambers

believe it to be valid based on their knowledge of the hare cycle and trapping returns from other areas in Yukon. Hoefs and Cowan (1979) believe that Lynx may become predators of Dall's sheep in the Sheep Mountain area in years when the hare population is low.

The lynx is a Holarctic boreal forest species. Youngman (1975) cites records of it from Pleistocene fossil assemblages in Alaska and presumes it to be of Beringian origin.

9.4.3.5 Cervidae - deer

Mule deer - Odocoileus hemionus hemionus (Refinesque)

The Mule deer is the common deer of the western mountains -and foothills and appears to be expanding its range northward and westward into the open coniferous forests of the southwest Yukon. Youngman (1975) does not include the Kluane area in their Yukon range. However, Mule deer have been seen on the Slims Delta and in the Kathleen Lake area (Hoefs 1973). The Warden Service reports frequent sightings between Whitehorse and Haines Junction as well as occasional observations in the Kluane Lake area and the lower Slims Valley. The species is still considered rare in the Park.

Moose - Alces alces gigas Miller

Moose are the most common cervid in Kluane. Their preferred habitat is shrubby parkland or river valley areas dominated by subclimax woody vegetation such as willows, aspen, balsam poplar. These successional vegetation types are often the result of natural disturbances, particularly fire or periodic flooding and channel migration, but can also follow clearing for road construction or other purposes. Moose habitat in Kluane is limited and marginal compared to other areas in Yukon (Hoefs 1973). This is due in part to the nature of the terrain with only limited lowland and marsh habitat - but also to the absence of fire from the Park particularly in the last 40-50 years, limiting early successional vegetation.

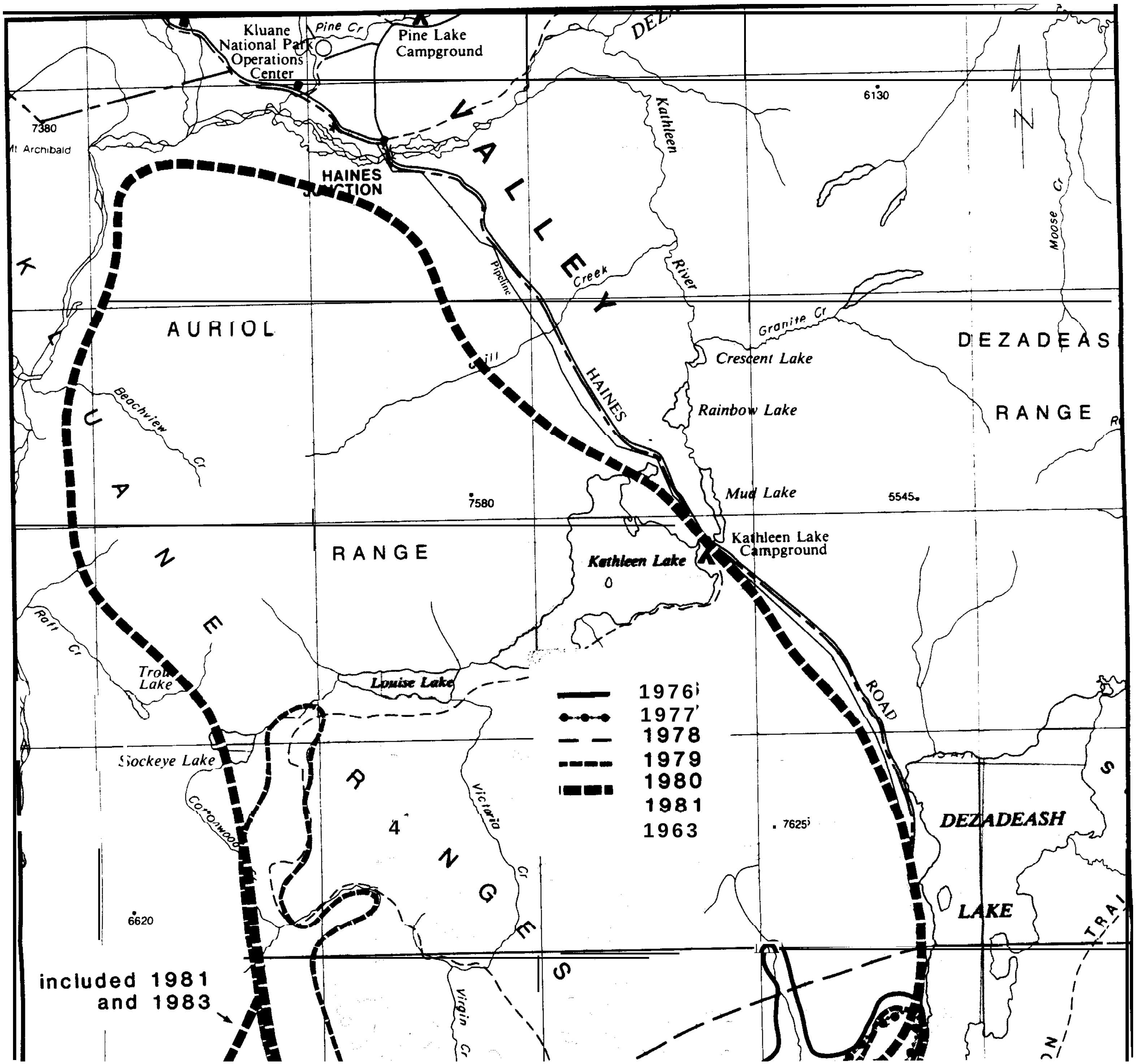
Hoefs (1973) identified only two areas of 'exceptional' moose habitat in Kluane. The Mush Lake - Alder Creek area has the best marsh habitat in the Park as well as a relatively recent fire history and suitable successional vegetation. The upper Duke valley provides good subalpine habitat. Together these two areas comprise less than 130 km^2 (50 mi^2) of prime moose habitat (Hoefs 1973). Other areas of fair habitat occur along the Shakwak Trench from Haines Junction south to the Kathleen Lakes area. Good habitat exists in peripheral areas near the Park, particularly in the south near Dezadeash Lake where there is considerable cross-boundary movement. Hoefs (1980) estimates that 400-500 moose live in the Park. Moose are hunted in the Sanctuary by native people and in areas outside the Park and Sanctuary by others.

Through the year moose migrate between the subalpine zone and valley bottoms in response to browse availability and to climatic conditions such as snow depth and temperature inversions. In summer moose are dispersed throughout their range. Some are in the subalpine zone where shrubby browse is abundant and others remain in lowland marshy areas feeding on aquatic vegetation. In the late fall and early winter moose congregate in the subalpine zone and their density can reach 2-3 animals per square mile, a high figure for any moose range but especially high for northern areas (Hoefs 1980). The Warden Service conducts aerial moose surveys at this time. Figures 9.9, 9.10, 9.11 and 9.12 present maps of the areas surveyed in various years in the Dezadeash, Duke, Donjek, and Alsek Pass areas. Currently, the Duke and Dezadeash surveys are done annually. The tables included in the legend contain actual counts recorded on the survey flights. Surveys are scheduled to coincide with the animals' period of maximum concentration. Map 9.1 (in pocket) shows the locations of this preferred late fall-early winter habitat throughout the Park.

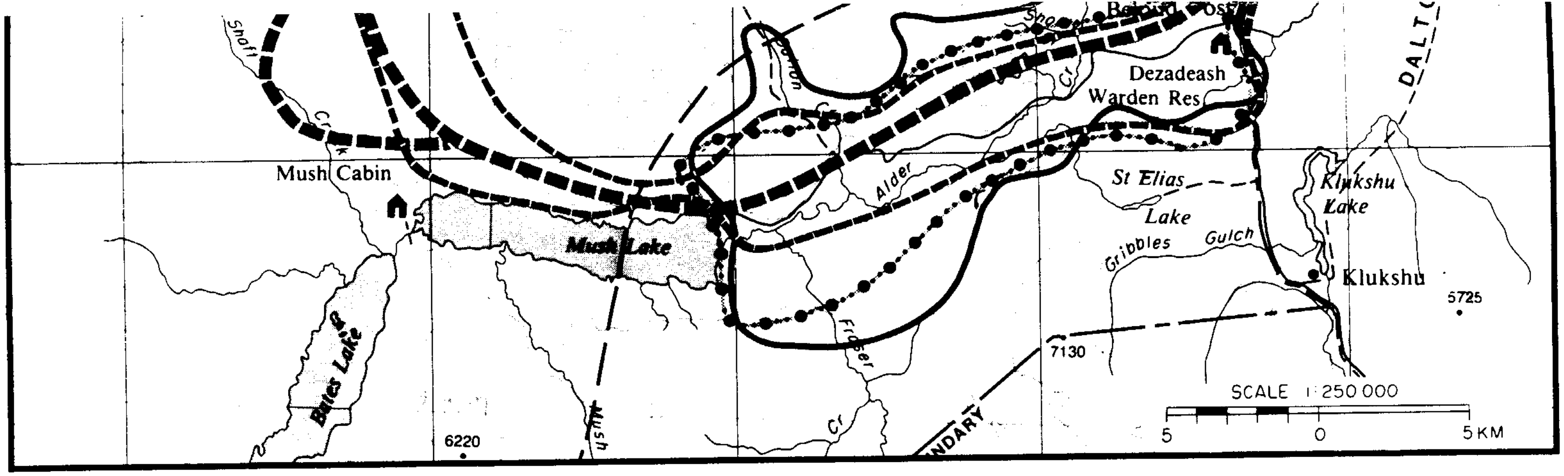
In mid-winter, deep or crusty snow in the subalpine makes moving about too difficult and to conserve energy the moose migrate down into the valley bottoms where they remain until spring. These snow depth related movements are particularly pronounced in southern areas of the Park where the climate is quite maritime and snowfall is abundant. Altitudinal movements in the Duke Valley are not tied as closely to snow conditions, primarily because snowfall is considerably less than that in the south. In this area, moose remain in the subalpine for most of the year but in winter move within that zone in response to temperature inversions (Warden Service, pers. comm.). In mid winter under calm conditions deep valley bottoms can be tens of degrees colder than areas upslope and many large mammals in Kluane move up or downslope to take advantage of zones of warmer temperatures.

In Kluane, the rut takes place in late September and early October. Calves, usually singles but sometimes twins, are born in late May or early June. The calves remain with their mother through the summer and are weaned by 4 or 5 months of age. They become sexually mature at 16 months but Hoefs (1980) indicates that in stable low productivity populations like Kluane's moose do not usually breed until the following year at about 28 months of age. Cows may breed every year and both males and females may live for up to 20 years (Hoefs 1980).

The subspecies in southwest Yukon, A. a. gigas, is the largest in North America (Youngman 1975). Bulls may reach fall weights of over 800 kg and stand nearly 2 m at the shoulder (Hoefs 1980). Antlers are massive and develop their characteristic palmate form after the males reach 4-5 -years of age. Antlers are shed every year.



Kluane National Park Operations Center
Pine Cr
Pine Lake Campground
7380
Mt Archibald
HAINES JUNCTION
VALLEY
Kathleen
River
Creek
Pipeline
6130
Moose Cr
AURIOL
Beachview Cr
Granite Cr
Crescent Lake
Rainbow Lake
DEZADEAS
RANGE
HAINES
Mud Lake
5545
7580
Kathleen Lake Campground
Kathleen Lake
RANGE
KLUANE RANGES
Raft Cr
Trout Lake
Louise Lake
ROAD
1976
1977
1978
1979
1980
1981
1963
Sockeye Lake
Cottonwood
Victoria Cr
7625
DEZADEASH
LAKE
6620
Virgin Cr
included 1981 and 1983



KLUANE NATIONAL PARK RESERVE

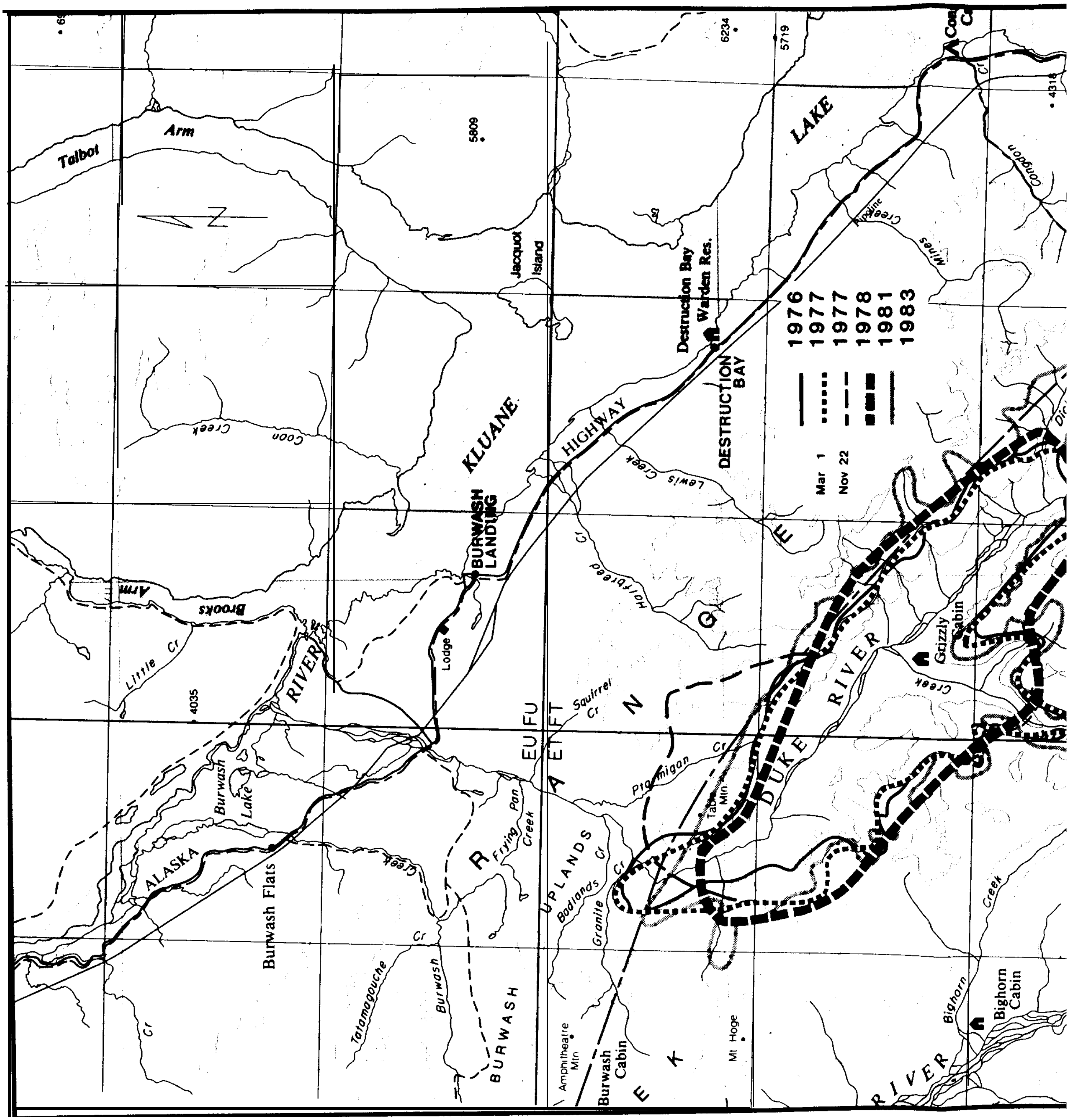
Figure 9.9 Moose surveys – Dezadeash area, 1976-1984.

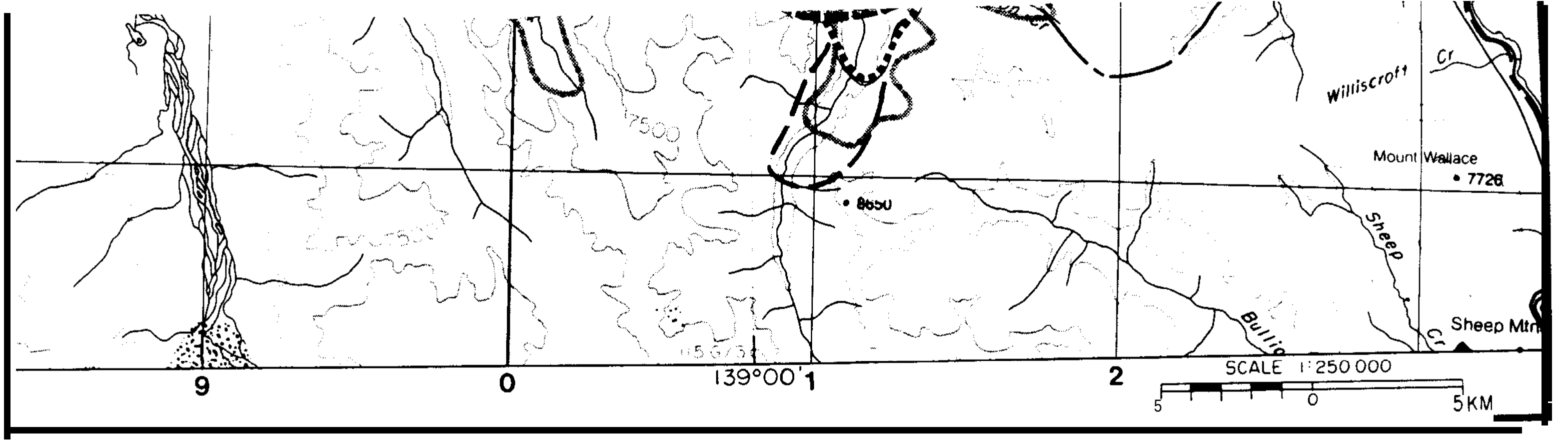
Parameter	976	1977		1 978	1978+	1979	1980	1981	1982	983	1984[4]
Date1	:6-10	14-3	28-10	:6-01	08-02	27-10	20-10	21-10	02-11	:1-10	-
Total	59	13	105	53	46	75	140	153	76	170	-
Unknown	15	7		2					76		-
Adult males	14	1	36	3	15	35	40	53		57	-
Adult females	26	1	53	8	13	32	81	83		100	-
Unknown		2		31	13						-
YOY[2]	4	1	6	9	5	8	19	16		13	-
YLY[3]											-
Dead		1									-

+ Extrapolated from biophysical survey data (Douglas 1980).

1. Date is written day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.
4. Not available.

Source: Park Warden reports listed in Literature Cited.


KLUANE
LAKE
Talbot Arm
Brooks Arm
Jacquot Island
Destruction Bay Warden Res.
DESTRUCTION BAY
HIGHWAY
ALASKA
BURWASH LANDING
Lodge
Burwash Flats
Burwash Lake
Little Cr
Coon Creek
Lewis Creek
Congdon
Mines Creek
Halfbreed Cr
Squirrel Cr
Ptarmigan Cr
Frying Pan Creek
Badlands Cr
Granite Cr
Tatamagouche
Burwash Cr
BURWASH UPLANDS
DUKE RIVER
Grizzly Cabin
Bighorn Cabin
Bighorn Creek
Burwash Cabin
Amphitheatre Mtn
Mt Hoge
5809
6234
5719
4035
Mar 1
Nov 22
1976
1977
1977
1978
1981
1983



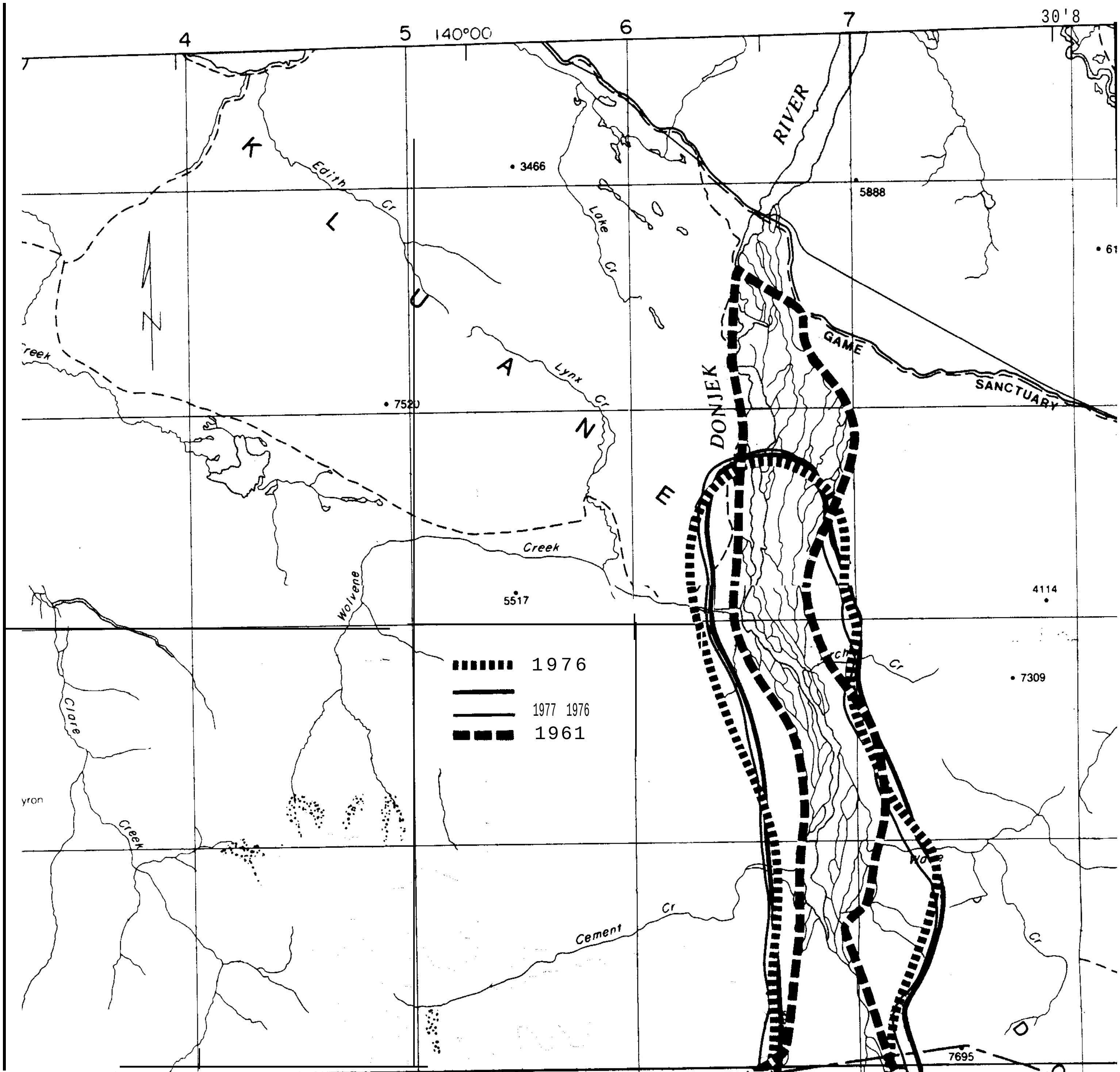
KLUANE NATIONAL PARK RESERVE

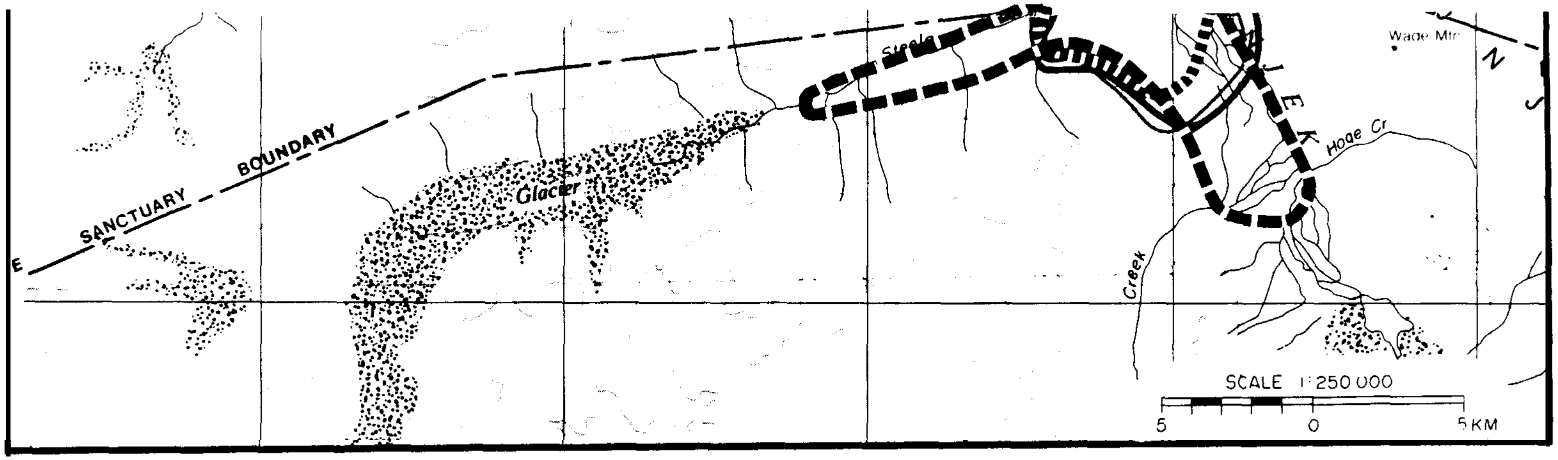
Figure 9.10 Moose surveys - Duke area, 1976-1984.

Parameter	1976	1977		1978		1979	1980	1981		1982	1983	1984[4]
Date[1]	10-12	01-03	22-11	.5-02	16-11	-		)4-02	16-11	)5-11	31-10	-
Total	69	44	49	21	68	-		78	91	114	99	-
Unknown				6		-		8			-	-
Adult males	36	26	15	1	20	-		14	28	38	33	-
Adult females	28	12	32	1	35	-		31	47	53	54	-
Unknown				18		-					-	-
YOY[2]	5	6	2	1	7	-		8	10	22	12	-
YLY[3]						-		17	6	1	-	-
Dead						-					-	-

1. Date is written day-month
2. YOY = Young of the year.
3. YLY = Young of last year.
4. Not available.

Source: Park Warden reports listed in Literature Cited.


4
5
140°00
6
7
30'8
K L U A N E
GAME SANCTUARY
DONJEK RIVER
Edith Cr
Lake Cr
Lynx Cr
Creek
Wolvene
Clare
Creek
Cement Cr
3466
5888
7520
5517
4114
7309
7695
1976
1977 1976
1961



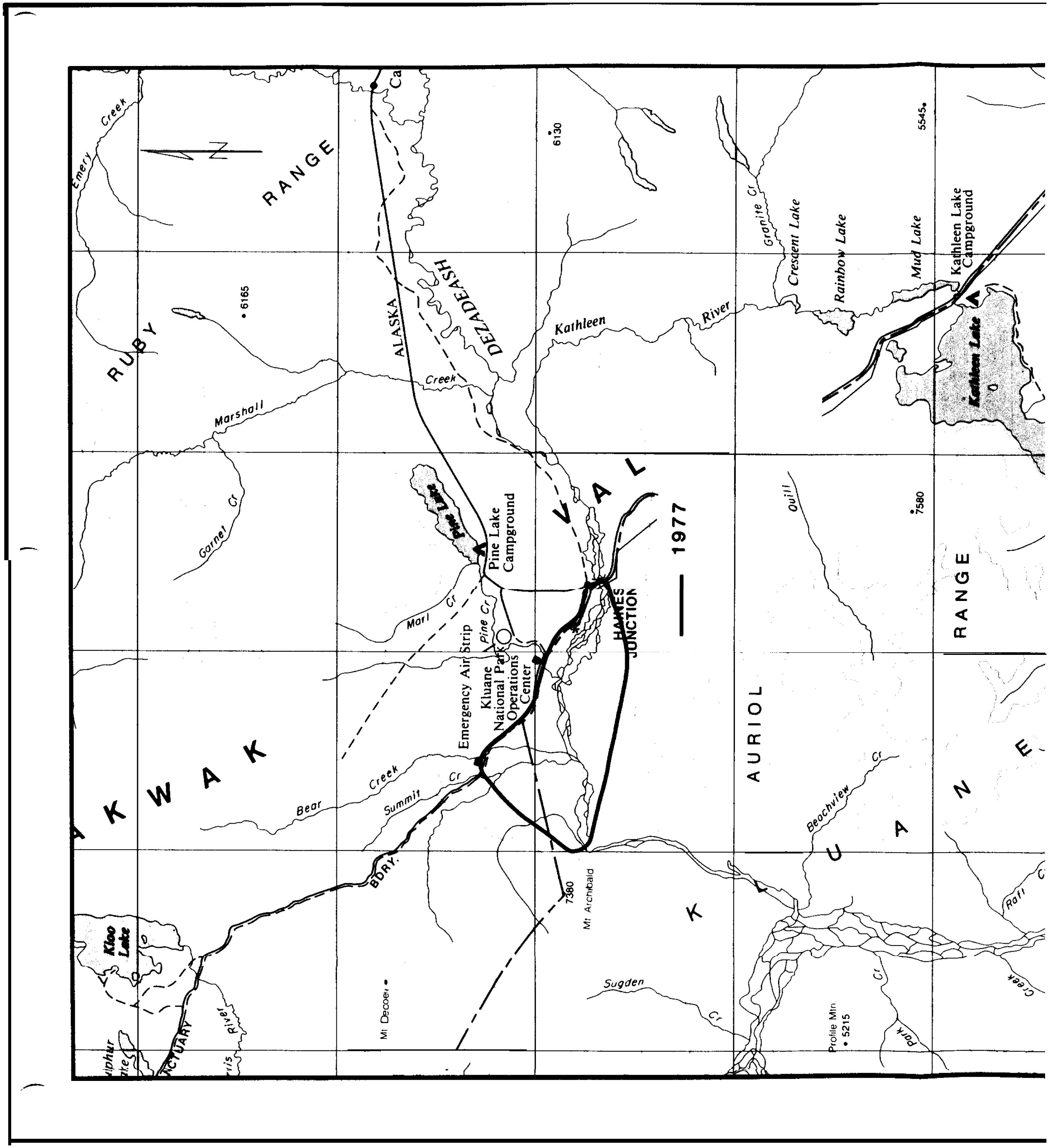
KLUANE NATIONAL PARK RESERVE

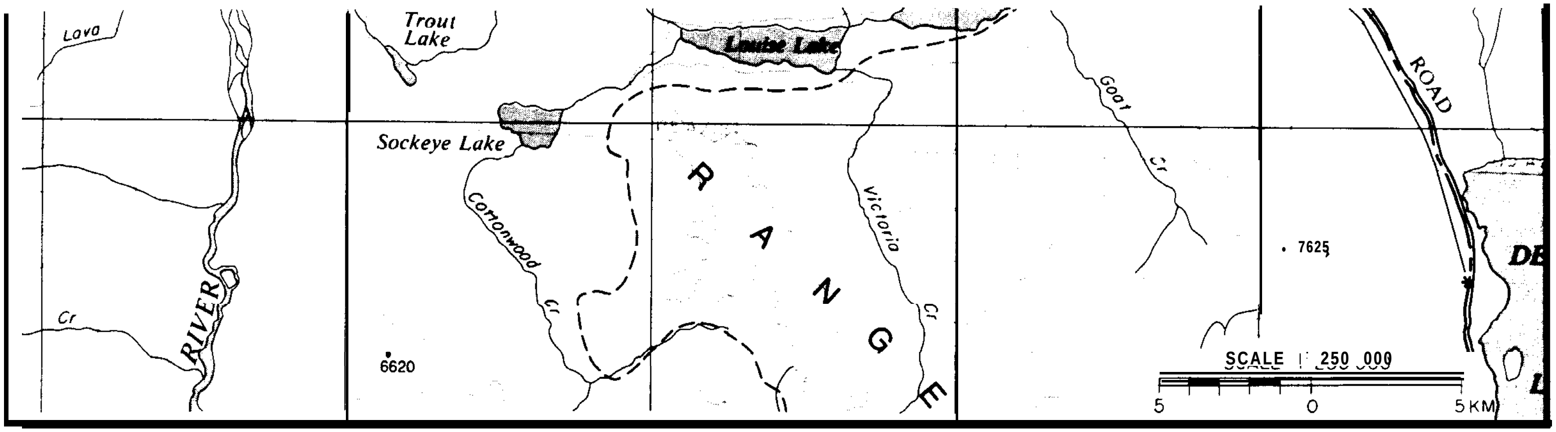
Figure 9.11 Moose surveys - Donjek area, 1976-1981.

Parameter	1976	1977		1978		1979	1980	1981	
Date[1]	10-12	24-02	22-11	15-02	01-12	-	-	04-02	19-11
Total	31	11	10	24	53			5	10
Unknown									
Adult males	12	10	1	-	28			3	1
Adult females	15	6	6	4	24			2	6
Unknown				17	1				
YOY[2]	4	3	3	3	-				3
YLY[3]		1	1	-	-				
Dead									

1. Date is written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.

Source: Park Warden Reports listed in Literature Cited.


RUBY RANGE
Emery Creek
6165
Marshall
Creek
Garnet Cr
ALASKA
DEZADEASH
Kathleen
River
6130
Granite Cr
Crescent Lake
Rainbow Lake
Mud Lake
5545
Kathleen Lake Campground
Kathleen Lake
Pine Lake
Pine Lake Campground
Marl Cr
Pine Cr
Emergency Air Strip
Kluane National Park Operations Center
HAINES JUNCTION
1977
Quill
7580
RANGE
AURIOL
Bear
Creek
Summit
Cr
BDRY.
7380
Mt Archibald
Kloo Lake
River
Sugden
Cr
Beachview
Cr
Profile Mtn
5215
Park
Creek



KLUANE NATIONAL PARK RESERVE

Figure 9.12 Moose surveys - Alsek Pass area, 1977-1978.

Parameter	1977		1978+
Date[1]	09-02	15-03	26-01
Total	17	2	16
Unknown			
Adult males			1
Adult females		1	3
Unknown	16	-	7
YOY[2]		1	3
YLY[3]	1		2
Dead			

\+ Interpolated from biophysical survey (Douglas 1980).

1. Date is written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.

Source: Park Warden reports listed in Literature Cited.

Wolves and Grizzly bears are the primary moose predators in the Park. Currently a wolf control program is underway in **areas** outside the Park and the Sanctuary following a decline in the moose population in 1982. The Grizzly bear hunting season has been extended as well to provide further predator control.
Moose are presumed to be of Beringian origin. No specific studies of moose have been undertaken in Kluane.

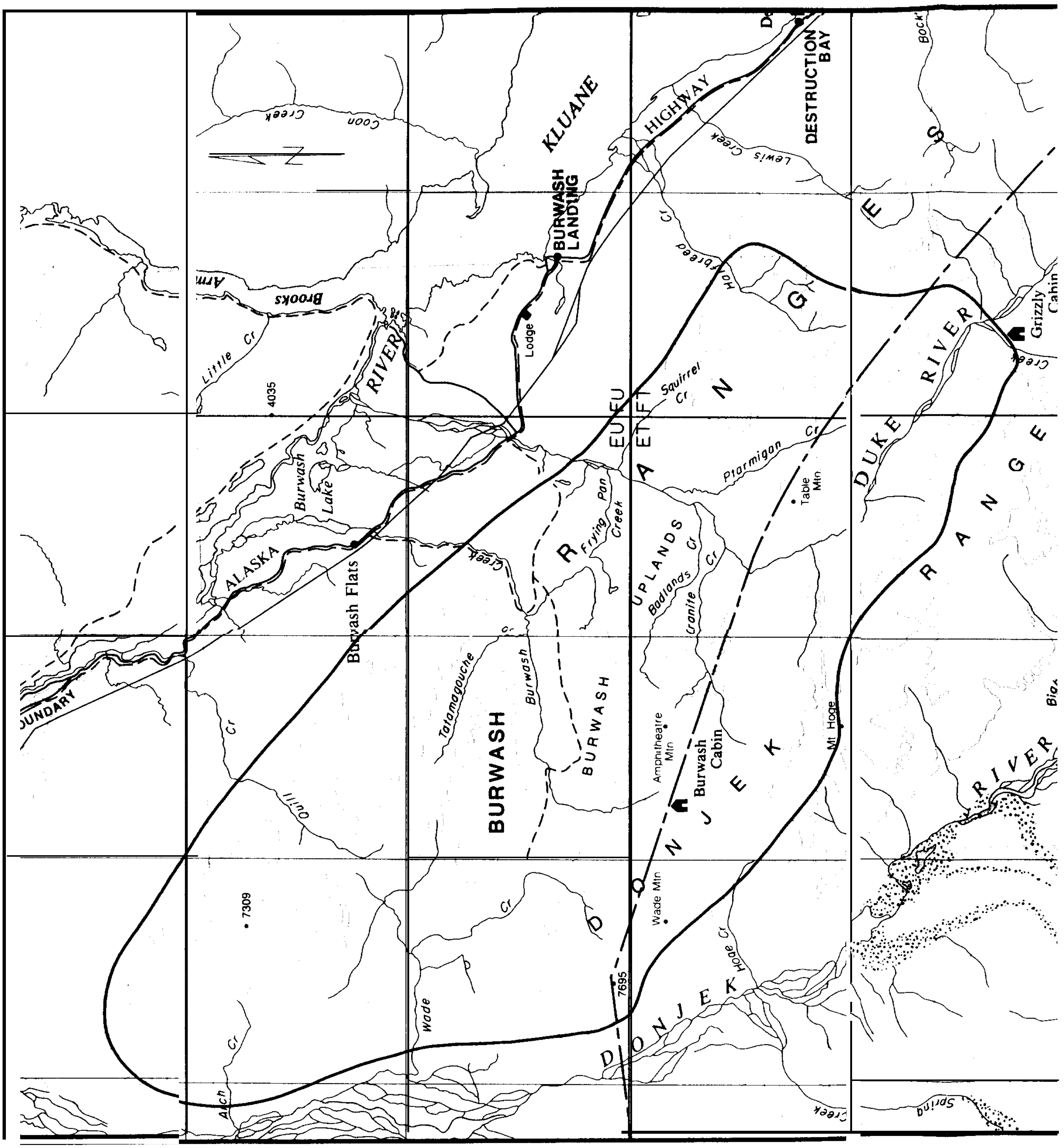
Woodland caribou - Rangifer tarandus caribou (Gmelin)

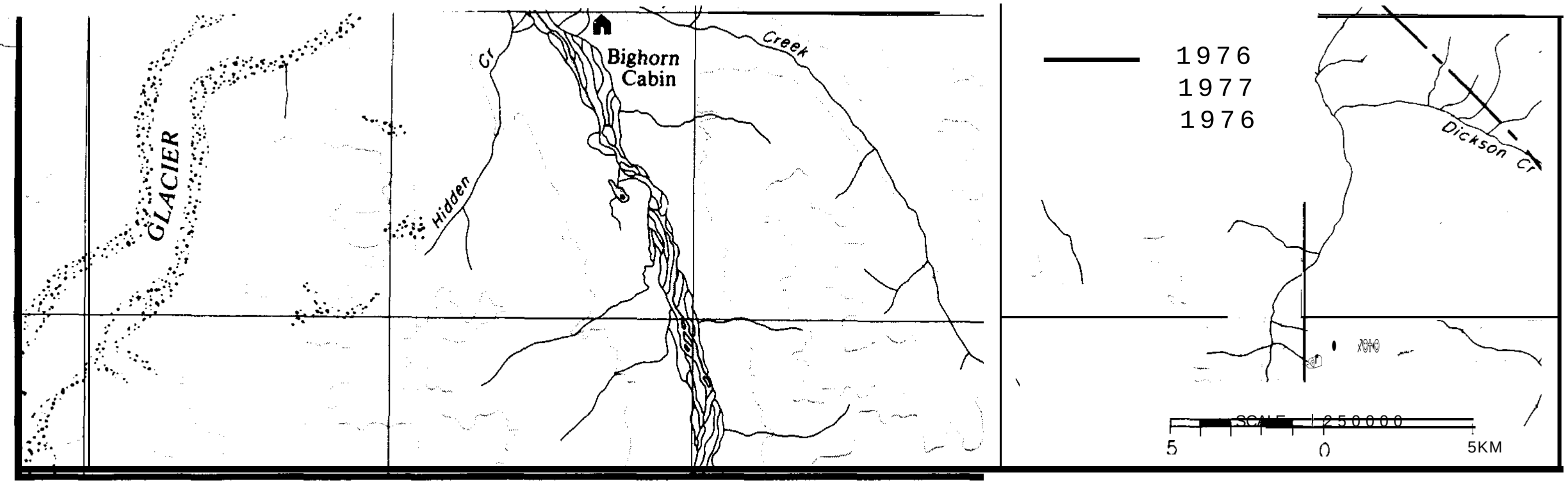
In the 1940's, caribou were frequently seen in the southern areas of the Park, as part of **a** herd using the Chilkat Pass area (Hoefs 1973). Recently caribou have been seen only occasionally and in small groups near Kathleen Lake. The apparent decline in the herd and abandonment of range is attributed by local residents to '*massive slaughter" by army personnel during building of the Haines Highway (Hoefs 1973). Murray and Murray (1970) observed caribou in the **Burwash** Uplands and the White River valley. Destruction Bay residents **saw** over 100 anaimals in the alpine *zone* near the headwaters of Halfbreed Creek in February 1971. These areas are not in the Park.

Kluane does not have a resident caribou population though two herds use areas adjacent to the Park. One herd ranges in the Burwash Uplands just north of the Park boundary and annually **migrates across** the Shakwak Trench to the hills east of the Brooks Arm on Kluane Lake. In **summer** individuals from this herd cross into the Park in search of alpine snowbed vegetation. Another herd uses the St. Clare - Boundary Creek **area** near the terminus of the Klutlan Glacier but this is further from the Park boundary and it is assumed that none of these aniamal range as far as the Park. A second discrete herd uses the Kluane Hills on the southeast side of Kluane Lake, north and east of the Alaska Highway.

From 1976 to 1978 the Warden Service flew aerial surveys of the Burwash **and** St. Clare herds. The survey areas and data collected are shown in Figure 9.13 and 9.14. The Burwash herd has been the object of further study by students from the University of Waterloo (Oosenbrug 1976; Gauthier 1980) and in 1981 by Foothills Pipe Lines (South Yukon) Ltd. The right-of-way of the proposed Alaska Highway Gas Pipeline bisects the migration route followed by cariiiou moving to and from the Brooks Arm range and radio-collar monitoring studies, started by Gauthier, were continued to determine the timing and patterns of movement (Beak 1981).

The Burwash herd has been estimated at 250-300 animals (Gauthier 1980). Woodland caribou are larger than barren-ground caribou and do not undertake long distance migrations. **They** Prefer plateau-like subalpine and alpine habitat in all seasons but move up or downslope in response to snow conditions, temperature inversions, and forage availability (Beak 1981). In the Foothills study, movements from the Burwash to the Brooks Arm upland areas


KLUANE
HIGHWAY
DESTRUCTION BAY
BURWASH LANDING
Lodge
Coon Creek
Lewis Creek
Brooks Arm
Little Cr
4035
RIVER
Burwash Lake
ALASKA
Burwash Flats
BOUNDARY
Squirrel Cr
Ptarmigan Cr
Table Mtn
Frying Pan Creek
RUFF
UPLANDS
Badlands Cr
Granite Cr
BURWASH
Tatamagouche
Burwash Cr
Amphitheatre Mtn
Burwash Cabin
Mt Hoge
Hoge Cr
Wade Mtn
7309
7695
Wade
Quill
Aach Cr
DONJEK
DONJEK RIVER
DUKE RIVER
DUKE RANGE
Grizzly Cabin
RIVER
Spring



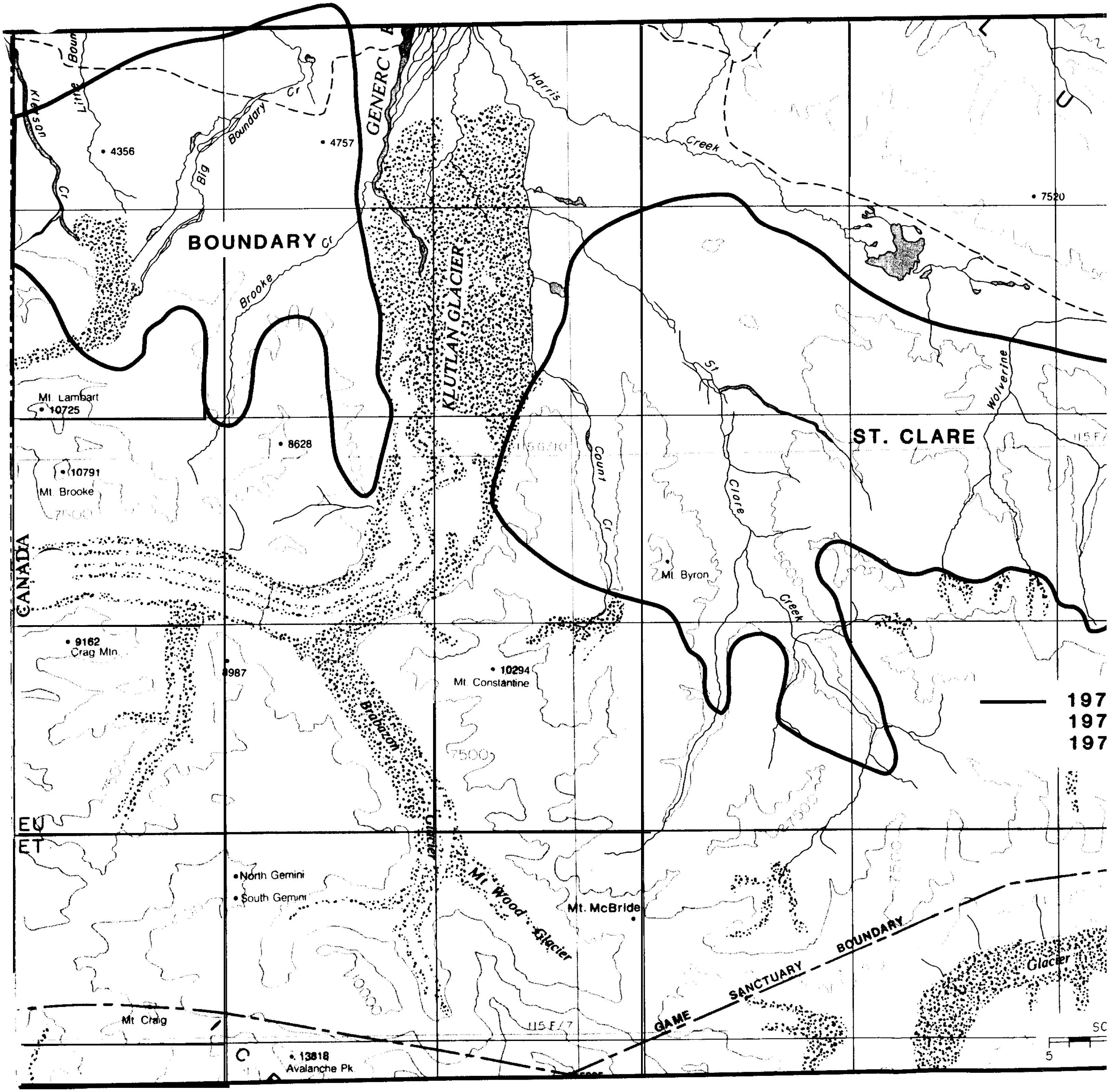
KLUANE NATIONAL PARK RESERVE

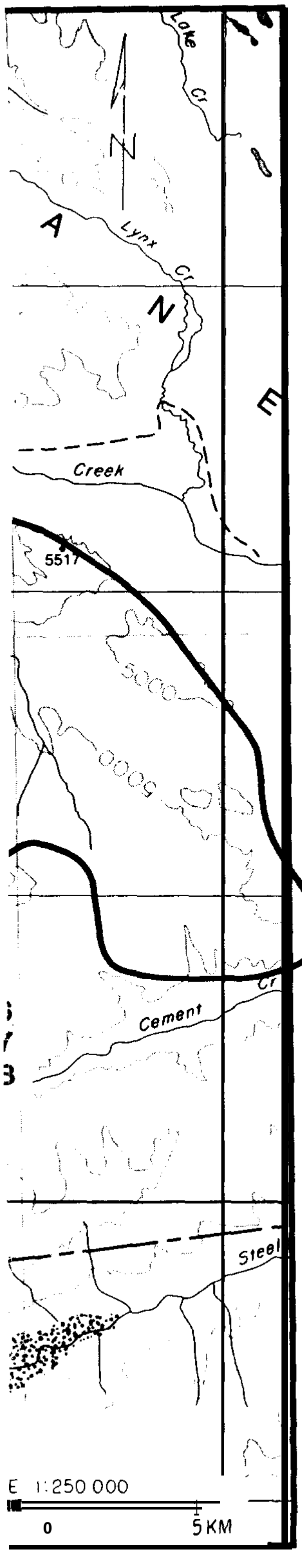
Figure 9.13 Caribou surveys - Burwash Uplands, 1976-l 978.

Parameter	1976		1977			1978			
Date[1]	26-09	35-11	16-02	09-06	OS-10	12-01	26-02	10-03	25-09
Total	157	145	37	154	167	65	35	100	138
Unknown	106	64	25	-	-	-	-	-	-
Adult males	24	23	2	7	27	11	12	10	27
Adult females	16	33	-	99	115	47	17	65	83
Unknown									
YOY[2]	11	14	6	40	24	7	5	11	20
YLY[3]		21	4	8	1	-	1	14	8
Dead									

1. Date is written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.

Source : Park Warden reports iisted in Literature Cited.


BOUNDARY
ST. CLARE
KLUTAN GLACIER
GENERC
CANADA
Harris Creek
Big Boundary Cr
Little Boun
Brooke
St Clare Creek
Count Cr
Wolverine
Brabazon
Mt. Wood Glacier
Glacier
Mt. Lambart
10725
4356
4757
8628
10791
Mt. Brooke
7520
Mt. Byron
9162
Crag Mtn.
8987
10294
Mt. Constantine
North Gemini
South Gemini
Mt. McBride
Mt. Craig
13818
Avalanche Pk
GAME SANCTUARY BOUNDARY
EU
ET
197
197
197



KLUANE NATIONAL PARK RESERVE

Figure 9.14 Caribou surveys - Boundary and St. Clare creek, 1976-1978.

Parameter	1976		1977			1978			
Date[1]	17-09	29-11 01-12	17-02	11-06	27-09	14-01	27-02	06-06	26-09
Total	250	122	123	142	212	203	195	106	235
Unknown	183	57	52						
Adult males	35	26	33	20	SC	25	48	12	52
Adult females	16	32	32	97	114	154	139	79	160
Unknown									
YOY[2]	14	1	1	11	18	24	18	4	10
YLY[3]	2	6	4	14				11	13
Dead									

1. Date is written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.

Source: Park Warden reports listed in Literature Cited.

Parks Canada Parcs Canada

occurred throughout the study period (December - June) and appeared to be direct and rapid, perhaps due to the increased threat of wolf predation in the denser vegetation of the Shakwak Trench (Beak 1981). Return movements were concentrated in the mid-April to mid-May period but with only 6 months data no firm conclusions can be drawn from these observations. The rut occurs in late September and early October (Oosenbrug and Theberge 1980) in the alpine zone. Rapid snow accumulation forces the animals to lower elevations shortly after. Calves are born from mid-May to early June on widely dispersed calving areas in all vegetation zones (Gauthier 1980; Beak 1981; Oosenbrug & Theberge 1980). Sedges are preferred summer forage and the animals move upward from subalpine to alpine areas through the summer in search of these preferred vegetation types as well as relief from insect harassment in windy high elevation areas (Oosenbrug & Theberge 1980). Two periods of aggregation occur - in the subalpine after calving and in the alpine zone prior to the rut (Oosenbrug & Theberge 1980). Hoefs (1980) indicates that the annual recruitment rate of the herd is very low, resulting from low birth and high death rates in young of the year.

Both sexes carry antlers which are shed annually. Males begin to grow their antlers in early spring and shed them following the rut in early winter. Females grow theirs through the summer and drop them the next spring at calving (Banfield 1974).

The early summer to late fall range of the Burwash herd is shown on Map 9.1. The Warden Service reports that year-round sightings in the Duke River valley part of this range have become more frequent in the last 3 to 4 years.

9.4.3.7 Bovidae - Sheep and Goats

Mountain goat- Oreanmos americanus (de Blainville)

Mountain goats are a wilderness species. They are sensitive to human disturbance of their rugged mountainous and usually inaccessible terrain and have abandoned areas of range in north B.C. following prolonged seismic and mineral exploration activity.

While somewhat similar in appearance to Mountain sheep, they are in fact mountain antelopes, and are more closely related to the Chamois of Europe than to any North American species (Rideout 1978).

Hoefs (1980) estimates that 700-800 Mountain goats remain in Kluane year round and another 100 migrate across the southern and western boundaries from north B.C. and Alaska. They are most common in southern areas of the Park in the Auriol Range, the Alsek Xanges, and the Goatherd Mountain area; goats have apparently completely displaced sheep from the latter two areas. The westerly parts of Goatherd Mountain are believed to be the best goat range in the

Park with densities of 3 goats per square mile, and a total estimated population of 200 (Hoefs 1973).

Winter and summer goat range is shown on Map 9.1. Delineation of these areas is based on aerial survey information collected by the Warden Service. Only the Goatherd Mountain area is surveyed annually specifically for goats; a count is made of those on the Auriol and Vulcan ranges during the sheep surveys (see Figures 9.1.; 9.16 & 9.17). Other habitat areas on Map 9.1 are based on observations made primarily during sheep surveys as in some areas the two species occupy overlapping or contiguous ranges.

There is no altitudinal difference between summer and winter ranges. Preferred winter range occurs as small pockets within the larger summer range and is comprised of precipitous south-facing slopes and cliffs and high ridge areas where sun and wind limit snow accumulation. Here the animals have little competition for winter grazing and are protected fran predators by the proximity of escape terrain. Goats cope *more* easily with deep snow than do sheep, and areas of sheep range which have been abandoned to goats are all subject to severe winter snow conditions (Hoefs 1980).

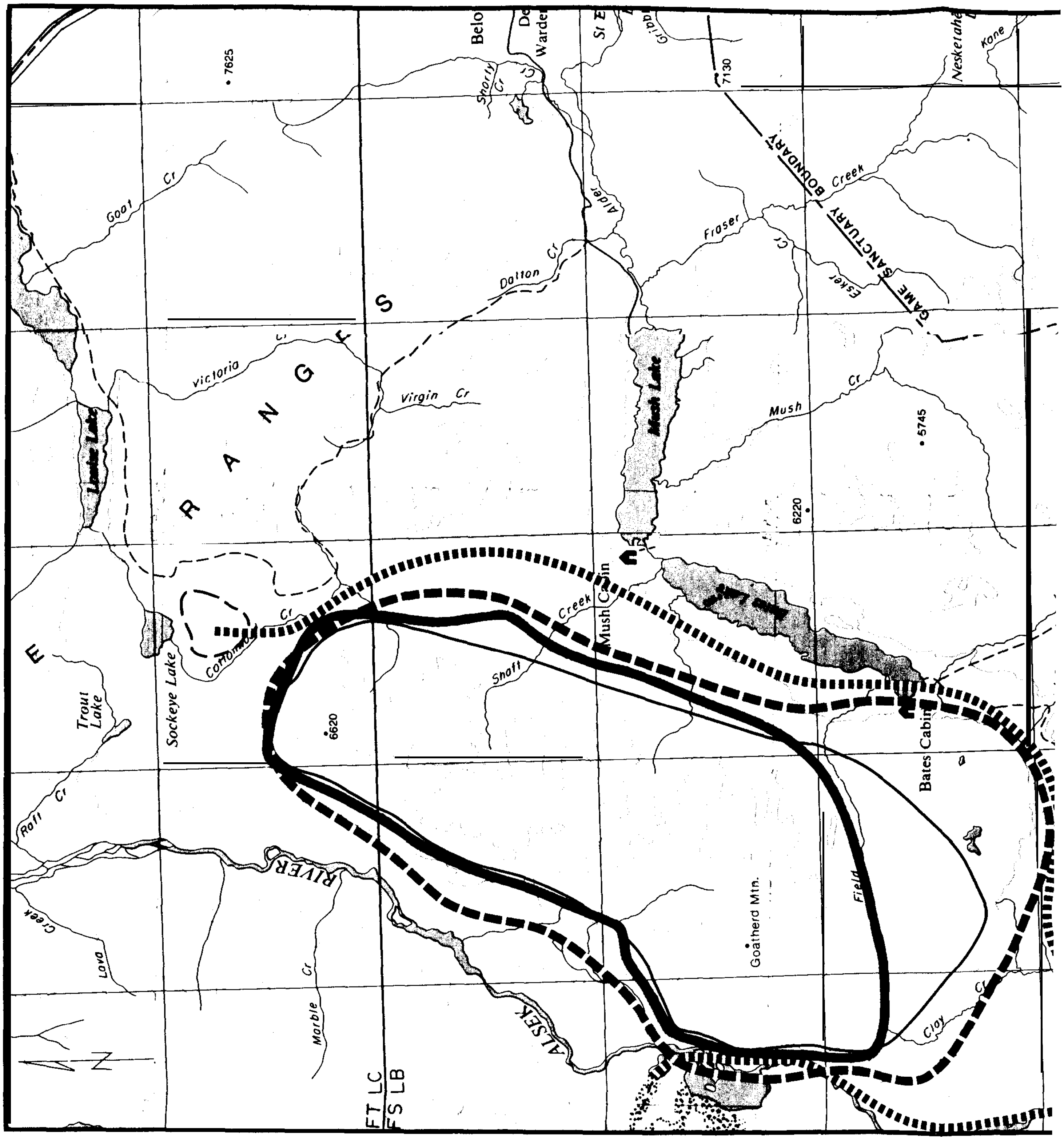
Summer range is more extensive and goats disperse throughout the areas indicated. Rideout (1978) suggests that north and east facing slopes are utilized more in summer as these tend to hold snow longer and support lush snowbed vegetation. This theory has not been tested in Kluane.

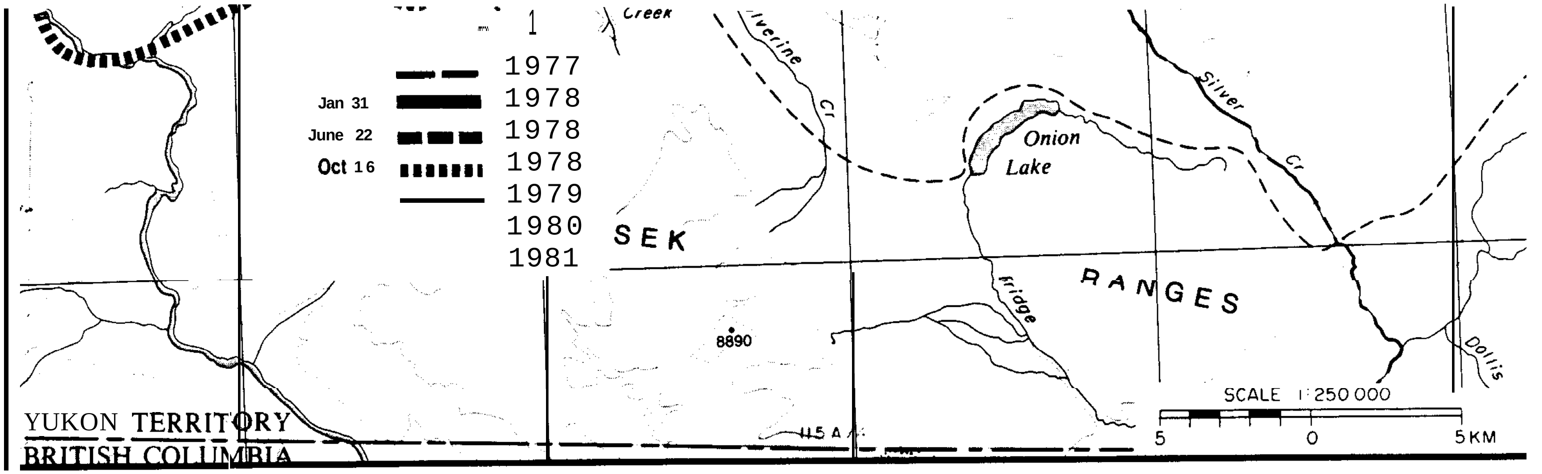
Goats are grazers perferring grasses, but they have a broad food tolerance and will feed on subalpine shrubs and low-growing conifers such as juniper (Hoefs 1980).

Only incidental observations of goats have been made north of the Kaskawulsh River and habitat utilization as indicated on Map 9.1 is much less well known. Hoefs (1973) reported the Grizzly Creek-Duke River area as the most northerly goat range in the Park. Murray and Murray (1970) report sightings from Kaskawulsh Nunatak in 1964, and 'recent' reports from the Steele Creek area. The Warden service has recorded incidental sightings as far north as White River and they conclude that goats are expanding their range to the north and west. If correct, this represents the northernmost limit in the Yukon.

The range indicated near Logan Glacier is used by goats from a large Alaskan herd which cross into the Park. Habitat use in areas west of the Alsek River is not well known and only small numbers of animals are seen on these ranges. Hoefs (1973) reports a large band of 40 goats on mountainous terrain east of Dusty River and a permanent population of 6 or 7 on Profile Mountain.

The rut occurs in early November and lasts till mid-December. Females give birth in isolated areas in late May or early June;


7625
7130
Shorty Cr
Alder
Goat Cr
Dalton Cr
Fraser Cr
Esker
Creek
BOUNDARY
SANCTUARY
GAME
Victoria
Virgin Cr
R A N G E S
Mush Lake
Mush Cr
5745
6220
Cottonwood Cr
Creek
Mush Cabin
Shaft
Sockeye Lake
Trout Lake
6620
Bates Cabin
Roll Cr
RIVER
Creek
Lava
Marble Cr
ALSEK
Goatherd Mtn.
Field
Clay Cr
FT LC
FS LB



KLUANE NATIONAL PARK RESERVE

Figure 9.15 Mountain goat surveys - Goatherd Mountain, 1977-1984.

Parameter	1977	1978		1978+	1979	1980	1981	1982	1983	1984[4]
Date1	01-07	31-01	22-06	16-10	11-09	25-08	28-06		12-06	18-06
Total	90	45	114	32	62	64	81		76	
Unknown										
Adult males			25							
Adult females		12	26	7	8	39				
Unknown	66	21	38	18	42		68		71	
YOY[2]	16	13	23	7	11	14	13		5	
YLY[3]	8		2		1					
Dead										

+ From biophysical survey data (Douglas 1980).

Source: Park Warden reports listed in Literature Cited.

1. Date writtep as day-month.
2. YOY = Young of the year.
3. YLY = Young-of last year.
4. Not available.

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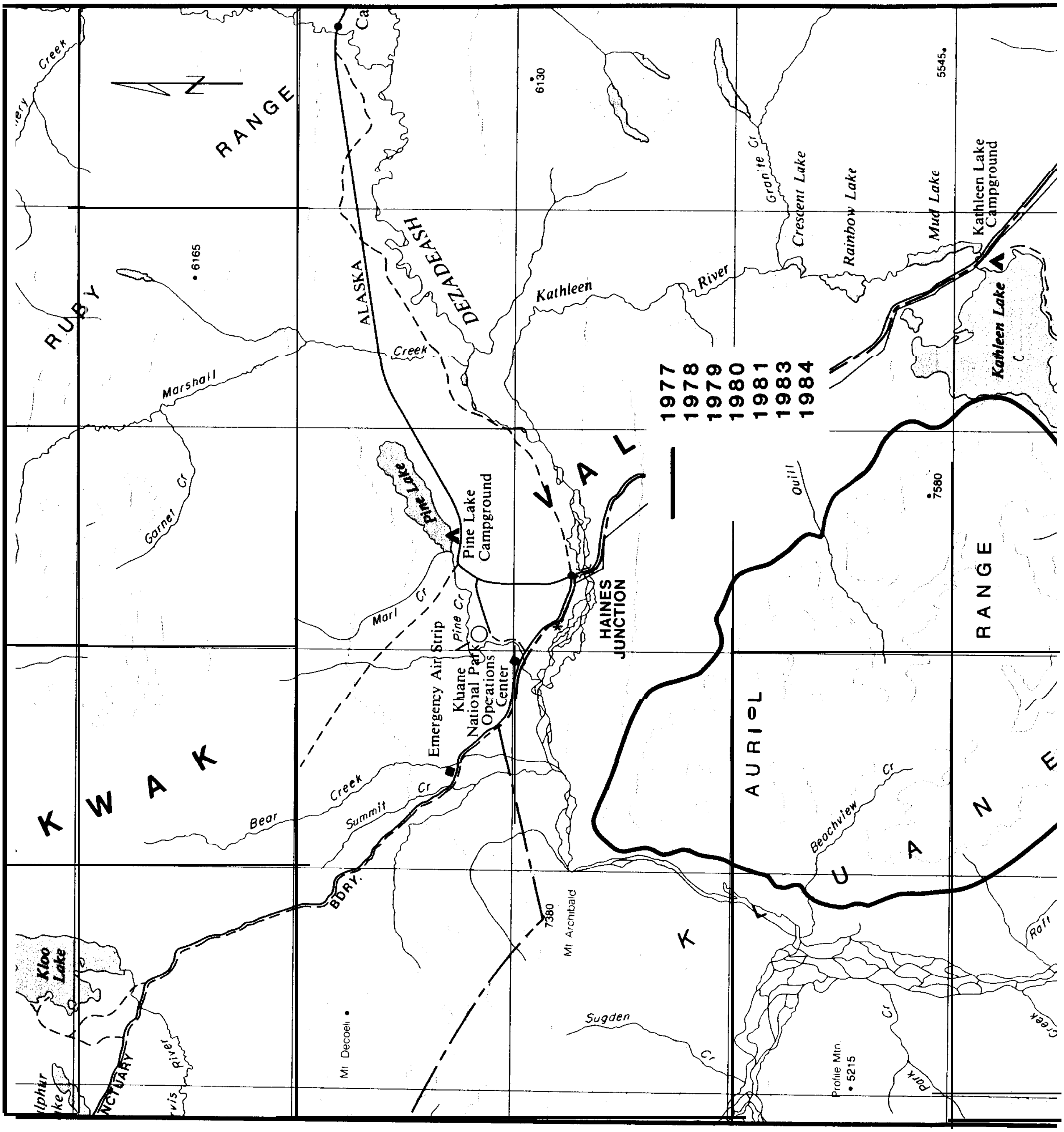
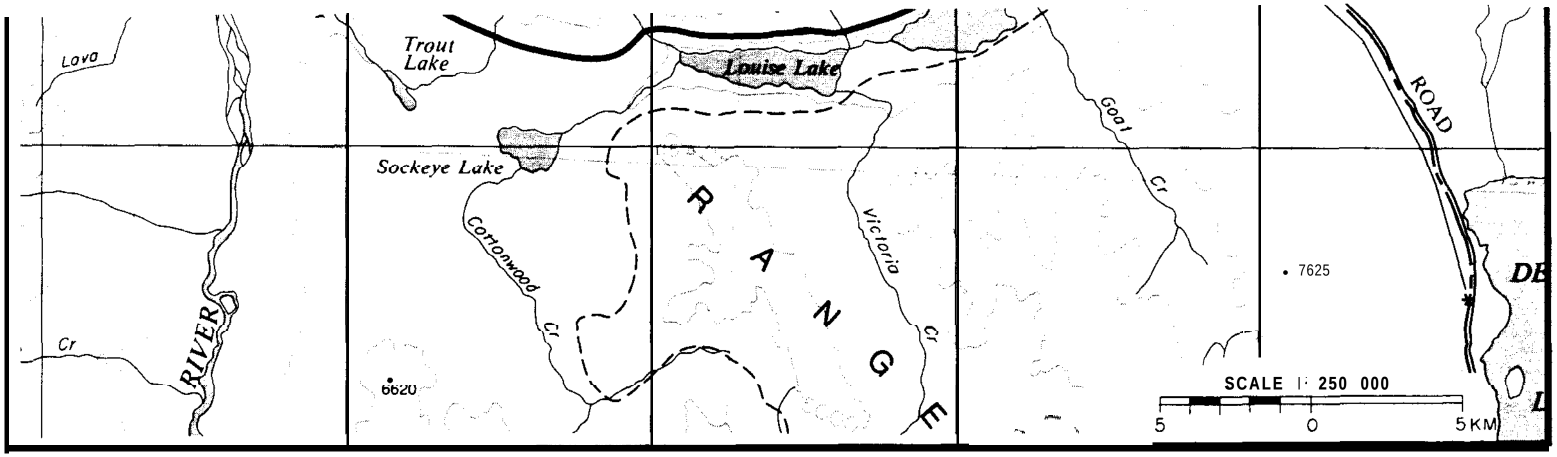

RUBY RANGE
KWAK
ALASKA
DEZADEASH
Kathleen River
Marshall Creek
Garnet Cr
Pine Lake
Pine Lake Campground
Marl Cr
Pine Cr
HAINES JUNCTION
Emergency Air Strip
Kluane National Park Operations Center
Bear Creek
Summit Cr
BDRY.
Kloo Lake
Mt Decoeli
7380
Mt Archibald
Sugden Cr
6130
6165
5545
7580
1977
1978
1979
1980
1981
1983
1984
Granite Cr
Crescent Lake
Rainbow Lake
Mud Lake
Kathleen Lake Campground
Kathleen Lake
Quill
AURIOL
RANGE
Beachview Cr
Profile Mtn
• 5215
Park



KLUANE NATIONAL PARK RESERVE

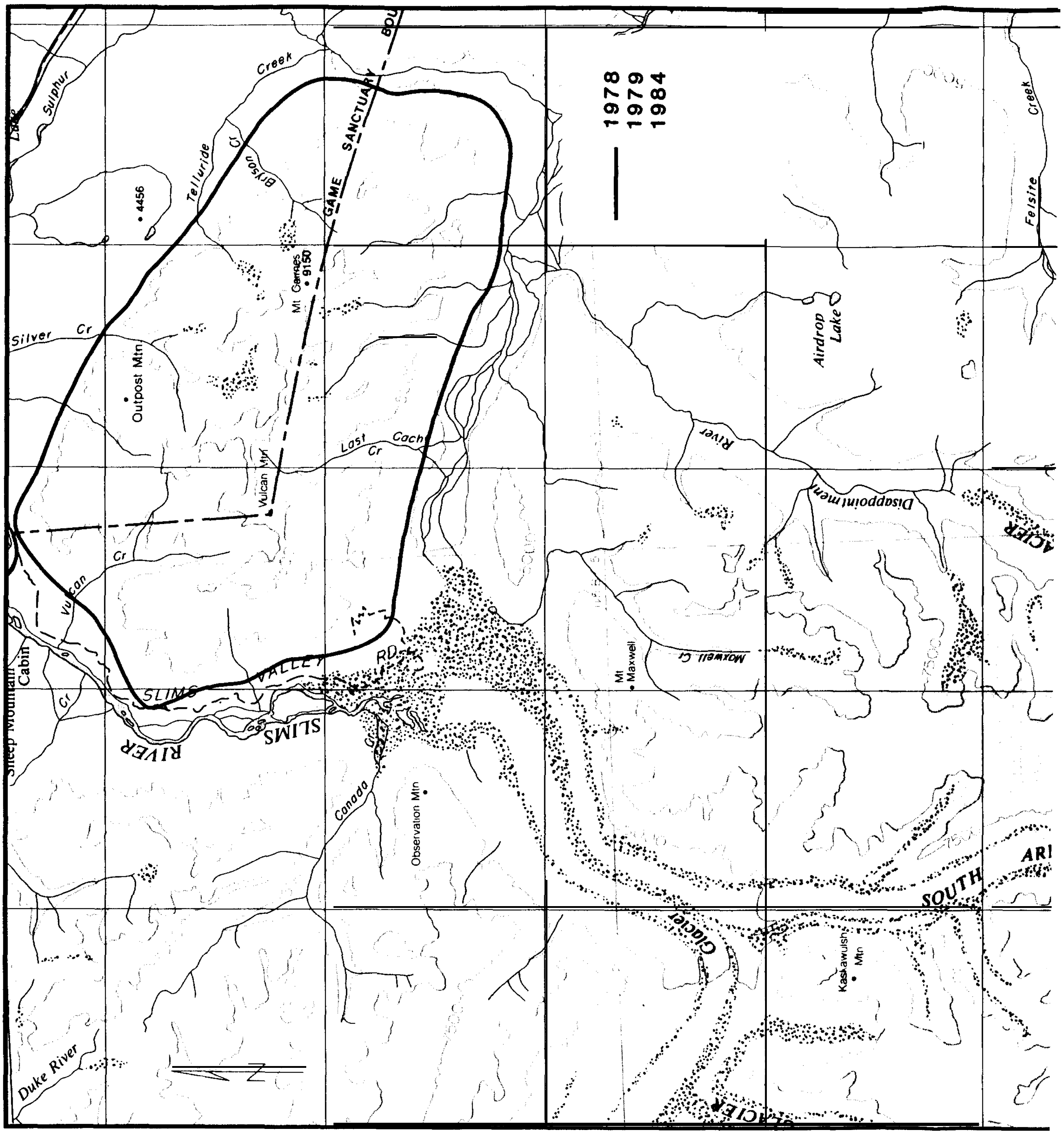
Figure 9.16 Mountain goat survey - Auriol area, 1977-l 984.

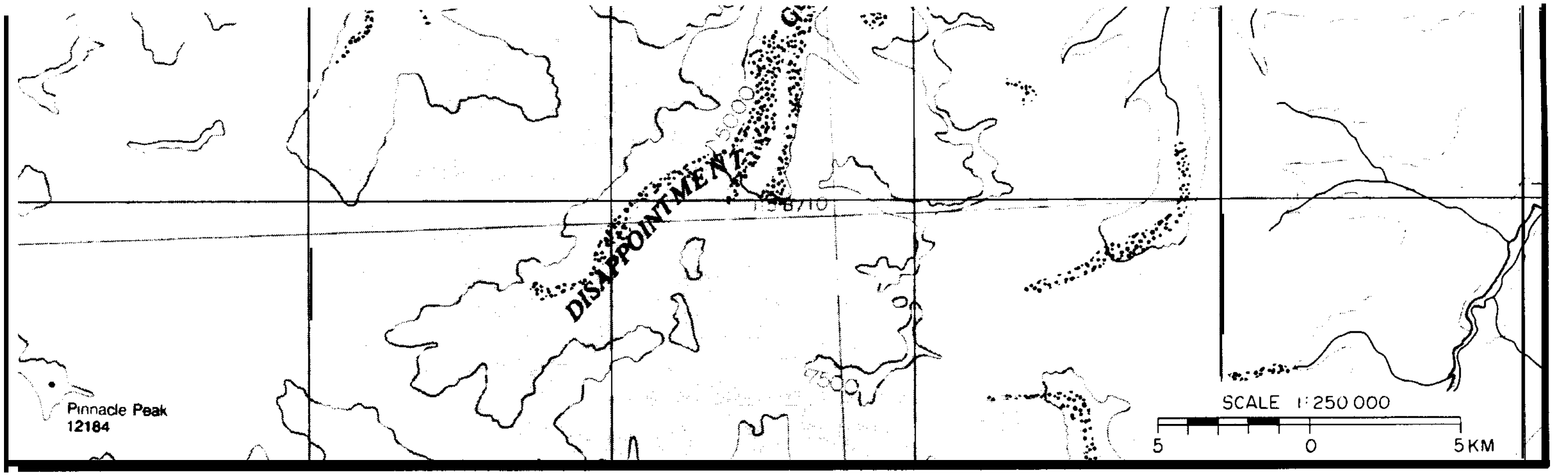
Parameter	1977+	.978		1979	1980	1981	1982	1983	1984[4]
Date'	.4-09	04-07	20-09	11-09	02-07	28-06	-	21-07	24-07
Total	5c	26	42	33	33	37	-	68	-
Unknown						33	-	57	-
Adult males	2	15	9	7			-		-
Adult females	37	3	24	21	24	-	-		-
Unknown	11	8	4	6	9	4	-	11	-
YOY[2]			5				-		-
YLY[3]	-					-	-	-	-
Dead	-					-	-	-	-

+ Data interpolated from biophysical survey (Douglas 1980).
1. Date is written in day-month.
2. YOY = Young of the year.
3. YLT = Young of last year.
4. Not available.

Source : Park Warden reports listed in Literature Cited.

SP PRO 85


1978
1979
1984
Sulphur
Creek
Telluride
Bryson Cr
GAME SANCTUARY BOU
4456
Mt Gerrges 9150
Silver Cr
Outpost Mtn
Last Cache Cr
Vulcan Mtn
Vulcan Cr
Sheep Mountain Cabin
SLIMS VALLEY RD
SLIMS RIVER
Canada Cr
Observation Mtn
Duke River
Airdrop Lake
River
Disappointment
Mt Maxwell
Maxwell Cr
Glacier
Kaskawulsh Mtn
SOUTH ARM
Creek
Felsite



KLUANE NATIONAL PARK RESERVE

Figure 9.17 Mountain goat surveys - Mount Vulcan, 1977-1984.

Parameter	1978 +	1979	1984
Date1	24-09	25-09	22-07
Total	20	10	20
Unknown			
Adult males			
Adult females	1	3	
Unknown	18	4	17
YOY[2]	1	4	3
YLY[3]			
Dead			

+ From biophysical survey data (Douglas 1980).
1. Date written as day-month.
2. YOY = Young of the year.
3. YLY - Young of last year.

Source: Park Warden reports listed in Literature Cited.

single births are usual but twins are not uncommon (Rideout 1978). No specific studies have been done on Mountain goats in Kluane.

Rideout (1978) lists Grizzly and Black bears and Coyotes as predators and states that Golden eagles have been observed carrying off newborn kids. In Kluane, Wolves and Wolverine are also known to prey on Mountain goats.

Mountain goats are assumed to be of southern postglacial origin. Their distribution in North America is limited to the Western cordillera from Kluane as far south as Idaho with an outlier population in the Mackenzie Mountains on the Yukon/NWT border, Youngman (1975) gives a sketchy report of *Oreamnos* remains dated at 4000 BP found in extreme northern Yukon but does not assume a wider distribution in historic time on this limited information.

Dall's sheep - *Ovis dalli dalli* Nelson

Dall's sheep are the most common large mammal in Kluane and the Park supports the greatest concentrations of the species in Yukon (Hoefs 1980). The total Park population is estimated at 4000 (Hoefs 1973). They are the most common mountain sheep in North America; their populations are at or near historic high levels, and they still occupy most of their traditional range (Hoefs 1984).

Dall's sheep occupy suitable alpine and subalpine mountain terrain throughout the Park with greatest numbers in the Slims and Donjek drainages. The species was the object of considerable trophy hunting in the early 1900's in southwest Yukon and, though recently reduced by effective enforcement, occasional poaching of trophy specimens from the Sanctuary and the Park continues. A large resident herd of Dall's sheep makes intensive use of Sheep Mountain above the Alaska Highway and for several summers Parks Canada has maintained an interpretation trailer and telescope at the site so that visitors can observe the animals closely and talk to Parks staff about them. Dall's sheep are one of the major viewing and photographic attractions of the Park.

O. d. dalli is one of two subspecies of North American thinhorn sheep. They are pure white and are found in Alaska, Yukon (except in south central area), and the Northwest Territories. The other subspecies *O. d. stonei* or Stone's sheep, are dark-coloured but otherwise very similar and are found in northern British Columbia and the area of south central Yukon excluded above (Nichols 1973). The ancestor of today's mountain sheep was originally of Beringian origin probably arriving in North America in Pleistocene time (Youngman 1975). Youngman (1975) postulates that the population subsequently split and subspeciated with *O. d. dalli* in the Beringian refugium, *O. d stonei* in isolated Rocky Mountain refugia, and *Ovis canadensis* (the Rocky Mountain Bighorn) in southern refugia.

Little is known of the importance of Dall's sheep to native people prior to the late 19th century. Trophy hunting was practised throughout southwest Yukon in the early 20th century. In the Sheep Mountain area, Hoefs (1981a) states that miners from Silver City hunted the local population heavily in the early 1900's and that commercial meat hunters travelled to the area fran as far away as Dawson. Their effect on population numbers is not known but trophy hunters had ceased to use the Slims area by 1913 (Martindale 1913; Auer 1916). Decline of mining activity allowed the population to recover and by the late 1930's there were 150-200 animals in the area (Hoefs 1981a). The population was hunted heavily again during the building of the Alaska Highway (Hoefs and Benjey 1971) but this activity ceased with the declaration of the Park Reserve and Sanctuary in 1942. The population recovered rapidly in the 1950's possibly as a result of wolf control programs combined with the ban on hunting. In 1951, the total winter population was counted at 43 but by the summer of 1955, estimates had risen to 200 (Scace and Assoc. 1975). Two hundred animals probably represent the carrying capacity of the small Sheep Mountain range and the population has remained relatively stable at the number (Burles & Hoefs 1984).

Our detailed information on Dall's sheep biology, population dynamics, and habitat utilization in Kluane comes largely from the work of Manfred Hoefs. He has studied the sheep Mountain population since 1969 and his work represents the only long term study of ungulates in the Park. The general patterns discussed below apply to sheep throughout Rluane and specific dates. elevations etc. are derived from Hoefs information on the Sheep Mountain population.

Dall's sheep are smaller than Rocky Mountain Bighorns. Males weigh 82-113 kg, stand about 90 cm at the shoulder and ewes weigh 45-59 kg and are about 76 cm tall at the shoulder (Hoefs 1980). Males develop magnificent flaring fully curled horns by about 8 or 9 years of age. Maximum life span is 12 or 13 years, a relatively short life expectancy. Ewes have their first lamb at about 3 years of age; rams mature at 1½ years but probably do not breed till they are 5 or 6 (Hoefs 1984). The population is subject to a variety of nandibular diseases commonly called 'lumpy jaw'.

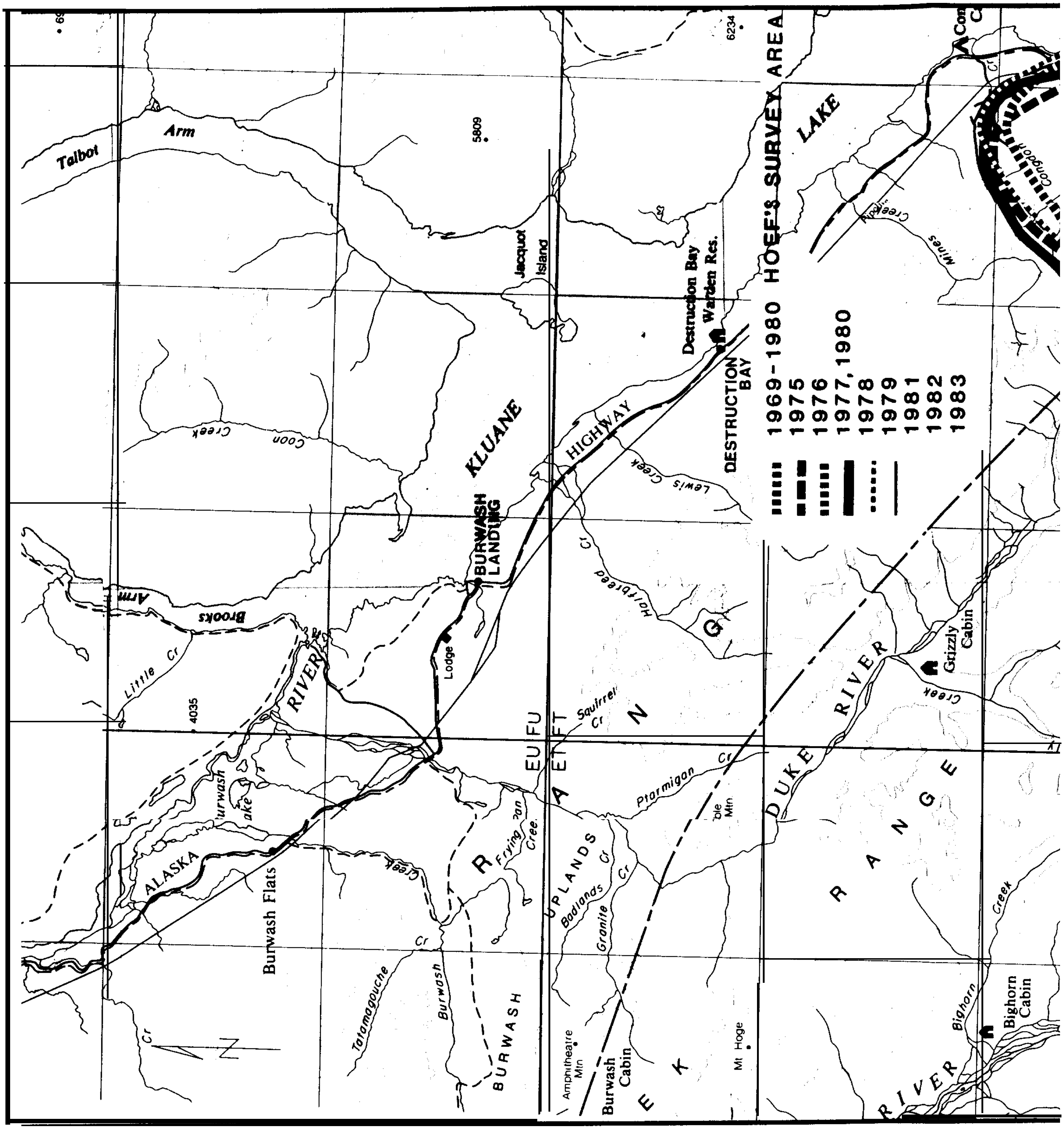
Winter and summer ranges throughout the Park are shown on Map 9.1. Winter range occurs as small pockets within the larger summer range areas and is comprised of steep low elevation south-facing windblown slopes where snow cover is either absent or very limited and access to adjacent escape terrain is available. Sheep do not feed where snow depths exceed 30 cm and Hoefs (1981b) reports that 85% of feeding takes place in areas with less than 10 cm of snow. Apparently suitable winter forage areas are not used if escape terrain is not close at hand (Hoefs 1981b). Winter range is thus critical to Dall's sheep and factors which inhibit successful use of the habitat can result in heavy winter losses. Burles & Hoefs (1984) document a 25% decline in the Sheep Mountain herd in 1981-82 and attribute this in part to a calm severe winter with above average snowfall. Sheep disperse more widely throughout summer range making use of steep open alpine slopes.

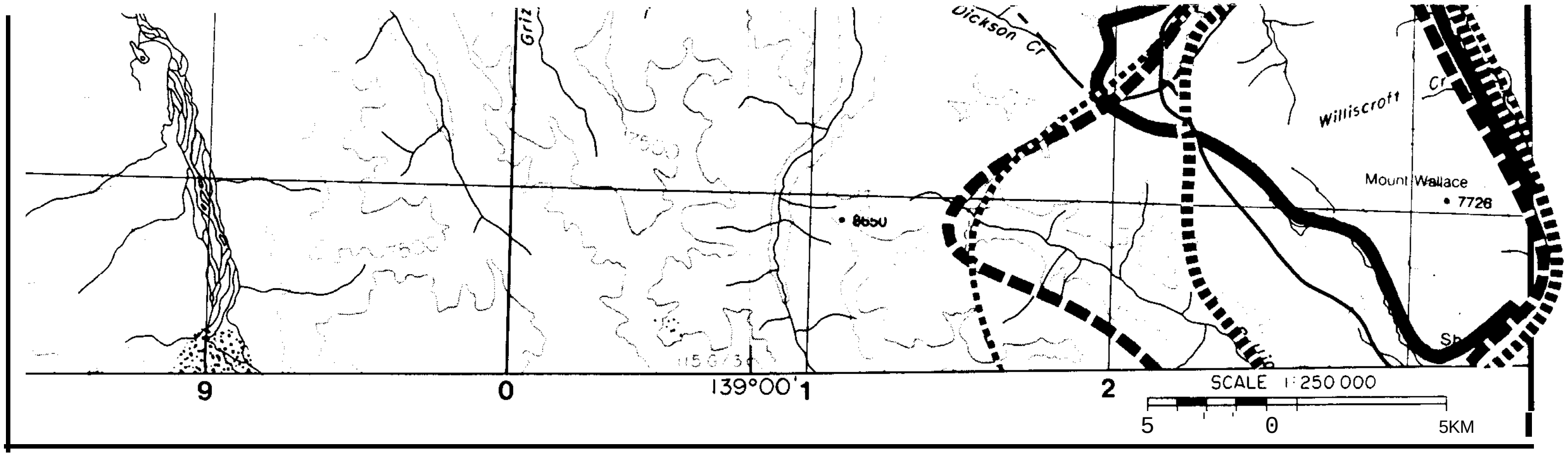
The Warden Service conducts aerial surveys of sheep range in late spring about 2 weeks after lambing. Figures 9.18 - 9.22 inclusive show the areas surveyed and the legends contain the actual survey data since 1976. Hoefs data since 1969 is included separately as Table 9.7.

Within these range areas the sheep undergo an annual pattern of migration based largely on altitudinal movements. Figure 9.23 illustrates this pattern through the year. Sheep remain on winter range from early December to early June and, although the sexes are in mixed groups at this time, **rams** are usually found at lower elevations than ewes and nursery bands, 980 m and 1100 m respectively at Sheep Mountain (Hoefs 1981a). Movements on winter range vary with snow distribution, temperature, and windchill. Hoefs (1979) tested the hypothesis that sheep would move upward to take advantage of temperature inversions but documented only a tendency to move downslope in colder weather. Very high densities are common at this time and averaged 17.7 sheep per km^2 for several months on Sheep Mountain, the highest known for a northern sheep population (Hoefs 1981a).

As spring approaches, pregnant ewes isolate themselves on alpine cliffs and give birth in the third and fourth weeks of May and early June. After a few days they rejoin the main groups and the sheep begin a gradual upward migration toward summer range and a slow separation of the sexes into nursery bands comprised of ewes, spring lambs and yearlings and ram bands. Access to mineral licks is particularly important for nursing ewes at this time. The upslope movement follows the availability of new vegetation and the retreating snowline. Nursery bands reach summer range by the end of June. The rams take longer and tend to go to higher elevations. Hoefs (1979, 1981a) and Hoefs & Cowan (1979) have tied the phenology of plant development on Sheep Mountain to these early summer vertical movements (see Figure 9.23). The highest elevation and the greatest distances from winter range are reached in July and August. Figure 9.24 shows the distribution of summer and winter range on Sheep Mountain. By mid-September the nursery bands have moved back close to winter range but remain at high elevations. Hoefs (1981a) indicates that they eat shrub willow in the high subalpine at this time as most ground vegetation has dried up. The rams come down to the subalpine in late October and the rut takes place in November, followed by downslope movement to winter range.

Based on data from 1969 to 1980, Hoefs (1981a) calculated the average total population on the Sheep Mountain range to be 223. This figure varied by ± 17%, with numbers of yearlings and lambs varying by 70-75%, rams by 16%, and ewes by only 10%. Hoefs


HOEF'S SURVEY AREA
1969-1980
1975
1976
1977,1980
1978
1979
1981
1982
1983
KLUANE LAKE
Talbot Arm
Brooks Arm
Jacquot Island
Destruction Bay Warden Res.
DESTRUCTION BAY
HIGHWAY
BURWASH LANDING
Lodge
ALASKA
RIVER
Burwash Flats
Burwash Lake
Coon Creek
Little Cr
Lewis Creek
Halfbreed Cr
Squirrel Cr
Ptarmigan Cr
Frying Pan Creek
Badlands Cr
Granite Cr
Tatamagouche Cr
Burwash Creek
BURWASH UPLANDS
Amphitheatre Mtn
Burwash Cabin
Mt Hoge
DUKE RIVER
Grizzly Cabin
Bighorn Creek
Bighorn Cabin
Mines Creek
5809
6234
4035



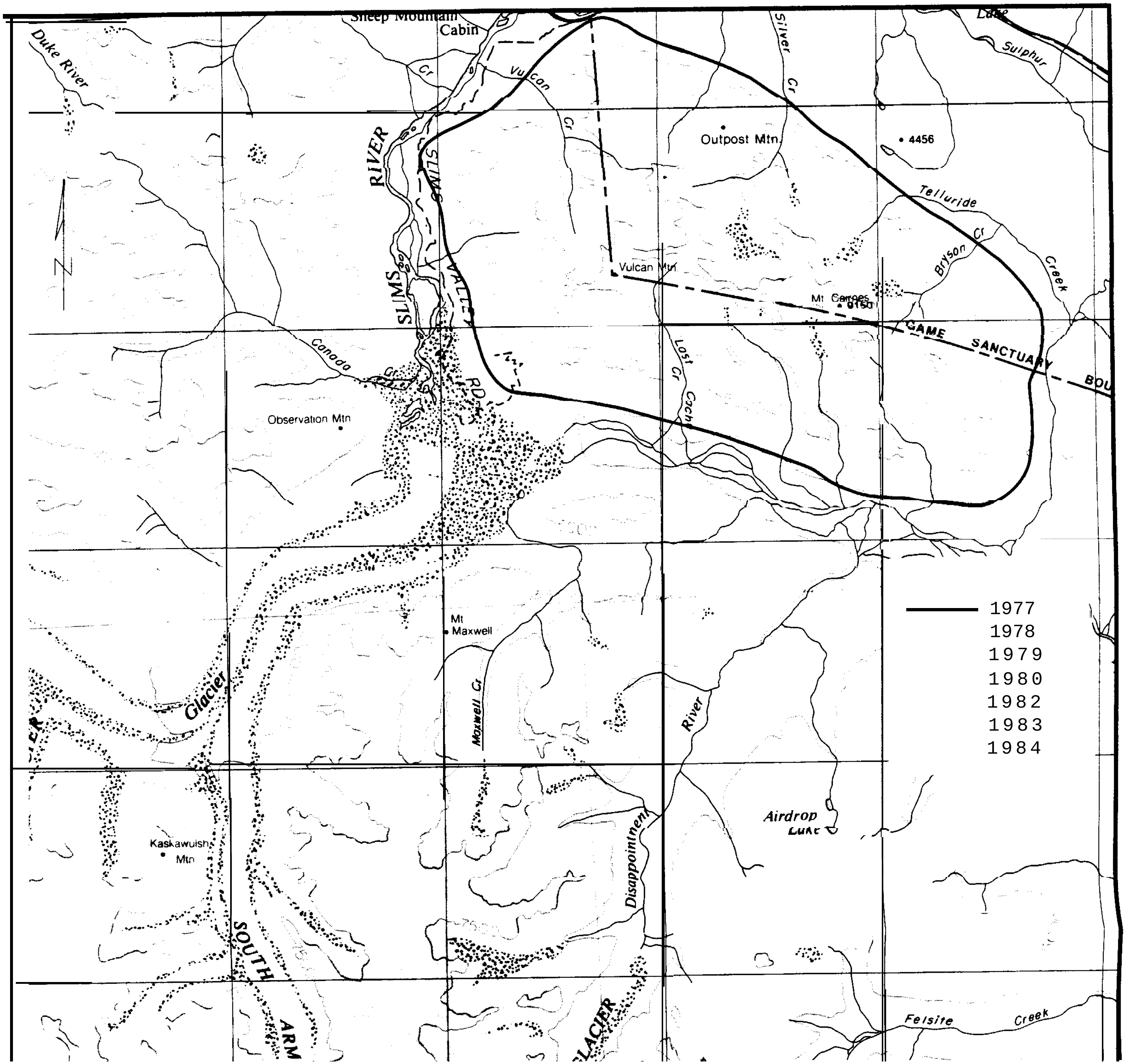
KLUANE NATIONAL PARK RESERVE

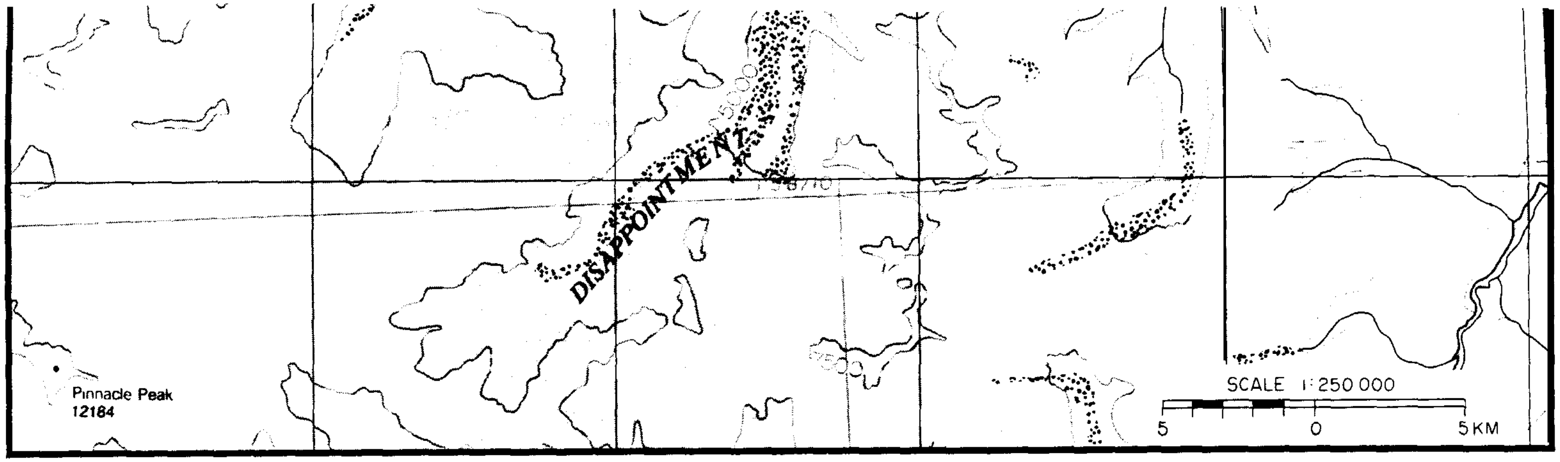
Figure 9.18 Dali's sheep surveys - Sheep Mountain, 1974-l 984.

Parameter	1974	1975			1976	1977		1978+	1978	1979	1980	1981	1982	1983	1984
Date1	24-07	19&20-03	05-06	24-06	02-07	23-06	09-07	21-05	10-07	15-06	11-06	08-06	20-06	06-06	06-06
Total	337	103	212	248	273	306	235	192	283	362	338	375	344	283	346
Unknown		-		28				192		17		24		6	
Adult males	123	53	75	97	146	165	82		141	100	154	100	112	89	92
Adult females	187*	45*	128*	162*	114	101	129*		91	141	127	178	216	157	179
Unknown		-													
YOY2	27	5	9	11	13	28	24		38	77	41	49	11	22	69
YLY3		-				12			13	27	16	24	5	9	6
Dead		-													

Source: Park garden reports listed in Literature Cited.

* Includes male and female nursery sheep
+ From biophysical survey data (Douglas 1980).
1. Date is written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.


Sheep Mountain
Cabin
Duke River
Vulcan Cr
Cr
Silver Cr
Lake
Sulphur
Outpost Mtn.
4456
RIVER
SLIMS
SLIMS VALLEY RD.
Telluride
Bryson Cr
Creek
Vulcan Mtn
Mt Cerges
GAME SANCTUARY BOU
Canada Cr
Lost Cr
Cach
Observation Mtn
Mt Maxwell
Maxwell Cr
Glacier
River
Airdrop Lake
Kaskawulsh Mtn
Disappointment
SOUTH ARM
GLACIER
Felsite Creek
1977
1978
1979
1980
1982
1983
1984



KLUANE NATIONAL PARK RESERVE

Figure 9.19 Dall's sheep surveys - Mount Vulcan, 1977-1984.

Parameter	L977	1978	L979	1980	1981	1982	1983	1984
Date'	22-06		'5-09	07-07	-	06-07	01-09	22-07
Total	410	357	432	425	-	294	347	418
Unknown					-		30	
Adult males	125	100	106	124	-	122	94	114
Adult females	179	190#	246#	187	-		186#	215#
Unknown		11			-	122		
YOY[2]	83	54	80	94	-	24	37	85
YLY[3]	23	2		20	-	26		4
Dead					-			

More correct .y called 'nursery sheep'; this category includes ewes, some 2-year old rams, and for the years indicated, yearlings.

1. Date written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year. Source: park Warden reports listed in Literature Cited.

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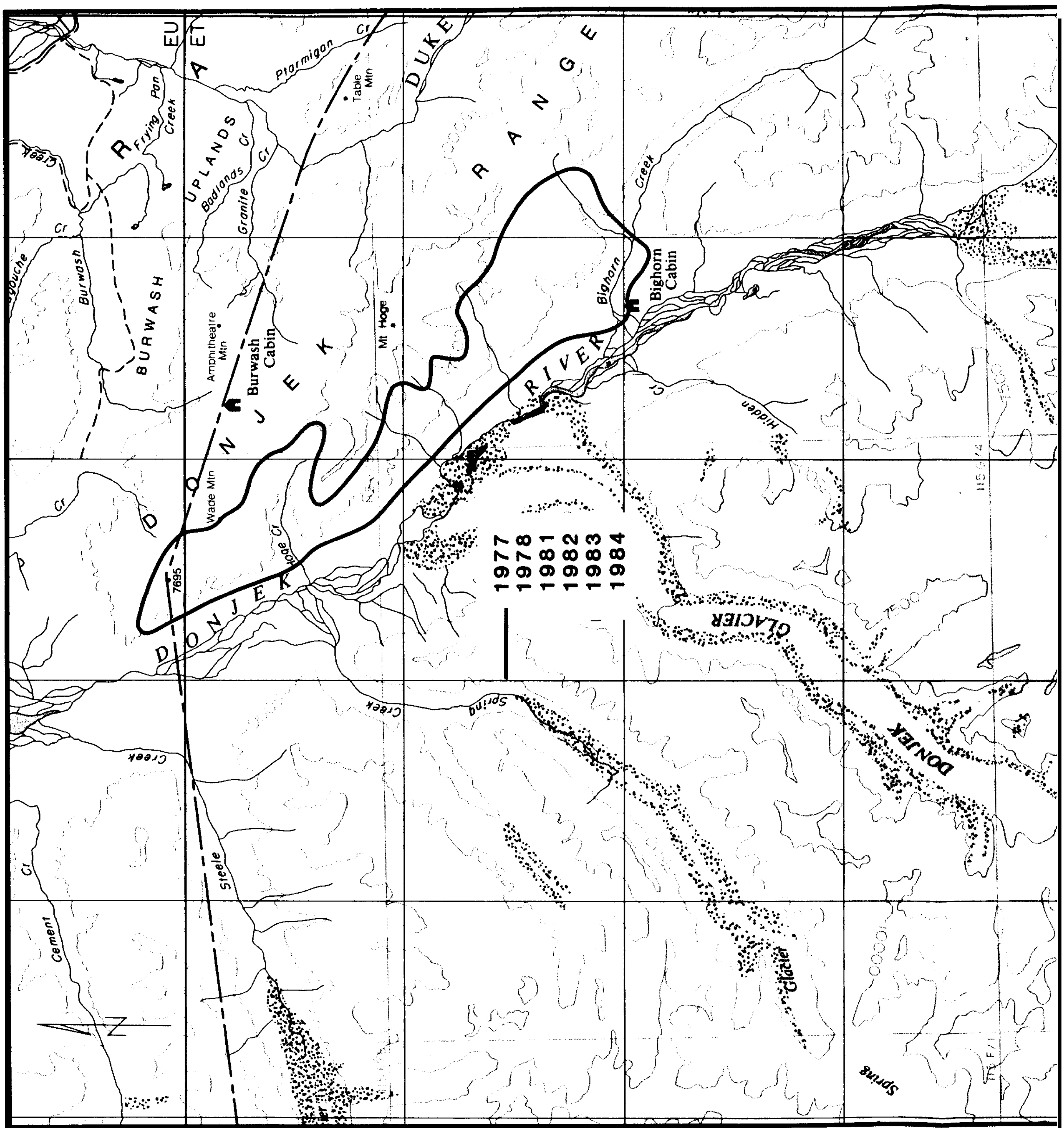
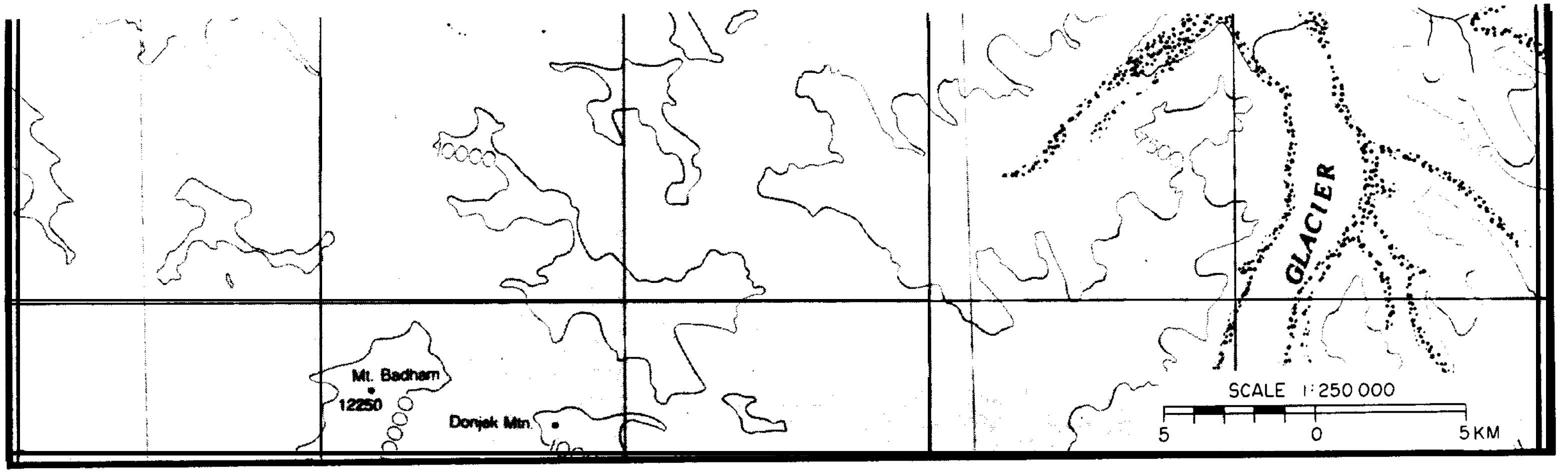

DUKE RANGE
BURWASH UPLANDS
DONJEK RIVER
DONJEK GLACIER
Burwash Cabin
Bighorn Cabin
Wade Mtn
Amphitheatre Mtn
Mt Hoge
Table Mtn
7695
1977
1978
1981
1982
1983
1984
Ptarmigan Cr
Frying Pan Creek
Badlands Cr
Granite Cr
Burwash Cr
Hoge Cr
Bighorn Creek
Hidden Cr
Spring Creek
Steele
Cement Cr
Glacier
Spring



KLUANE NATIONAL PARK RESERVE

Figure 9.20 Dall's **sheep surveys - Donjek** area, 1977-1984.

Parameter	1977	1978+	1978	1979	1980	1981	1982	1983	1984
Date[1]	08-07	14-03	12-07	-		05-07	06-07	27-07	24-09
Total	513	315	461	-	-	730	437	678	475
Unknown		315	-	-	-	7	3	-	-
Adult males	154	-	153	-	-	203	193	243	191
Adult females*	234	-	192	-	-	272	158	368	231
Unknown									
YOY[2]	89	-	72	-	-	182	43	67	46
YLY[3]	36	-	44	-	-	66	40	-	7
Dead									

+ Extracted from biophysical survey (Douglas 1980).

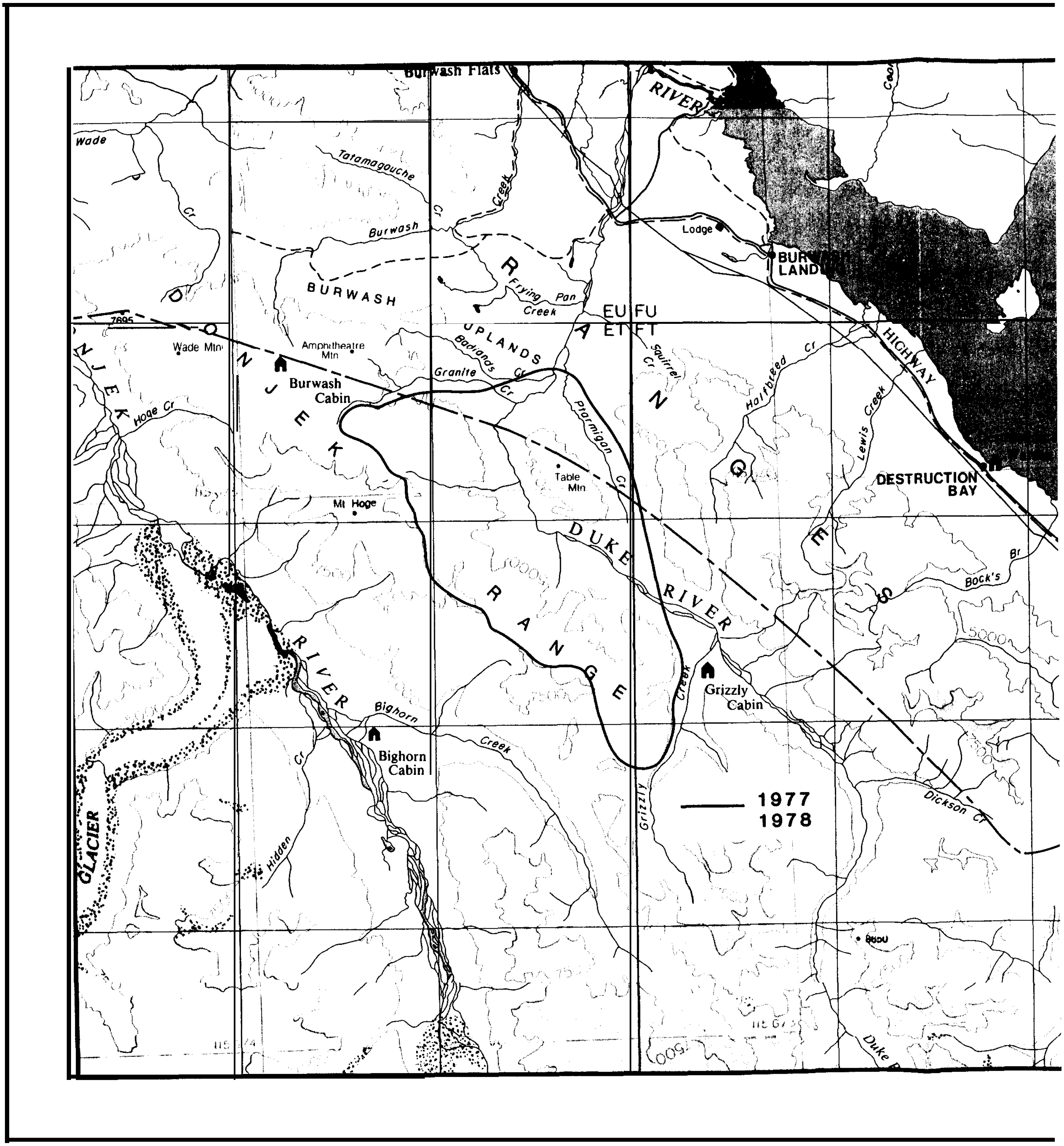
Source : Park Warden reports listed in Literature Cited.

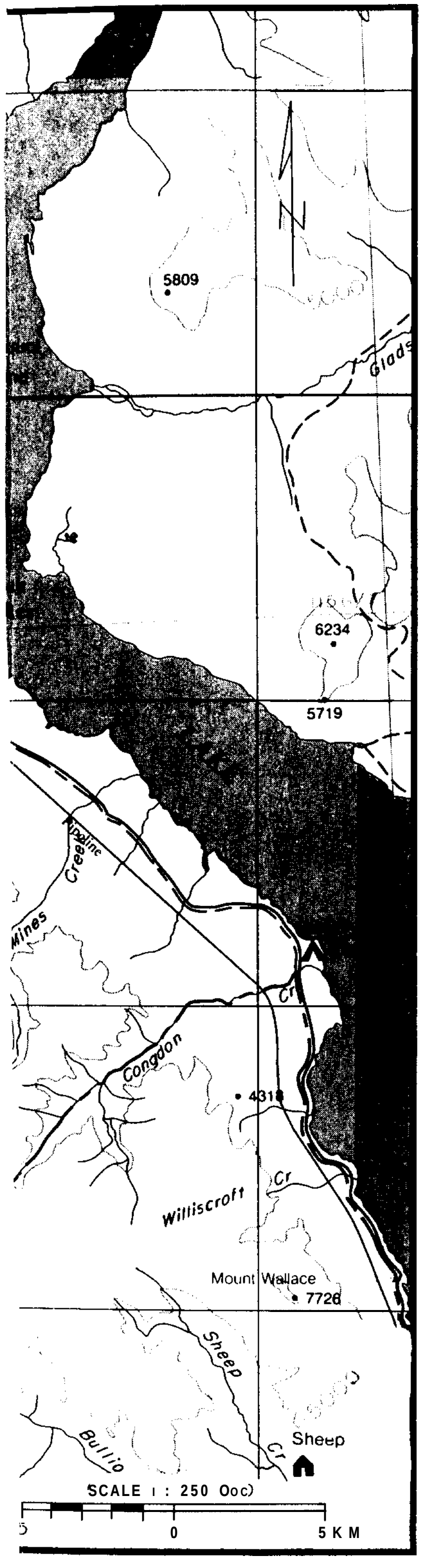
1. Date is written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.

* Note that the difficulty of distinguishing 2-year old rams from ewes has resulted in consistent overestimation of ewes and underestimation of rams throughout the survev.

Parks Canada Parcs Canada

SP PRO 85


Burwash Flats
RIVER
Wade
Tatamagouche
Cr
Creek
Burwash
Lodge
BURWASH
UPLANDS
Frying Pan Creek
Wade Mtn
Amphitheatre Mtn
Burwash Cabin
Badlands Cr
Granite Cr
Squirrel Cr
Halfbreed Cr
HIGHWAY
Hoge Cr
Ptarmigan Cr
Lewis Creek
Table Mtn
DESTRUCTION BAY
Mt Hoge
DUKE RIVER
RANGE
Bock's Br
RIVER
Bighorn Creek
Bighorn Cabin
Grizzly Creek
Grizzly Cabin
1977
1978
Dickson Cr
Hidden
GLACIER
Duke



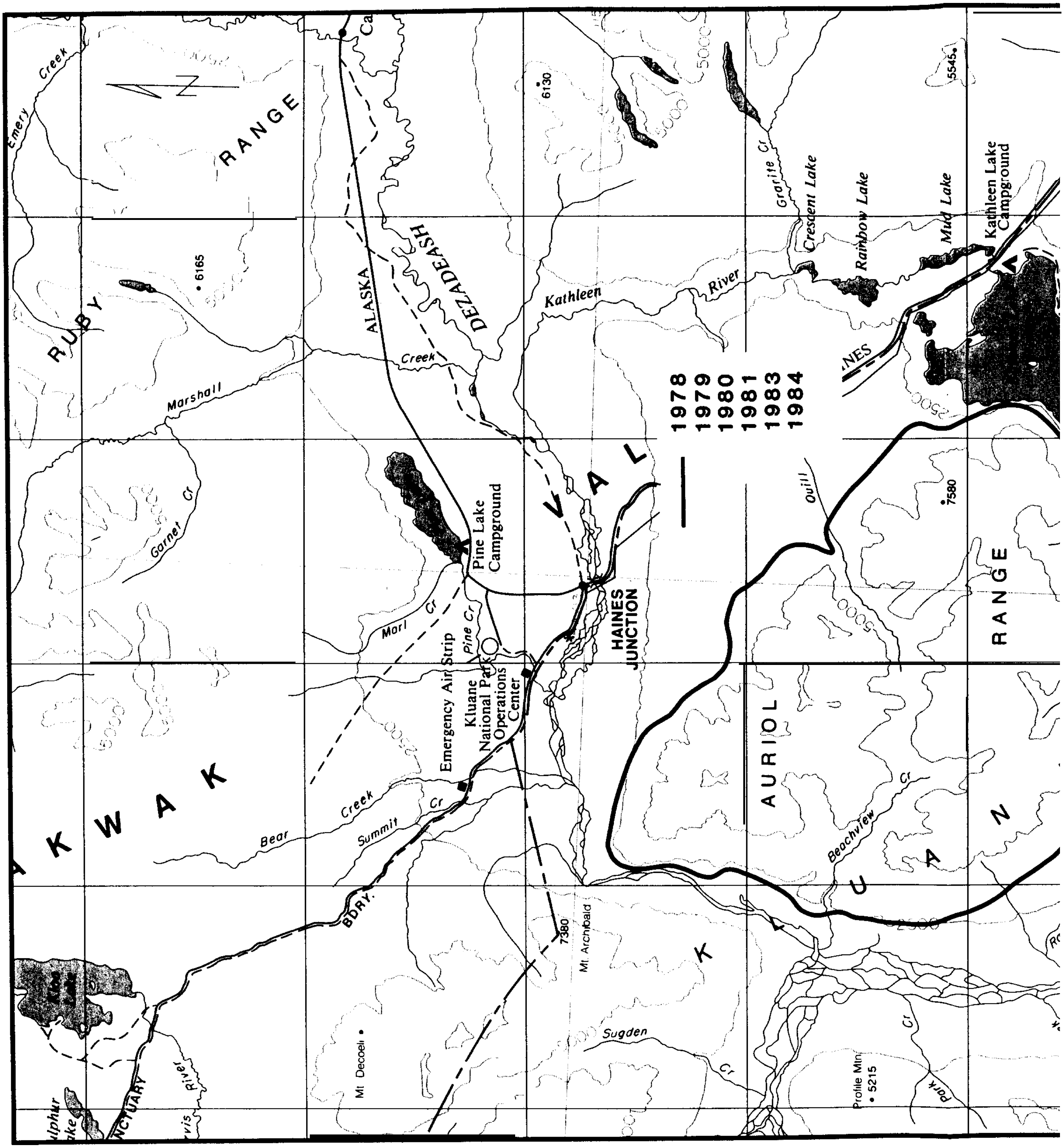
KLUANE NATIONAL PARK RESERVE

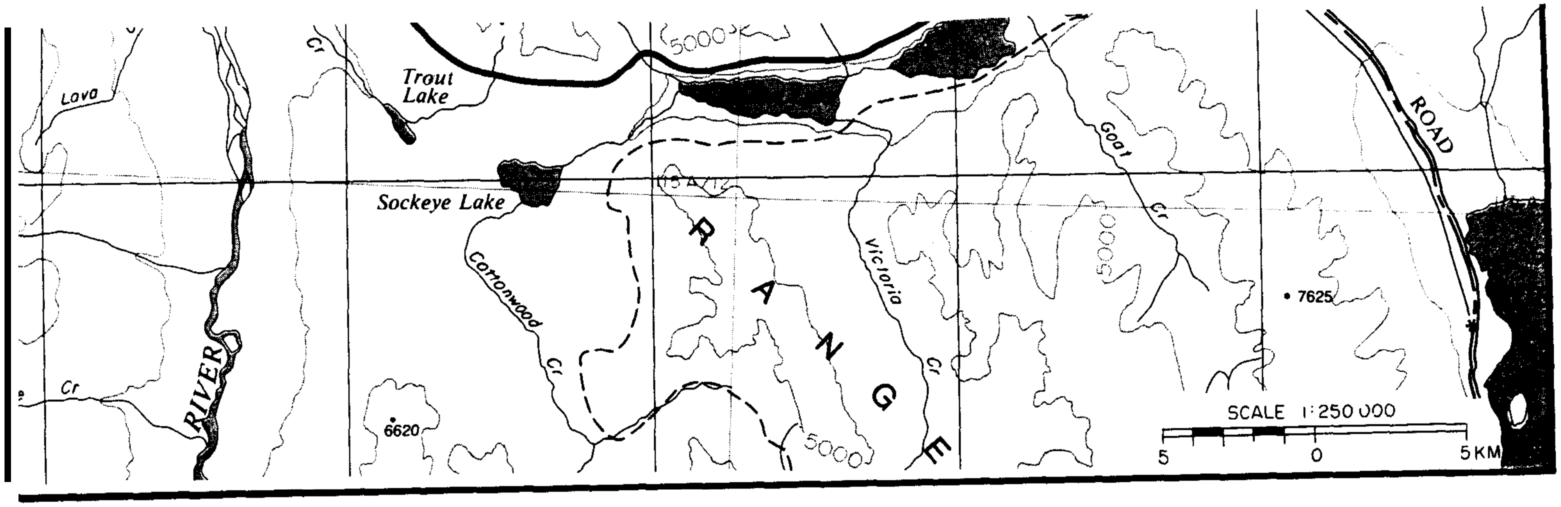
Figure 9.2 1 Dall's sheep surveys - Duke area, 1977-1978

Parameter	.977	1978+	1978
Date[1]	)8-07	18-03	12-07
Total	275	396	267
Unknown		396	
Adult males	168		132
Adult females	85		94
Unknown			
YOY[2]	10		26
YLY[3]	12		15
Dead			

+ From biophysical survey (Douglas 1980).
1. Date written as day-month.
2. YOY = Young of the year.
3. YLY = Young of last year.

Source: Park Warden reports listed in Literature Cited.


RUBY RANGE
KWAK
ALASKA
DEZADEASH
Emery Creek
Marshall
Garnet Cr
Creek
Kathleen
River
Granite Cr
Crescent Lake
Rainbow Lake
Mud Lake
Kathleen Lake Campground
6130
6165
5545
7580
1978
1979
1980
1981
1983
1984
Quill
Pine Lake Campground
HAINES JUNCTION
Marl Cr
Pine Cr
Emergency Air Strip
Kluane National Park Operations Center
Bear Creek
Summit Cr
BDRY.
AURIOL
RANGE
Beachview Cr
7380
Mt. Archibald
Mt Decoeli
Sugden Cr
Profile Mtn
5215
River



KLUANE NATIONAL PARK RESERVE

Figure 9.22 Dall's sheep surveys - Auriol area, 1977-1984.

Parameter	1978	1979	1980	1981	1982	1983	1984
Date1	04-07	11-09	10-07	14-07		21-07	24-07
Total	357	298	394	390		314	334
Unknown							
Adult males	190	101	152	88		92	109
Nursery sheep 2	113	137	179	200		208	193
YOY3	54	60	63	72		14	32

Source: Park Warden reports listed in Literature Cited.

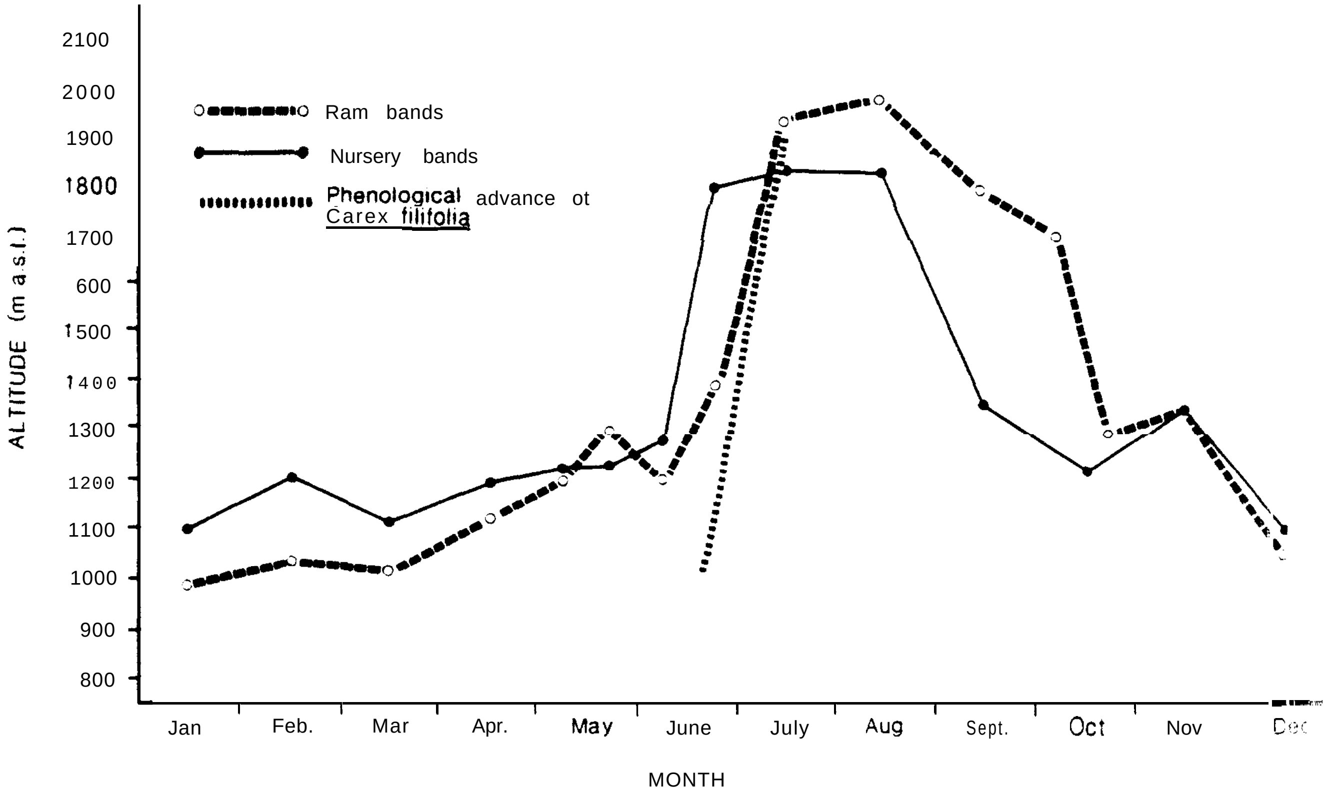
1. Date written as day-month.
2. Nursery sheep includes ewes, some 2-year olf rams, and yearlings.
3. YOY = Young of the year.

Table 9.7 Composition of the Sheep Mountain Dall's sheep population, 1969-1980.

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	x
Male ≥3y.	?	68	74	67	61	75	77	79	59	66	62	64	68.4
Male 2y.	?	13	11	15	16	16	13	7	5	4	4	16	10.9
Male total	65*	81	85	82	77	91	90	86	64	70	66	80	78.1
Female ≥3 y.	?	77	78	71	68	79	87	94	85	86	96	71	81.1
Female 2 y.	?	13	11	15	16	17	13	6	1	10	4	16	11.1
Female total	69*	90	89	86	84	96	100	100	86	96	100	87	90.3
Yearling	30	24	32	36	36	28	14	6	15	8	35	24	24.0
Lambs	33	37	50	40	29	17	9	15	19	43	43	29	30.0
SUM	197	232	256	244	226	232	213	207	184	217	244	220	222.7

Source: Hoefs 1981b.

* count incomplete.



Source: Hoefs 198 1).

Figure 9.23 Annual vertical migration pattern of Dall's sheep on Sheep Mountain, Kluane National Park.

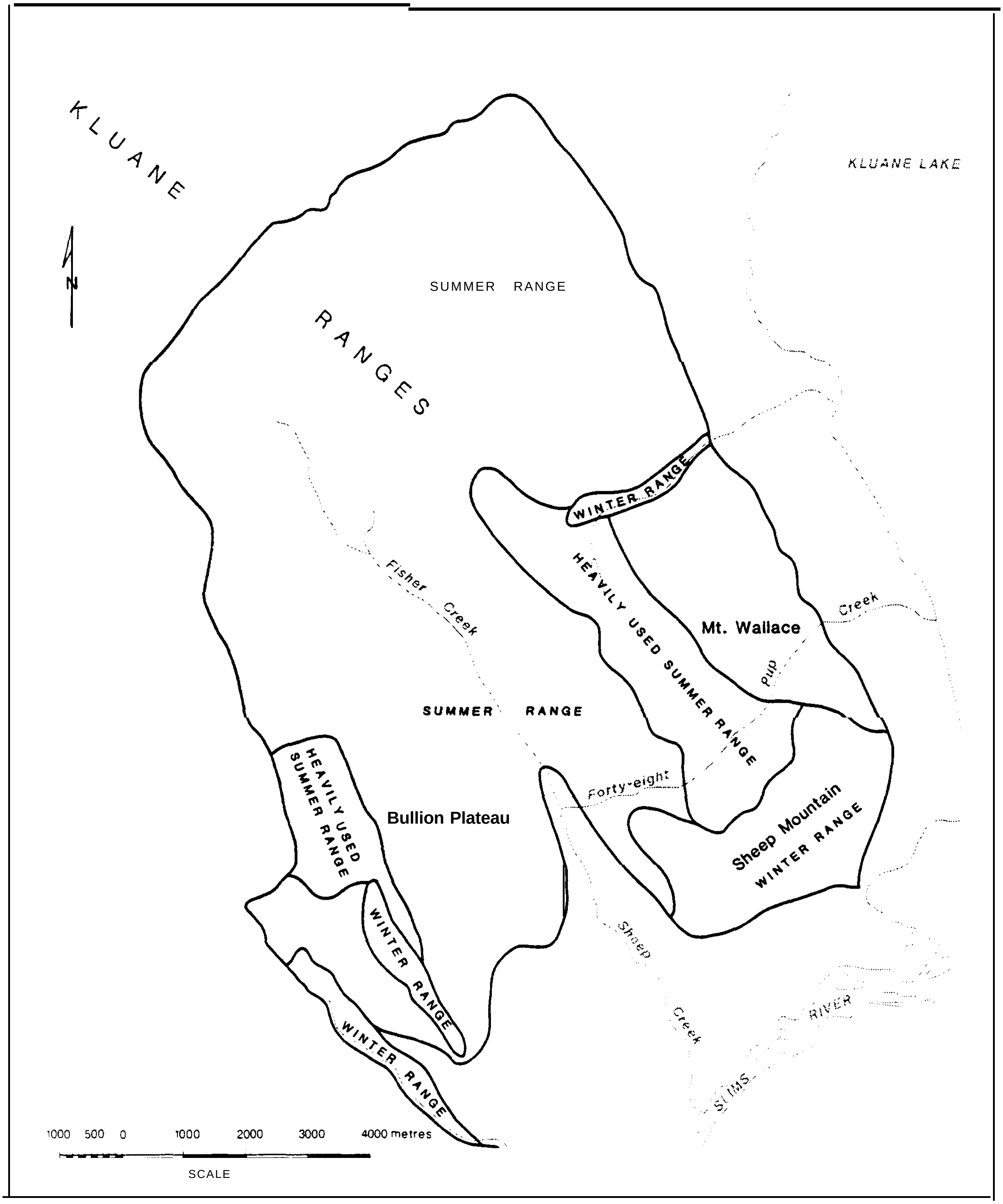


Figure 9.24 Summer and winter Dall's sheep range - Sheep Mountain, Kluane National Park.

(1981a) believes this figure of 223 to represent a stable population at or near the range carrying capacity.

The Warden Service data indicates greater total numbers and greater variability. This is attributed to in and out migration of adult sheep probably from the Congdon Creek and Bullion Creek areas which support separate populations on winter range and during lambing but which mix with the Sheep Mountain population on summer range (Hoefs 1981a). This highlights the need for careful assessment of survey objectives and boundaries. Similarly, Burles (1983*) suggests that up to 40% of the population increase reported on the Donjek Range in 1983 (see Figure 9.19) was due to immigration to the survey area. He recommends changes in the survey boundaries to include the entire available range of a group and at the same time obtain an area bounded by topographic barriers.

The winter of 1981-82 was unusually severe and sheep populations throughout the Park and Yukon declined substantially according to Burles and Hoefs (19841, who document a 25.3% decline at Sheep Mountain and at least 30% declines on the Donjek and Mount Vulcan ranges. Only the data for Sheep Mountain are verified by ground observations so some of the decline on tine Donjek and Vulcan ranges may be due to out migration or other unknown causes. At Sheep Mountain, a higher than average population of 241 in June 1981 may have exceeded winter forage production and, combined with the severe weather conditions, contributed to the decline. Spring was also delayed in 1982 and Burles and Hoefs (1984) found that most sheep died in May in emaciated condition. Predation by Coyotes, wolves, and Golden eagles was heavy in 1981-82 as well, due in part to the poor condition of the animals and also to the scarcity of alternate prey as Snowshoe hare, Ptarmigan, and Arctic ground squirrels were all at low points in their populations cycles (Burles & Hoefs 1984). The oldest and youngest age groups were most severely depleted. The 9-13 year age class suffered a 63% decline and the 1982 lamb crop was at a minimum 60% lower than average (Burles & Hoefs 1984). However, the 1983 and 1984 surveys indicate that populations throughout the Park have recovered, due to good lamb crops and high survival rates in the last two years.

Hoefs (1975) and Hoefs et al (1975) have studied the forage habits of Dall' sheep in detail and, while they eat in total 110 different species of plants through the year, only four - Carex filifolia, Artemisia frigida, Calamaqrostis purpurascens, and Salix qlauca - make up over half their diet. Winter forage production studies on sheep Mountain show a link between good forage years and the following years lamb crop (Hoefs 1981a) and Hoefs believes that winter forage is the factor which limits maximum population size on the Sheep Mountain range.

Sheep in the Sheep Mountain area are subject to predation by coyotes, Golden eagles, Wolves, and infrequently by Wolverine, Lynx, and Grizzly bears (Hoefs & Cowan 1979). Mortality of newborn lambs, other than by accidental causes, is attributed primarily to Golden eagles as at this time the ewes and lambs are isolated on terrain too difficult for terrestrial predators to attempt. Nette et. al. (1984) record several incidents of attack and wounding of sheep by Golden eagles. They document one occurrence of predation in the Ruby Range, and another observation on Sheep Mountain of a Golden eagle carrying off a newborn lamb after first causing the ewe to back off slightly from the protective stance she had assumed on becoming aware of the eagle. The importance of predation by Coyotes and Golden eagles is characteristic of the Sheep Mountain area; and other predators may be more important on other ranges.

Hoef's many publications on Sheep Mountain herd deal with the whole ecosystem and provide considerable detail beyond the scope of this description. The user is referred to these papers for further information.

9.5 Evaluation - Mammals

9.5.1 Scientific Research and Monitoring

Kluane's wildlife populations are essentially naturally-regulated and free of human influence. The only exceptions are animals which cross Park 'boundaries and are subject to hunting and predator control programs. Active management is generally unnecessary under naturally-regulated conditions and is usually only considered when a serious imbalance has been detected (Parks Canada 19841. The present wildlife survey program is designed to provide this advance warning by monitoring fluctuations in representative large mammal populations and, where necessary and possible, determining the influencing or causitive factors responsible for changes. Some of the factors known to influence numbers and success are winter severity, forage production, habitat changes, predator or prey abundance, and availability of alternate prey species. Only Dall's sheep and Grizzly bears have been studied in detail and knowledge of the range requirements and ecological interrelationships of most other species is based on observation alone. Should active management become necessary for the welfare of any population, decision-making and policy implementation will depend on an analytical database. The type of detailed study required is outside the time and manpower capabilities of the Warden Service and can probably be obtained most readily and inexpensively through encouraging research by university students, channelled when possible, into areas of application to long term management and planning in the Park.

As recommended in the Park Conservation Plan (Parks Canada 1984), the current wildlife monitoring program should continue and the extensive database accumulated since 1972 should be analysed and evaluated to decide if it is adequate to meet current Resource Conservation objectives and to cope with decisions associated with proposed future Park developments, such as the Slims River Access Road and Mush-Bates Area Planning. The ultimate objective will be a Wildlife Management Plan for the Park, as outlined in the Park Conservation Plan.

9.5.2 wilderness Management and Public Safety

The abstract concept we call 'Wilderness' is comprised of eiements from all parts of the ecosystem and the management of wilderness must be based on an integrated approach which acknowledges the interrelationships between the elements and thus can prevent incremental erosion of the integrity and value of the whole. This principle is recognized by the Park Conservation Plan (PCP) in proposing development of, a wilderness management plan. The Park conservation Plan emphasizes the need for active wilderness management to deal with issues arising from increased backcountry use. These issues include public safety concerns related to an increased potential for man/bear encounters, air-supported backcountry rafting, heli-skiing and hiking trips, increased public access through Park development in the Slims and Mush-Bates areas, and other issues arising from recreational use of wilderness areas.

Where wildlife populations are directly affected by increasing visitor use, the potential effects should be anticipated and monitored, and measures taken to prevent or control harmful activities. The studies discussed in the previous section could be an integral part of this process, initially providing input at the planning stage in evaluation of critical habitats and times, and providing baseline data against which changes can be evaluated.

Critical habitats are those areas which are essential to the survival of a population. For ungulates, they include winter range and spring birthing areas. Winter range for Dall's sheep and Mountain goats is indicated on Map 9.1 and is the most spatially and environmentally restricted habitat in the Park. Lambing takes place on winter range. Moose congregate on winter range as well but their needs are not as demanding and access is available to better habitat outside the Park.

At the present time in Kluane, most species are essentially undisturbed throughout their life cycles. Sheep Mountain and the Slims Valley are the only areas where this is not the case. The slims Valley is used extensively by Grizzly bears and may support the highest density population in the Park. With increasing visitor use the need to develop a bear management plan to protect both bears and people is recognized as an important objective in the Park Conservation Plan (Parks Canada 1984) with application in the Slims, Mush-Bates, and other areas. Sheep Mountain provides critical habitat for Dall's sheep including winter range, lambing areas, traditional mineral licks, and migration trails (Hoefs 1981b). In this area, winter range and lambing areas are above but immediately adjacent to the Alaska Highway, and much of the herd's summer range is in one of the Park's most accessible and popular hiking areas. Hoefs (1981b) believes it is essential that the animals not be disturbed on winter range and at lambing when they are often in poor physical condition. Maintenance of winter range productivity is also extremely important to the population and unnecessary disturbance to surface vegetation in these areas should be avoided (Hoefs 1981b).

Hoefs (1981b) makes a number of recommendations for management in the area, including expansion of the present Class 1 or Special Preservation Area on Sheep Mountain to include the entire range of this herd. He suggests that the public be made aware of the nature and importance of the area to sheep, that Sheep Mountain be closed to hikers from January 1 - May 31, and that a limit be set on the number of parties allowed access per day at other times of the year to prevent excessive surface damage of fragile vegetation communities.

Eventually similar management decisions may be necessary in other areas of the Park and, once an overall evaluation of the wildlife database has been completed, it will become apparent where further study is needed to deal with site specific problems. Application of the Environmental Assessment and Review Process to individual proposals will also highlight data gaps.

9.5.3 Opportunities

Kluane's large mammal populations are one of its prime attractions for hikers, photographers, and naturalists. Very little wildlife is seen along the Alaska Highway and visitors to Yukon are anxious to get off the road and see 'wilderness' and its inhabitants. Sheep Mountain offers the general public a quick view from the roadside and probably encourages people to hike in a bit further. Other areas of sheep range are accessible from Kathleen Lakes or Mush-Bates area. Development of backcountry access in Mush-Bates and the Slims Valley will open the Goatherd Mountain and Mount Vulcan areas to hikers.

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Staley, R. 1981a. Aerial Goat Survey - Goatherd Mountain - Summer 1981. Parks Canada, Kluane National Park. 1 p.

Staley, R. 1981b. Aerial Sheep Survey - Auriol Range - Summer 1981. Parks Canada, Kluane National Park. 1 p.

Sundbo, B.R. 1982. Sheep Survey - Donjek Range - July 6, 1982. Parks Canada, Kluane National Park. 5 p.

Map 9.1 Important wildlife Habitat areas - Kluane National Park.

APPENDIX

9.1 Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983.

9.2 Avifauna Species List - Abundance and Breeding Status of Birds of Kluane National Park.

PPENDIX 9.1: **Kluane National Park Warden Service Aerial Surveys and Reports,** 1973-1983.

Date	Survey Area* Species, Comments	Author, Citation +
1973	- 19-27 March winter ungulate distribution	J. Christiansen
1974	- May, June - expand summer goat & sheep range data and obtain accurate estimates of lamb crop	Christiansen, 1974
	- 24 July Sheep Mt. - Dall's sheep	Hoefs, 1974
1975	- 19, 20 March Sheep Mt. - Dall's sheep	Hoefs, 1975
	- 05 June Sheep Mt. - Dall's sheep	Hoefs, 1975
	- 24 June Sheep Mt. - Dall's sheep	L. Harbidge, J. McIntyre
	- Reproductive Status of Dall's Sheep, Sheep Mt.	Harbidge, 1975
1976	- 1 July Goatherd Mt. - goats	G. Hume
	- 2 July Sheep Mt. - Dall's sheep	Hoefs, 1976
	- 26 Sept. Burwash Uplands. Caribou Aerial Census No. 1	Harbidge, 1976
	- 27 Sept. Boundary & St. Clare Creeks. Caribou Aerial Census No. 1	Harbidge, 1976
	- 14-25 Nov. Burwash Uplands. Caribou Aerial Census No. 2	McIntyre, 1977a
	- 29 Nov. - 1 Dec. Boundary & St. Clare Creeks. Caribou Aerial Census No. 2	McIntyre, 1977a
	- 26 Nov. Dezadeash - Moose Aerial Census No. 1	McIntyre, 1976
	- 10 Dec. Donjek Valley - Moose Aerial Census No. 1	McIntyre, 197G
	- 10 Dec. Duke Valley - Moose Aerial Census No. 1	McIntyre, 1976

APPENDIX 9.1: **Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983 (Continued).**

Date	Survey Area* Species, Comments	Author, Citation t
1977	Summer 1977 Biophysical Surveys**	
	Dall's Sheep - Auriol	
	- Decoeli	
	- Vulcan	
	Goats - Goatherd	
	- Auriol	
	- Decoeli	
	- Vulcan	
	- Kaskawulsh	
	- Lowell	
	- 09 Feb. Alsek Pass - Moose	
	- 16 Feb. Burwash Uplands. Caribou Aerial Census No. 3	McIntyre, 1977b
	- 17 Feb. Boundary & St. Clare Creeks. Caribou Aerial Census No. 3	McIntyre, 1977b
	- 24 Feb. Donjek R. Valley - Moose	Freese & McIntyre, 1977
	- 01 March Duke R. Valley - Moose	Freese & McIntyre, 1977
	- 14 March Dezadeash - Moose	Freese & McIntyre, 1977

** See Figure 9.25.

APPENDIX 9.1: Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983 (Continued).

Date	Survey Area* Species, Comments	Author, Citation +
	- 15 March Alsek Pass - Moose	Freese & McIntyre, 1977
	- 11 June Boundary & St. Clare Creeks. Caribou Aerial Survey No. 4	McIntyre, 1977c
	- 22 June Mount Vulcan. Aerial Sheep Survey No. 1	Chambers, 1977
	- 23 June Sheep Mt. Aerial Sheep Suvey No, 1	Chambers, 1977
	- 01 July Goatherd Mt. - Goats	Hume, 1977
	- 08 July Duke R. - Dall's sheep	McIntyre, 1977d
	- 08 July Donjek Range - Dall's sheep	McIntyre, 19773
	- 09 July Sheep Mt. - Dall's sheep	Hoefs, 1977
	- 27 Sept. Boundary & St. Clare Creeks. Caribou Aerial Survey No. 5	McIntyre, 1978a
	- 22 Nov. Duke R. Valley. Moose Aerial Survey No. 3	McIntyre, 1978d
	- 22 Nov. Gonjek R. Valley. Moose Aerial Survey No. 3	McIntyre, 1978d
1978	Winter 1978 Biophysical Surveys** Sheep - Klukshu - Dalton Creek - Vulcan - Kluane - Donjek	

** see Figure 9.25.

APPENDIX 9.1: Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983 (Continued).

Date	Survey Area* Species, Comments	Author, Citation †
	Goats - Klukshu - Mush Creek - Dalton Creek - Decoeli - Donjek - Lowell	
	Summer 1978 Biophysical Surveys** Sheep - Auriol - Dusty - Decoeli - Vulcan - Chitina Goats - Goatherd - Auriol - Decoeli - Vulcan - Kaskawulsh - Lowell	Staley, 1979a

APPENDIX 9.1: Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983 (Continued).

Date		Survey Area* Species, Comments	Author, Citation +
1978	- 12 Jan.	Burwash Uplands - Caribou Aerial Survey No. 6	McIntyre, 1978b
	- 14 Jan.	Boundary & St. Clare Creeks - Caribou Aerial Survey No. 6	McIntyre, 1978b
	- 26 Jan.	Dezadeash - Moose	Freese, 1978
	- 31 Jan.	Goatherd Mt. - Aerial Goat Survey No. 2	Nume, 1978
	- 15 Feb.	Donjek Valley - Moose	Harbidge, 1978b
	- 15 Feb.	Duke Valley - Moose	Harbidge, 1978b
	- 26 Feb.	Burwash Uplands - Caribou Aerial Survey No. 7	McIntyre, 1978c
	- 27 Feb.	Boundary & St. Clare Creeks - Caribou Aerial Survey No. 7	McIntyre, 1978c
	- 06 June	Boundary & St. Clare Creeks - Caribou	R. Staley, J. McIntyre
	- 10 June	Burwash Uplands - Caribou	R. Staley, J. McIntyre Elliot
	- 22 June	Goatherd Mt. - Goats	R. Chambers, B. Liddle
	- 04 July	Auriol - Sheep	R. Chambers, C. Hume
	- 04 July	Auriol - Goats	L. Freese, C. Hume
	- 10 July	Sheep Mt. - Sheep	L. Freese, J. McIntyre
	- 12 July	Duke River - Sheep	L. Frecse, J. McIntyre
	- 12 July	Donjek Valley - Sheep	J. McIntyre, L. Freese
	- 20 Sept.	Auriol - Goats	R. Staley, D. Burles
	- 20 Sept.	Auriol - Sheep	R. Staley, D. Burles

APPWDIX 9.1: Kluane National Park Warden Service Aerial Surveys and Reports 1973-1983, (Continued).

Date	Survey Area* Species, Comments	Author, Citation +
	- 25 Sept. Burwash Uplands - Caribou	D. Burles, R. Staley, J. McIntyre
	- 26 Sept. Boundary & St. Clare Creeks - Caribou	D. Burles, R. Staley, J. McIntyre, R. Frey
	- 16 Nov. Duke River Valley - Moose	R. Staley, J. McIntyre Elliot
	- 1 Dec. Donjek River Valley - Moose Annual Wildlife Census Report, KNP 1976-1977	Harbidge & McIntyre, 1978
1979	- 05 June Sheep Mt. - Sheep	R. Frey, J. McIntyre, M. Hoefs
	- 11 Sept. Auriol - Sheep	R. Staley, L. Freese, R. Frey
	- 11 Sept. Auriol - Goats	R. Staley, L. Freese, R. Frey
	- 25 Sept. Vulcan - Sheep	R. Staley, L. Freese, R. Frey
	- 25 Sept. Vulcan - Goats	R. Staley, L. Freese, R. Frey
	- 27 Nov. Dezadeash - Moose	Staley, 1979b
1980	- 11 June Sheep Mt. - Sheep	J. McIntyre, K. McLaughlin
	- 02 July Auriol - Sheep	R. Staley, R. Chambers
	- 02 July Auriol - Goats	R. Staley, R. Chambers

APPENDIX 9.1: Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983 (Continued).

Date		Survey Area* Species, Comments	Author, Citation +
	- 07 July	Vulcan - Sheep	L. Freese, J. McIntyre
	- 25 Aug.	Goatherd Mt. - Goats	M. Hoefs
	- 20 Oct.	Dezadeash - Moose	Staley, 1980
1981	- 04 Feb.	Don jek R. Valley - Moose	Burles, McLaughlin, Gauthier
	- 08 June	Sheep Mt. - Sheep	Burles, 1981a
	- 20 June	Goatherd Mt. - Goats	Staley, 1981a
	- 28 June	Auriol Range - Goats	Staley, 1981a
	- 28 June	Auriol - Dall's Sheep	Staley, 1981b
	- 05 July	Donjek Range - Sheep	Burles, 1981b
	- 21 Oct.	Dezadeash - Moose	Morrison, 1981
	- 16 Nov.	Duke R. Valley - Moose	uurles, 1981c
	- 19 Nov.	Donjek R. Valley - Moose	Burles, 1981c
1982	- 20 June	Sheep Mt. - Dall's Sheep	Morrison, 1982
	- 06 July	Mount Vulcan - Sheep	Burles, 1982a
	- 06 July	Donjek Range - Dall's Sheep	Sundbo, 1982
	- 02 Nov.	Dezadeash - Moose	R. Frey, R. Staley, L. Freese
	- 05 Nov.	Duke R. Valley - Moose	Burles, 1983a

APPENDIX 9.1: Kluane National Park Warden Service Aerial Surveys and Reports, 1973-1983 (Concluded).

Date	Survey Area* Species, Comments	Author, Citation +
1983	- 06 June Sheep Mt. - Sheep	D. Burles, C. Hume, M. Hoefs
	- 12 June Goatherd Mt. - Goats	R. Staley, H. Morrison
	- 21 July Auriol - Goats	R. Staley, R. Frey, L. Freese
	- 21 July Auriol - Sheep	R. Staley, R. Frey, L. Freese
	- 27 July Donjek - Sheep	D. Burles, R. Chambers Hurd
	- 01 Sept. Vulcan - Sheep	D. Burles, R. Frey, H. Morrison
	- 21 Oct. Dezadeash - Noose	L. Freese, R. Chambers
	- 31 Oct. Duke R. Valley - Moose	D. Burles, L. Freese, Balmer
1984	- 06 June Sheep Mt - Sheep	D. Burles, M. tloefs
	- 18 June Goatherd Mt - Goats	D. Burles, R. Staley 1984a
	- 22 July Vulcan - Sheep & Goats	Hurd, 1984a
	- 24 July Auriol - Sheep	Hurd, 1984h
	- 24 Sept. Bighorn - Sheep	Hoggins, 1984

* see Figures 9.1, 9.2, 9.25.
t see Section 9.9.2.

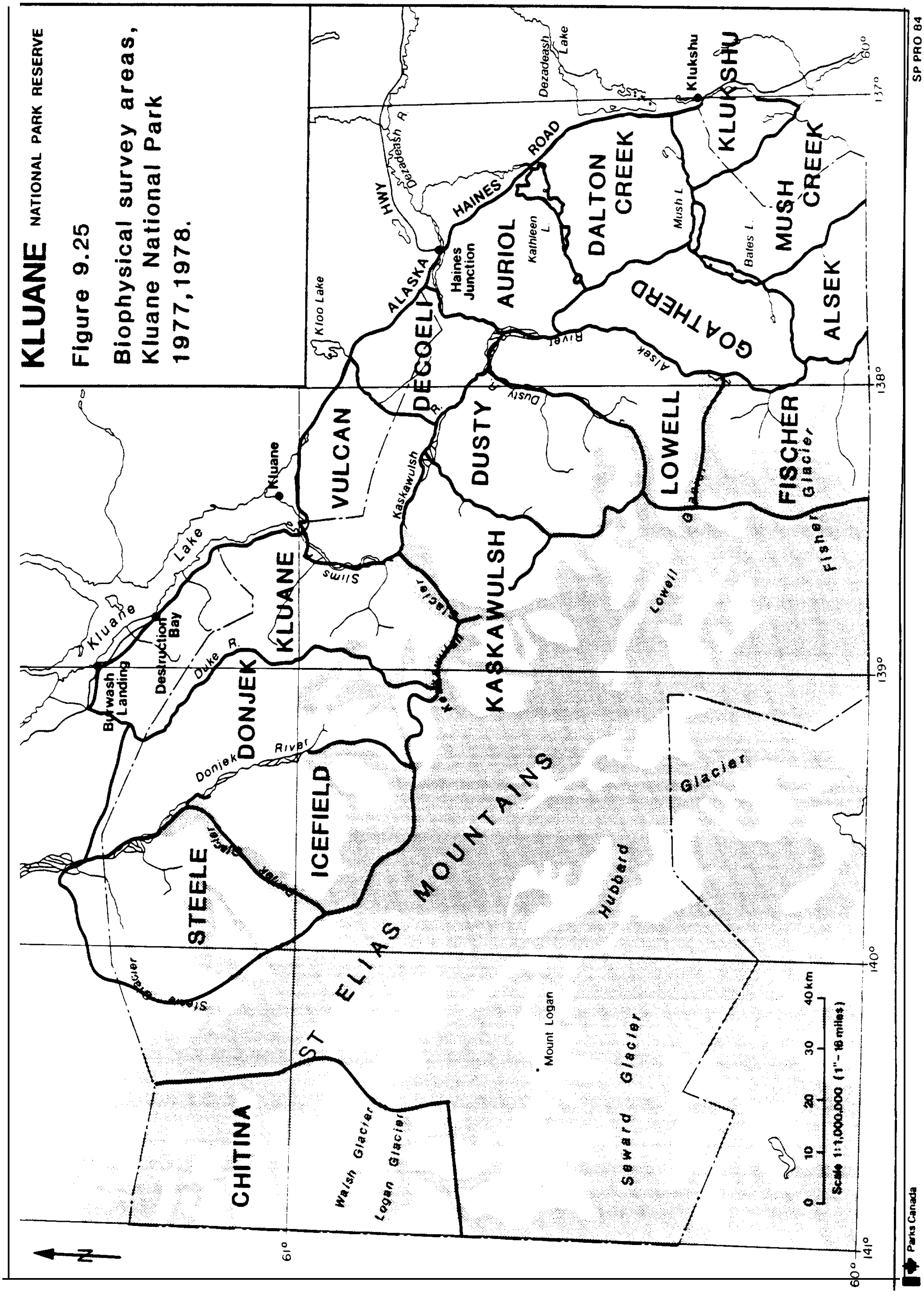

Figure 9.25
Biophysical survey areas, Kluane National Park 1977,1978.

Appendix 9.2: **Avifauna** Species List - **Abundance** and **Breeding Status of Birds of** Kluane **National Park.**

Scientific Name'	Common Name	Relative Abundance	status	Miscellaneous records and notes
Order Gaviformes				
Family Gaviidae				
Gavia immer (Brünnich)	Common Loon	f	b	breeds throughout the Kluane area.
F. artica (Linnaeus)	Arctic Loon	o	(b)	breeding range is Northern Yukon and N.W.T. Most sightings are of migratory birds; Theberge (1974) reports a pair on Mush Lake in 1972 and 1973 which may or may not have been a breeding pair.
G. stellata (Pontoppidan)	Red-throated Loon	o	(b)	seen occasionally during migration. Weeden (1960) reported a breeding pair near summit of Haines road.
Order **Podicipediformes**				
Family Podicipedidae				
Podiceps grisegena (Boddaert)	Red-necked Grebe	r	(b)	Breeds throughout the Yukon but rare in the Kluane area. Only recorded sightings by Banfield (1951 on the Hainss Road.
P. auritus (Linnaeus)	Horned Grebe	f	b	nests on small lakes with a single breeding pair per lake. Warden staff report nesting pairs in Donjek valley lakes.
Podilymbus podiceps (Linnaeus	Pie-billed Grebe	r	w	only sighting was reported to Clarke (1941) while in the Dezadeash area.
Order **Aneriformes**				
Family Anatidae				
Olor columbianus (Ord)	Tundra Swan	f	m	seen during both spring and fall migrations in large or small flocks. Warden staff have reported sightings at north end of Kluane Lake, in the Donjek valley and flying over the Icefields near Mount Logan.

Appendix 9.2: Avifauna species List - Abundance and Breading Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
O. buccinator (Richardson)	Trumpeter Swan	r	(b)	Warden staff report a nesting pair on Alder Creek fan in 1979 and a single bird there in 1980. Other sightings have been in Dezadeash River swamp area "ear Haines Junction, the Mush-Bates lake portage, the Pickhandle Lakes area, and Trout Lake.
Branta canadensis (Linnaeus)	Canada Goose	f	b	
Anser albifrons (Scopoli)	Greater White-fronted Goose (White-fronted Goose)	o	m	
Chen caerulescens (Linnaeus)	Snow Goose	o	m	
Anas platyrhynchos Linnaeus	Mallard	c	b	
Anas acuta Linnaeus	Northern Pintail (Pintail)	c	b	
A. carolinensis Gmelin	Green-winged Teal	c	b	
A. discors Linnaeus	Blue-winged Teal	r	(b)	this species is at the northern limit of its breeding range in southern Yukon and therefore rarely see". Holfs (1972) reports a number of them along Koidern River in August, probably breeding.
A. cyanoptera Vieillot	Cinnamon Teal	r	w	only reported sighting in Kluane is by Park warden staff. Godfrey (1966) has range as southern B.C. and Alberta.
Mareca americana (Gmelin)	American Widgeon	f	(b)	Park warden staff report widgeons nesting in the Alder Creek fen area. Theberge (1974) reports a pair sighted at Mush Lake. The American widgeon breeds throughout south and central Yukon.
Spatula clypeata (Linnaeus)	Northern Shoveler (Shoveler)	o	b	see" in Kluane area during migration Park warden staff have observed shovelers on Sulfur Lake in summer, probably nesting.

Appendix 9.2: Avifauna Species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name[1]	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Aythya americana (Eyton)	Redhead	r	w	- Park staff report one sighting in Slims River Area.
A. valisineria (Wilson)	Canvasback	r	b	- Godfrey (1966) places Kluane well within the breedinq range of this duck but it is rarely seen. Godfrey (1951) reports a breeding pair on Sulfur Lake and Holfs (1972) observed migrants near Sheep Mountain.
A. marila (Linnaeus)	Greater Scaup	f	b	- Godrey (1966) reports breeding pairs near the Haines Road, but these ducks are more commonly seen during migration.
A. affinis (Eyton)	Lesser Scaup	f	b	
Bucephala clangula (Linnaeus)	Common Goldeneye	o	b	- common summer resident in Kluane and quite common during spring and fall migration, (Soper, 1951).
B. islandica (Gmelin)	Barrow's Goldeneye	f	b	- Godfrey (1951) reports beeding pairs from Burwash Lake, Haines Road and near Kathleen Lake. Park wardens have observed these birds frequently at the south end of Kluane Lake during migration.
Bucephala albeola (Linnaeus)	Bufflehead	c	b	- Banfield (1953) reports nests from Kathleen River, Haines Junction, and Sulfur Lake.
Clangula hyemalis (Linnaeus)	Old Squaw	r	m	- rare in the Kluane area. Only sighting is by Weeden (1958) on Keldal Lake along the Haines Road.
Histrionicus histrionicus (Linnaeus)	Harlequin Duck	o	b	- occasionally breeds in the Kluane area, especially at the south end of Kluane Lake. Flocks of males are seen on Kluana Lake in summer, but generally Harlequins are more commonly seen during migration.

Appendix 9.2: Avifauna species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Melanitta deglandi (Bonaparte1	Ihita-winged Scoter	f	b	Breeds widely in Yukon but seen most often during migration, especially on Kluane and Dezadeash lakes (Soper 1951).
M. perspicillata (Linnaeus)	;urf Scoter	f	b	
Oidemia nigra (Linnaeus)	:ommon Scoter	r	m	Godfrey (1966) indicates that this scoter is rarely seen in the Yukon. Only sighting is by Holfs (19721 and was probably accidental.
Oxyura jamaicensis (Gmelin)	:uddy Duck	r	w	breeding range is southern British Columbia and the Prairie Provinces. Banfield (1951) reported seeing a few in the Kluane area but these may have been accidental. Reported as rare and possibly breeding in central Alaska.
Mergus merganser (Linnaeus)	:ommon Merganser	o-f	b	the Kluane area is near the limit of the common merganser's breeding range. Hoefs (1972) reports it breeding in the Park.
M. serrator (Linnaeus)	:ed-breased Merganser	f	b	Most sightings are during migration but Godfrey (1966) has breeding range throughout the southern Yukon.
Order Falconiformes				
Family Accipitridae				
Accipiter gentilis (Linnaeus)	lorthern Goshawk Merganse:	f	b	The goshawk is one of the more common hawks in the Kluane area, inhabiting timbered areas. Snowshoe hare is a main food item and its numbers respond to cyclical fluctuations in the hare population. The goshawk also breeds locally.
A. striatus vieillot	;harp-shinned Hawk	0	b	more common in drier northern part of Kluane. less common than the goshawk. sometimes seen hunting small birds near timbered or brushy areas. breeds locally; increased sightings in spring and fall are probably migrants.

Appendix 9.2: Avifauna species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	common Name	Relative Abundance	Status	Miscellaneous records and notes
Buteo jamaicensis (Gmelin)	Red-tailed Hawk	c	b	a common hawk in the area especially Harlan's and Krider's colour phases, and a common breeder (Godfrey 1966).
B. swainsoni Bonaparte	Swainson's Hawk	o	m	no breeding records in Yukon but summer sightings near Whitehorse have been reported.
B. lagopus (Pontoppidan)	Rough-legged Hawk	o	m	Autumn records only in southern Yukon.
Aquila chrysaetos (Linnaeus)	Golden Eagle	c	b	most common eagle in Kluane with a high breeding concentration in the Slims River valley.
Haliaeetus leucocephalus (Linnaeus)	Bald Eagle	c	b	although bald eagles do nest in Kluane, they are more often seen during migration. They are seen mainly along the major salmon spawning rivers - the Tatshenshini, Klukshu & Kluane.
Circus cyaneus (Linnaeus)	Northern Harrier (Marsh Hawk)	f	b	breeds in Yukon but most frequently seen in the Park during migration.
Family Pandionidae				
Pandion haliaetus (Linnaeus)	osprey	r	(b)	recorded by Mossop (Yukon Wildlife Branch) at Kathleen Lake and by Hoefs (1973) along Koidern River. Warden staff have recorded occasional sightings around Kluane Lake in autumn. Godfrey (1966) includes Kluane in breeding range.
Family Falconidae				
Falco rusticolus Linnaeus	Gyrfalcon	f	b	. Burles (1980) reported 4 active eyries in the Kluane area. Most sightings are migratory. Gyrfalcons are quite numerous near the Haines Road summit in fall where they hunt ptarmigan. Hayes and Mossop (1983) report that population is relatively healthy; numbers related to ptarmigan cycle.

Appendix 9.2: **Avifauna Species** List - Abundance and **Breeding** Status of Birds of **Kluane** National Park **(continued).**

Scientific Name'	Common Name	Relative Abundance	tatus	Miscellaneous records and notes
L. mutus (Montin)	Rock Ptarmigan	f	b	breeds in the Park (Godfrey 1966) but is not as common as the willow ptarmigan and is found higher in the alpine,
L. leucurus (Richardson)	**White-tailed** Ptarmigan	f	b	found in small groups in Kluane. Breeds in the Park and a number winter in the St. **Elias** Lake area.
Pedioecetes phasianellus **(Linnaeus)**	sharp-tailed Grouse	o	(b)	no reports of sharp-tails in the Park proper. **Hoefs (1972)** reports breeding in the Donjek Valley.
Order Gruiformes				
Family Gruidae				
Gru canadensis (Linnaeus)	Sandhill Crane	r	m	Does not breed in interior Yukon. **Most** sightings are of **migrating** birds and small groups are seen in April of most years on the Slims River flats.
Family **Rallidae**				
Fulica americana Gmelin	America1 Coot	r	w	. accidental sightings reported by Park Warden staff in Donjek Valley and Slims River area: breeding range does not extend beyond **north-**central B.C. Reported as rare and possibly breeding in central Alaska (Armstrong 1983).
Order Charadriiformes				
Family Charadriidae				
Charadrius semipalmatus Bonaparte	**Semipalmated** Plover	f	b	

Appendix 9.2: **Avifauna** species List - **Abundance** and Breeding **Status of Birds** of **Kluane** National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
C. vociferus Linnaeus	**Killdeer**	o	(b)	the **killdeer** is uncommon on southwest Yukon and according to Godfrey (1966) there is an isolated population here outside its normal continuous range. **Hoefs** (1972) reports a number of sightings. Park Warden staff have seen **them** a number of times in June at **Cultus** Bay, probably nesting.
Pluvialis dominica (Müller)	Lesser Golden Plover	o	b	Seen only occasionally and only one report of breeding in the Kluane area. Godfrey (1966) suggest it probably breeds in the mountains near Burwash Creek, Edith Creek, Teepee Lake and near the **Klutaln** Glacier. Kluane is the southwest **limit** of its **known** breeding range.
Family Scolopacidae				
Capella gallinago (Linnaeus)	**Common Snipe**	f	b	known to breed throughout Yukon, but there are no definite records for Kluane. also called Wilson's snipe.
Numenius phaeopus (Linnaeus)	**Whimbrel**	r	(b)	also call Hudsonian curlew. Godfrey (1966) indicates that the **whimbrel** should breed in the northern part of Kluane and suggests Burwash Creek summit as a probable breeding area. There have **been** no sightings to date.
Bartramia longicauda (Bechstein)	Upland Sandpiper (Upland Plover)	f	b	breeds near Burwash Landing (Godfrey, 1966) and locally throughout Southern Yukon.
Actitis macularia (Linnaeus)	Spotted Sandpiper	c	b	breeds throughout **kluane.**
Tringa solitaria Wilson	solitary Sandpiper	r	b	Kluane is within the breedrng range and it has been observed in the Sockeye Lake - Kathleen River area (Godfrey 1966).
Heteroscelus incanus (Gmelin)	Wandering Tattler		(b)	Godfrey (1966) indicates that this bird nests in the interior mountains of Yukon though most sightings are from the coast mountains to the south of Kluane.

Appendix 9.2: Avifauna Species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Totanus melanoleucus (Gmelin)	Greater Yellowlegs	r	w	known breeding range extends only into northern B.C. (Godfrey 1966). Hoefs (1972) reports two birds on the Slims River and Weeden (1960) made a number of sighting in the Chilkat Pass area. These are considered accidental.
T. flavipes (Gmelin)	Lesser Yellowlegs	c	b	
Calidris minutilla (Vieillot)	Least Sandpiper	f	b	observed breeding on Sockeye and Mush lakes.
Family Phalaropodidae				
Phalaropus lobatus (Linnaeus)	Red-necked Phalarope (Northern Phalarope)	o	b	observed breeding in Slims River valley and in Johobo area.
Family Stercorariidae				
stercorarius longicaudus Vieillot	Long-tailed Jaeger	I	b	one nesting pair located in Gladstone Lakes (Prig, 1969).
Family Laridae				
Larus argentatus (Pontoppidan)	Herring Gull	c	b	observed breeding on Sockeye, Mush and Kathleen lakes and throughout southern Yukon.
L. canus Linnaeus	Mew Gull	c	b	breed commonly in southern Yukon, observed nesting on Sockeye, Mush, and Kluane lakes.
L. glaucescens Gunnerus	Glaucous-winged Gull	r	w	one found dead on road near Kluane Lake by Park staff.
L. Philadelphia (Ord)	Bonaparte's Gull	f	b	breeds throughout southern Yukon. Observed nesting near Haines Junction.
Sterna paradisaea Pontoppidan	Arctic Tern	c	b	observed nesting in suitable habitat throughout the Park.

Appendix 9.2: Avifauna Species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Order Columbiformes				
Family Columbidae				
Zenaida macroura (Linnaeus)	Mourning Dove	r	w	. range confined to south-central Prairies and Eastern Canada. Ranges widely in fall. Hoefs (1972) observed a pair on Slims River Delta; Drury (1953) reported one dove near Experimental Farm. Warden staff report one sighting near Dezadeash.
Order Strigiformes				
Family Strigidae				
Bubo virginianus (Gmelin)	Great Horned Owl	c	b	inhabits all parts of Canada north to the tree line and appears rarer than it is because of its nocturnal habit. Park warden staff know of one nest in the Kluane Lake area and two more near Dezadeash and Kathleen lakes.
Surnia ulula (Linnaeus)	Northern Hawk Owl	c	b	
Strix nebulosa Forster	Great Gray Owl	r	(b)	breeds throughout the Boreal forest west of Quebec. Only one observation by Park warden staff on Koidern River several years ago.
Asio flammeus (Pontoppidan)	Short-eared Owl	c	(b)	breed throughout Yukon.
Nyctea scandiaca (Linnaeus)	snowy Owl	r	w	. wanders widely from common range in response to general food availability and lemming cycle.
Aegolius funereus (Linnaeus)	Boreal Owl	f	(b)	. also called Richardson's owl. Breeds throughout Yukon below tree Line. Park warden staff collected one bird near Kathleen Lake in 1980.

Appendix 9.2: Avifauna Species List - Abundance end Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	status	Miscellaneous records and notes
Order Caprimulgiformes				
Family Caprimulgidae				
Chordeiles minor (Forster)	ommon Nighthawk	r	b	Godfrey (1966) reports nesting near Kathleen River. Park warden staff have observed them near Haines Junction.
Order Apodiformes				
Family Trochilidaa				
Selasphorus rufus (Gmelin)	ufous Hummingbird	r	w	. possibly breeds in southwestern Yukon. Observed near Mr. Logan - hence the name Hummingbird Ridge on southeast side of Logan. Also observed by Park staff near Dezadeash Lake and Destruction Bay. These may be accidental sightings resulting from the birds wandering or being blown north of their normal range.
Or&r Coraciiformes				
Family Alcedinidae				
Megaceryle alcyon (Linnaeus)	elted Kingfisher	o	(b)	breeds throughout most of forested Canada (Godfrey 1966). Kingfishers have been observed along Alder Creek fan, near Dezadeash Lake, Klukshu River and along Kluane Lake by Park warden staff.
Or&r Piciformes				
Family Picidae				
Colptes auratus (Linnaeus)	orthern Flicker Yellow-shafter)	c	b	
Dendrocopus villosus (Linnaeus	airy Woodpecker	o	(b)	Kluane lies within breeding range defined by Godfrey (1966).

Appendix 9.2: **Avifauna** species **List - Abundance** and Breeding Status **of Birds** of **Kluane** National **Park** (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
D. pubescens (Linnaeus)	Downy woodpecker	r	(b)	Kluane is near the northern range limit for the downy woodpecker. Godfrey (1966) suggests it may breed near Dezadeash Lake.
Picoides arcticus (Swainson)	Black-backed Woodpecker (Black-backed Three-toe Woodpecker)	r	b	There is only one record of breeding in the Park (Laing 1925). Godfrey (1966) places Kluane near the northern breeding range limit.
P. tridactylus (Linnaeus)	Three-toed Woodpecker (Northern Three-toed Woodpecker)	f	b	
Order **Passeriformes**				
Family Tyrannidae				
Tyrannus tyrannus (Linnaeus)	Eastern Kingbird	r	W	Clarke (1945) recorded the only sighting in the Park. This is well west of its range and probably accidental. Godfrey (1966) calls it a casual visitor to southern Yukon on the basis of an observation at Champagne.
Sayornis phoebe (Latham)	Eastern Phoebe	r	b	Godfrey (1966) reports casual observation from southern Yukon (Pine Creek). Theberye (1972) also reports an observation.
S. saya (Bonaparte)	Say's Phoebe	c	b	
Empidonax alnorum (Audubon)	Alder Flycatcher (Traill's Flycatcher)	o	b	also called Alder Flycatcher.
E. minimus (Baird and Baird)	Least Flycatcher	r	(b)	Godfrey (1951, 1966) reports probable breeding near Haines Junction and Dezadeash Lake. Theberge (1974) reports an observation. Kluane is on the extreme western edge of breeding range.
E. hammondii (Xantus)	Hammond's Flycatcher	r	W	Lainy (1925) and Hoefs (1972) report sightinys. Kluane is just outside the known range.

Appendix 9.2: **Avifauna** Species List - **Abundance** and Breeding Status of Birds of **Kluane** National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
E. oberholseri Phillips	Dusky Flycatcher	r	w	Clarke (1944) reports one near Dezadeash. Godfrey (1966) reports breeding near Carcross.
Contopus sordidulus Sclater	Western Wood Peewee	f	(b)	
Nuttallornis borealis (Swainson	Olive-sided Flycatcher	f	(b)	
Family Alaudidae				
Eremophila alpestris (Linnaeus)	Horned Lark	c	b	
Family Hirundinidae				
Tachycineta thalassina (Swainson	Violet-green Swallow	c	b	
Iridoprocne bicolor (Vieillot)	Tree Swallow	o	b	
Riparia riparia (Linnaeus)	Bank Swallow	o	b	
Hirundo rustica Linnaeus	Barn Swallow	c	b	
Petrochelidon pyrrhonota (Vieillot)	Cliff Swallow	c	b	
Family corridae				
Perisoreus canadensis (Linnaeus	Gray Jay	a	b	also called Canada Jay.
Cyanocitta stelleri (Gmelin)	Steller's Jay	r	(b)	known range extends only to northwestern B.C. Soper (1956) records one observation in the Kluane area and Park warden staff report a single observation at Sheep Mountain.
Pica pica (Linnaeus)	Black-billed Magpie	a	b	
Corvus corax Linnaeus	Common Raven	a	b	

Appendix 9.21 Avifauna species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	Status	Miscellaneous records and notes
C. brachyrhynchos Brehm	Northwestern Crow (Common Crow)	r	w	Clarke (1944) reports crows in the Kluane area. Godfrey (1966) places Kluane well west of known range. Common in southeastern Alaska. Warden staff report sightings at Deradeash Lake.
Nucifrage columbiana (Wilson)	Clark's Nutcraker	r	w	Wanders into Yukon from common range in south and central B.C. Fisher and Myers (1980) report peculiar dispersal periods every 3-4 years. Spring sightings by Hoefs (1972) near Sheep Mountain suggest it may breed there.
Family Paridae				
Parus atricapillus Linnaeus	Black-capped Chickadee	c	(b)	Godfrey (1966) reports breeding from Dezadeash Lake.
Parus gambeli Ridgway	Mountain Chickadee	r	w	range extends north to northwestern B.C. but has wandered into southern Yukon (Dezadeash Lake).
P. hudsonicus Forster	Boreal Chickadee	c	b	
Family Sittidae				
Sitta canadensis Linnaeus	Red-breased Nuthatch	o	(b)	near northern limit in Kluane. Hoefs (1972) reports sighting at Sheep Mountain. Godfrey (1966) reports breeding at Kathleen River.
Family Certhiidae				
Certhia familaris Linnaeus	Brown Creeper	r	w	has been sighted near Dezadeash Lake in summer but this was probably accidental as Kluane is well north of the Brown Creeper's range.
Family Cinclidae				
Cinclus mexicanus Swainson	American Dipper	f	b	Kluane is near the western range limit. Hoefs (1972) sighted them in the Donjek drainage and in the upper Kathleen Lake area. Park warden staff report them from Mush-Bates portage, and Bates, Klukshu, and Kluane rivers.

Appendix 9.2: Avifauna species List - Abundance and Breeding Status of Birds of Kluane National Park (continued).

Scientific Name'	Common Name	Relative Abundance	status	Miscellaneous records and notes
Family Turdidae				
Turdus migratorius Linnaeus	American Robin	c	b	
Ixoreus naevius (Gmelin)	Varied Thrush	c	b	
Catharus guttata (Pallas)	Hermit Thrush	o	b	
C. ustulata (Nuttall)	Swainson's Thrush	o	b	
C. minima (Lafresnaye)	Gray-cheeked Thrush	o	b	• Hoefs (1972) reports a sighting from Sockeye Lake.
Sialia currucoides (Bechstein)	Mountain Bluebird	o	b	• known to breed on Experimental Farm near Haines Junction,
Oenanthe oenanthe (Linnaeus)	Northern Wheatear	r	b	• Kluane is southern limit of breeding range. Reported by Hoefs (1972) and Park warden staff near Donjek Glacier, and by Tasker (1971) near Steele Creek area.
Myadestes townsendii (Audubon)	Townsend's Solitaire	f	b	
Family Sylviidae				
Regulus satrapa Lichtenstein	Golden-crowned Kinglet	f	b	• near northwestern range limit. Godfrey (1966) suggests probable breeding near Kathleen R.
R. calendula (Linnaeus)	Ruby-crowned Kinglet	f	(b)	
Family Motacillidae				
Anthus spinoletta (Linnaeus)	Water Pipit	f	b	
Family Bonbycillidae				
Bonbycilla garrulus (Linnaeus)	Bohemian Waxwing	f	b	

Appendix 9.2: Avifauna species List - Abundance and Breeding Statue of Birds of Kluane National Park (continued).

Scientific Name[1]	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Family Laniidae				
Lanius excubitor Linnaeus	Norther Shrike	o	b	occasionally seen in the Park; more commonly in Sheep Mountain area.
Family Sturnidae				
Sturnus vulgaris Linnaeus	European Starling	r	b	Hoefs (1972) reported the first sightings in the Kluane area. The starling is an introduced species in North America and is still expanding its range. Nests at Experimental Fans near Haines Junction.
Family Vireonidae				
Vireo solitarius (Wilson)	Solitary Vireo	r	w	northwestern limit is norther B.C. and southwest N.W.T.
Family Parulidae				
Vermivora peregrine (Wilson)	Tennessee Warbler	o	b	
Vermivora celata (say)	Orange-crowned Warbler	o	b	
Dendroica petechia (Linnaeus)	Yellow Warbler	b	b	
D. coronata (Linnaeus)	Yellow-rumped Warbler (Myrtle Warbler)	c	b	recent nomenclature combines Myrtle and Audubon's as yellow-rumped warbler.
D. auduboni (Townsend)	(Audubon's Warbler)			The variety common to Kluane is Myrtle.
D. striata (Forster)	Blackpoll Warbler	f	b	
D. palmarum (Gmelin)	Palm Warbler	r	w	Kluane is west of known range; Hoefs (1972) reports flocks of up to a dozen birds in the Slims River area and a single bird near Mile 1070 Alaska Highway.
Seiurus noveboracensis (Gmelin)	Northern Waterthrush	r	b	Hoefs (1972) reports sighting near Sheep Mountain and along Koidern River.

Appendix 9.2: **Avifauna** species List - **Abundance and** Breeding Status **of Birds of Kluane National Park (continued).**

Scientific Name[1]	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Oporornis tolmiei (Townsend)	MacGillivry's Warbler	r	(b)	breeds in extreme southwest Yukon along Haines Road (Godfrey 1966). Soper (1954) records one sighting.
Goethlypis trichas (Linnaeus)	Common yellow-throat	r	(b)	Parts of Kluane within breeding range (Godfrey, 1966). Theberge (1972) reports them along Alder Creek and near Haines Junction.
Wilsonia pusilla (Wilson)	Wilson's warbler	c	b	
setophaga ruticilla (Linnaeus)	American Redstart	r	b	Hoefs (1972) observed and located the nest of a pair along Sheep Creek.
Family Icteridae				
Agelaius phoeniceus (Linnaeus)	Red-winqed Blackbird	r	b	Hoefs (1972) reports nesting in the Slims River valley, Sulfur Lake and Koidern River area. Some nests were active in 2 consecutive years indicating a stable breeding population and a range extension from Godfrey (1966).
Euphagus carolinus (Müller)	Rusty Blackbird	o	b	
Molothus ater (Boddaert)	Brown-headed Cowbird	r	w	. Hoefs (1972) reports 5 birds associated with cattle near Haines Junction. Park warden staff have seen a pair at the Experimental Farm near Haines Junction. These sightings place the birds considerably northwest of their known range (Godfrey 1966).
Family Thraupidae				
Paranqa ludoviciana (Wilson)	Western Tanager	r	w	. Clarke (1945) reports one sighting. Kluane is slightly northwest of known range.
Family Fringillidae				
carpodacus purpureus (Gmelin)	Purple Finch	r	w	. Summer sightings have been reported in the Kluane area. The Park is north of known range.

Appendix 9.2: **Avifauna** Species List **- Abundance and** Breeding status of **Birds of** Kluane **National Park (continued).**

Scientific Name[1]	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Pinicola enucleator (Linnaeus)	Pine Grosbeak	r	(b)	
Leucosticte tephrocotis (Swainson)	Gray-Crowned Rosy Finch	o	b	
Acanthis flammea (Linnaeus)	Common Redpoll	c	b	
Spinus pinus (Wilson)	Pine Siskin	f	b	
Loxia Curvirostra (Linnaeus)	Red Crossbill	o	b	
L. leucoptera Gmelin	White-winged Crossbill	c	b	nest in nature spruce stands in Kluane (Theberge 1974).
Passerculus sandwichensis (Gmelin)	Savannah Sparrow	c	b	
Junco hyemalis (Linnaeus)	Dark-eyed Junco (Slate-coloured Junco)	a	b	most common bird in Kluane National Park.
Spizella arborea (Wilson)	American Tree Sparrow (Tree Sparrow)	f	b	
S. passerina (Bechstein)	Chipping Sparrow	c	b	
S. Breweri Cassin	Brewer's Sparrow	o	b	Theberge (1974) records 6 breeding pairs in a sub-alpine area west of Sheep Creek. Within breeding range of Godfrey (1966).
Zonotrichia leucophrys (Forester)	White-crowned Sparrow	a	b	
Z. atricapilla (Gmelin)	Golden-crowned Sparrow	o	b	
Z. albicollis (Gmelin)	White-throated Sparrow	r	w	Drury (1953) reports an observation. Kluane is west of know-n breeding range which extends only to Watson Lake.
Passerella iliaca (Merrem)	Fox Sparrow	o	b	
Melospiza lincolnii (Audubon)	Lincoln's Sparrow	o	b	

Appendix 9.2: **Avifauna** Species List - **Abundance and Breeding Statue** of **Birds of Kluane National Park (concluded).**

Scientific Name[1]	Common Name	Relative Abundance	Status	Miscellaneous records and notes
Melospiza melodia (Wilson)	Song Sparrow	0	b	- Theberge (1974) reports beeding near Kathleen Lake.
Calcarius lapponicus (Linnaeus)	Lapland Longspur	f	m	- Hoefs (1972) reports large flocks observed during spring migration. He also reports summer sighting which may indicate local breeding,
C. pictus (Swainson)	Smith's Longspur	0	(b)	- status in Yukon is uncertain, Breeds along Arctic coast but is occasionally seen in Kluane. Clarke (1945) believed it to be breeding in the Park.
Plectrophenax nivalis (Linnaeus)	Snow Bunting	o	b	- Tasker (1971) reports beeding near the Steele Glacier. Sightings are usually of migratory birds.

Relative Abundance
- r: rare - only 1 or 2 observations
- 0: occasional - up to 10 observations
- f: frequent - up to 50 observations
- c: common - up to 100 observations

Status
- b - positively breeding in the Park
- (b) - probably breeding in the Park
- m - migrant
- w - wanderer

[1] Nomenclature after Godfrey (1966) with recent revisions after American Ornithologists' Union Field Guide to the Birds of North America. National Geographic Society, 1983.

CHAPTER 10

Limnology and Aquatic Biology of Kluane National Park

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

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10.1 Introduction

Kluane's varied topography presents a wide range of aquatic environments from clear cold mountain lakes and streams at high altitude torrents and lakes nearly to silty glacier-fed rivers where few unexpected fish survive to more moderate environments in the large low elevation lakes and wooded valley streams which support a diverse community of aquatic plants and animals. Kluane's lakes and rivers are one of its greatest resources and recreational fishing is a major attraction for anglers. Aquatic resources are also one of the Park's most sensitive and careful management is necessary to ensure their protection. Fish grow very slowly in northern lakes which are characteristically poor producers and under these conditions the line between moderate harvest and over-fishing is often fine and if not carefully monitored, a population can decline rapidly. Similarly the protection of water quality in the face of increasing visitor use and peripheral development is a growing problem which must be addressed.

10.2 Data Sources and Limitations

In the early 1900's only incidental observations of the aquatic resources of Kluane were recorded by explorers and scientists in the southwest Yukon. Clarke (1946) included a brief section on fish in his study of flora and fauna along the Alaska Highway. The first general study of waters in the region was undertaken by Wynne-Edwards (1947) and his work provides the fundamental records for the area. He first documented the presence of pygmy whitefish in Sockeye lake (the species was not recorded again until 1975 (Wickstrom 1977)), and noted the presence of land-locked sockeye salmon (kokanee) and steelhead (rainbow) trout in Kathleen Lake. In a later publication, Wynne- Edwards (1952) made the first mention of lake chub in the Donjek River, Arctic grayling and round whitefish in the Alsek (a unique occurrence as the Alsek is the only Pacific Coast watershed to contain these species) and noted the migration of Chum salmon to Kluane Lake. Nelson's (1968a, b) studies of kokanee included specimens from Kathleen Lake. The Canadian Fisheries and Marine Service (1977) enumerated anadramous salmon runs on the Klukshu River just south of the Park to provide information *on* declining salmon stocks in the area.

The primary sources of information on the limnology and fisheries of Kluane are a series of comprehensive reports by Wickstrom (1977a, b; 1978; In Prep. a,b). Wickstrom (1978) provides the major reference for this chapter and most material herein is attributed to this sources unless otherwise noted.

Wickstrom's work was undertaken as part of a Basic Resource Inventory designed to provide baseline data on the aquatic resources of the Park. He collected valuable and detailed information on lake bathymetry and water chemistry. Summer field investigations and sampling of aquatic vascular plants, aquatic bryophytes, periphyton, phytoplankton, zooplankton, benthic and littoral communities, aquatic invertebrates, and fish were carried out on all large and most intermediate-sized flowing waters and lakes. A cross-section of smaller ponds and flowing waters was also studied. Waters in all vegetation zones (montane, subalpine, and alpine) and major geologic and landform areas were sampled. Limited time and the extremely large study area permitted Wickstrom to visit each site only once. As a result, some species, particularly aquatic insects, may not have been collected because their stage of development was ahead or behind the sampling time, and no record could be made of the progression of ecological changes occurring over the year. No data on winter conditions are available. The development of population and productivity estimates also require more extended study than was possible and figures in the report are regarded as preliminary or useful only for general comparisons.

The initial study (1978) led to more detailed work on the Kathleen lakes chain population of kokanee (Wickstrom In prep. a) and on the productivity and harvest of fish from Kathleen Lake, Wickstrom In prep. b) the most heavily fished standing water in the Park.

10.3 Limnology

10.3.1 Physical Characteristics of Waterbodies in Kluane

10.3.1-l Drainage System

The major drainage systems in Kluane are shown in Figure 6.14 and described in section 6.4.1. Briefly, two major systems drain the Greenbelt and front range areas of the Park - the Yukon in the north and the Alsek in the south. The drainage divide lies in the Kluane Hills just south of Kluane Lake. The Duke, Slims, and Donjek are the major rivers of the Park tributary to the Yukon System. All are glacier- fed, turbid, and braided along at least some of their length. Water in the Yukon system flows 2500 km through Yukon and Alaska to the Bering Sea. The Alsek system is comprised of the Kaskawulsh, Jarvis, Dezadeash, Bates, and Alsek rivers and many smaller streams. The Dezadeash and Bates drain the only major lakes that lie within the Park area. The Alsek is a large powerful, glacier-fed, turbid river. The terminus of the Lowell Glacier calves into the Alsek River which then carries huge ice blocks downstrean. The Alsek was once studied for hydroelectric potential but abandoned because of its heavy silt load. The Alsek system flows 300 km through Yukon and the Alaska Panhandle southward to the Gulf of Alaska.

10.3.1.2 Watersheds

The Icefields, valley glaciers, cirque glaciers in the front range;,. and large areas of unvegetated alpine terrain make up the greatest proportion of watershed area in Kluane. According to Douglas (1980) permanent snowfields and icefields cover 733 of the Park area. Vegetated alpine and subalpine areas cover 11% of the area, while the forested montane zone makes up only 7%. The remainder is rock, Unvegetated floodplains, and lakes.

10.3.1.3 Flowing Waters

The major flowing waters of the Park area are listed in Table 10.1 along with information on drainage area, length, stream order, and a number to key their location to Figure 10.1. Most major streams and their drainage basins lie only partly within Kluane National Park. The Slims River is the only exception. Values in Table 10.1 refer to the entire physical unit and include areas both inside and outside the Park.

Rluane lies in the rainshadow of the St. Elias Nountains. Consequently, the central and northern areas of the Park experience a semi-arid climate, with July precipitation seldom exceeding 4 cm. Streamflow is virtually all derived from meltwater. The southern areas of the Park experience a more maritime climate with higher precipitation in all seasons, but meltwater is still a major component of streamflow. This dependence on meltwater sources causes the major rivers and their tributaries to exhibit marked seasonal and diurnal variations in flow, as described in section 6.4.2. Glacially-fed streams exhibit peak flow in summer while those fed by snowmelt peak in spring. On a daily scale, peak discharge occurs in late afternoon on small streams and progressively later in the day with increasing stream size, drainage area, and distance from source.

Wickstrom (1978) identified six major stream types in Kluane:

1. Large glacial valley streams. These large rivers have large valley glaciers as their sources and are fed directly by glacial meltwater. They flow rapidly through shallow braided anastomosing channels cut in coarse glacial material or infrequently in silt, as in the Slims River. Waters are turbid, carrying a high silt load. Flow continues through the winter but at much reduced levels and may occur as through-bed rather than channel flow. Freezing and overflow are common. In summer, water temperatures are consistently cool due to the glacial meltwater source but this is partially offset by the interception and absorption of solar radiation by the silt which in turn radiates heat to the water. All the major rivers in Kluane except the Dezadeash are of this type. The Slims, Donjek, and Kaskawulsh are typical examples. These rivers provide poor habitat for aquatic life and have very low productivity for their size. At a scale of 1:250,000, these rivers are 4th to 6th order streams.

2. Cirque glacial streams. These streams are often the major tributaries of the larger rivers. They originate in the alpine and subalpine zones carrying meltwater from small cirque glaciers or semi-permanent snowfields. They are turbid and debris-charged and descend rapidly along high gradient channels through coarse material to join the major rivers, often building alluvial fans onto the major floodplain. Flow usually ceases by autumn either when the source melts completely or when it freezes with the onset of falling temperatures at high elevations. Water

Table 10.1 Drainage area, length, and stream order of flowing waters in and near Kluane National Park.'

Water	Ref. No. Fig. 10.1)	Drainage Area[2] km^2	Stream Length km	Stream Order[3]
Aishihik River [a]	62	4,374.1	32.2	5
Alder Creek	112	407.6	28.8	4
Alsek River	74	29,298.0[d]	261.6	6
Bates Lake Creek #1*		1.5	3.0	1
Bates Lake creek #10*	85	1.5	3.0	1
Bates Lake Creek #15*		1.5	3.0	1
Bates River	95	1,291.0	20.6	4
Beachview Creek		62.5	12.2	2
Bear Creek (north)	54	110.6	20.0	2
Bear Creek (south)+	87	18.0	6.4	1
Bighorn Creek	30	180.3	22.1	3
Bock's Creek	25	38.5	13.3	2
Bridge River	99	217.0	18.9	3
Bryson Creek		23.6	7.4	2
Bullion Creek	36	IRO.2	21.5	3
Burwash Creek	13	256.7	38.0	4
Campsite-March Creek*	73	15.2	6.4	1
Canada Creek	42	203.3	20.5	3
Christmas Creek	49	243.6	17.0	3
Clay Creek		65.2	11.2	3
Clear Creek*	78	ld.5	7.0	1
Climbing Creek*	101	11.5	4.6	3
Coin Creek	37	10.7	8.7	1
Congdon Creek	33	59.6	15.8	3
Cottonwood Creek	75	133.7	16.9	3
Dalton Creek		29.9	7.2	1
Dezadeash River	121	9,072.7	145.6	5
Dickson Creek		34.3	8.4	2
Disappointment River		517.4	25.3	3
Donjek river	8	26.868.6	291.8	6
Duck Creek*	68	20.4	4.0	2
Duke River	15	733.5	68.3	4
Dusty River		1,027.8	32.2	3
Edith Creek [a]	3	282.3	30.1	4
Esker Creek		40.7	10.7	2

TABLE 10.1 Drainage area, length, and stream order of flowing waters in and near Kluane National Park[1] (Continued).

Water	Ref. No. (Fig. 10.1)	Drainage Area[2]	Stream[1] Length	Stream Order[3]
Felsite Creek		215.6	20.5	2
Field Creek	92	65.2	16.0	2
Fraser Creek	110	211.4	24.5	3
Fruit Creek*	43	2.4	2.3	1
Glacier Creek [a]	7	11.8	7.3	2
Goat Creek	79	65.5	12.4	2
Granite creek	14	41.5	11.9	3
Gribbles Gulch		21.8	10.4	1
Grizzly Creek	31	95.6	15.1	3
Halfbreed Creek	16	73.5	20.0	3
Hiking Creek*	102	12.5	5.7	2
Hoge Creek		25.9	8.9	2
Iron Creek		55.4	5.9	2
Jarvis River	53	1,071.4	29.7	4
Jessie Creek		7.4	5.0	1
Kaskawulsh Glacier		1.677.0		
Kaskawulsh River	56	3,977.4[d]	48.2	4
Kathleen River	63	1,078.3	19.8	4
Kimberley Creek		64.3	12.3	2
Kluane River [a]	4	8,151.7[d]	81.0	5
Klukshu River [a]	118	212.7	22.8	3
Knob Creek*	22	28.0	6.7	2
Koidern River [a]	2	1.223.2	70.4	4
Lava Creek		20.2	7.8	1
Lewis Creek [a]	21	45.3	14.3	2
Lost Cache Creek		34.2	10.2	1
Marble Creek		42.3	11.4	2
Maxwell Creek		117.0	16.3	2
Middle Creek*	27	10.0	4.8	1
Mush Creek	108	147.9	23-5	3
Mush Lake Creek X2*		1.5	3.0	1
Mush Lake Creek #12*	89	1.5	3.0	1
Mush Lake Creek #13*		1.5	3.0	1
Hush River*	106	2.8	1.1	4

TABLE 10.1 Drainage area, length, and stream order of flowing waters in and near Kluane National Park' (Continued).

Water	Ref. No. Fig. 10.1'	Drainage Area[2]	Stream Length	Stream Order[3]
Nines Creek	32	64.7	18.3	4
Park Creek		28.8	7.6	2
Pine Creek	60	157.4	10.5	3
Plug Creek		282.8	26.8	3
Plum Creek*	91	24.1	9.6	2
Pool Creek*	23	10.1	6.0	1
Ptarmigan Creek		40.8	9.8	2
Quill Creek (north) [a]	10	78.0	23.4	3
Quill Creek (south)		151.5	25.4	2
Raft Creek		79.3	7.8	2
Rain Creek'	45	10.2	5.2	1
Red Creek*	86	0.3	1.1	1
Peed Creek [a]	6	43.7	13.1	2
Shaft Creek	84	53.3	12.7	2
Sheep Creek	35	49.0	15.1	3
Ship Creek*	18	10.5	6.0	2
Shorty Creek		28.3	3.8	3
Sickle Creek		22.3	7.6	2
Silver Creek (north) [a]	48	101.7	19.9	2
Silver Creek (south)		60.3	15.2	2
Slims River	40	1,488.6[d]	24.2	4
Slipping Creek*	28	28.0	7.4	2
Sockeye River*	69	12.7	4.8	3
Spring Creek		466.6	22.7	2
Steeple Creek	-	738.4	22.3	2
Suyden Creek		31.8	9.3	1
Sulphur Creek [a]	50	113.5	11.6	2
Summit Creek		51.6	14.9	2
Super Cub Creek		126.5	17.0	2
Swede Johnson Creek a	5	120.8	16.5	3
Tatshenshini River	117	6,365.5	155.4	5
Telluride Creek [a]		77.2	13.4	2
Victoria Creek	81	178.2	20.6	3
Village Creek [a]	116	31.3	4.8	2
Virgin Creek		25.7	6.7	2

TABLE 10.1 Drainage area, length, and stream order of flowing waters in and near Kluane National Park.[1] (Concluded)

Water	Ref. No. Fig. 10.1)	Drainage Area[2]	stream Length	Stream Order[3]
uclan Creek	46	59.1	10.3	2
ade Creek [a]	9	95.7	18.3	3
hite River [a]	1	46,749.5	282.6	6
'illiscroft Creek	34	12.3	6.6	2
'olverwine Creek	96	86.9	16.6	3
ukon Rivet [a]		39,160.0	2,554.0	8

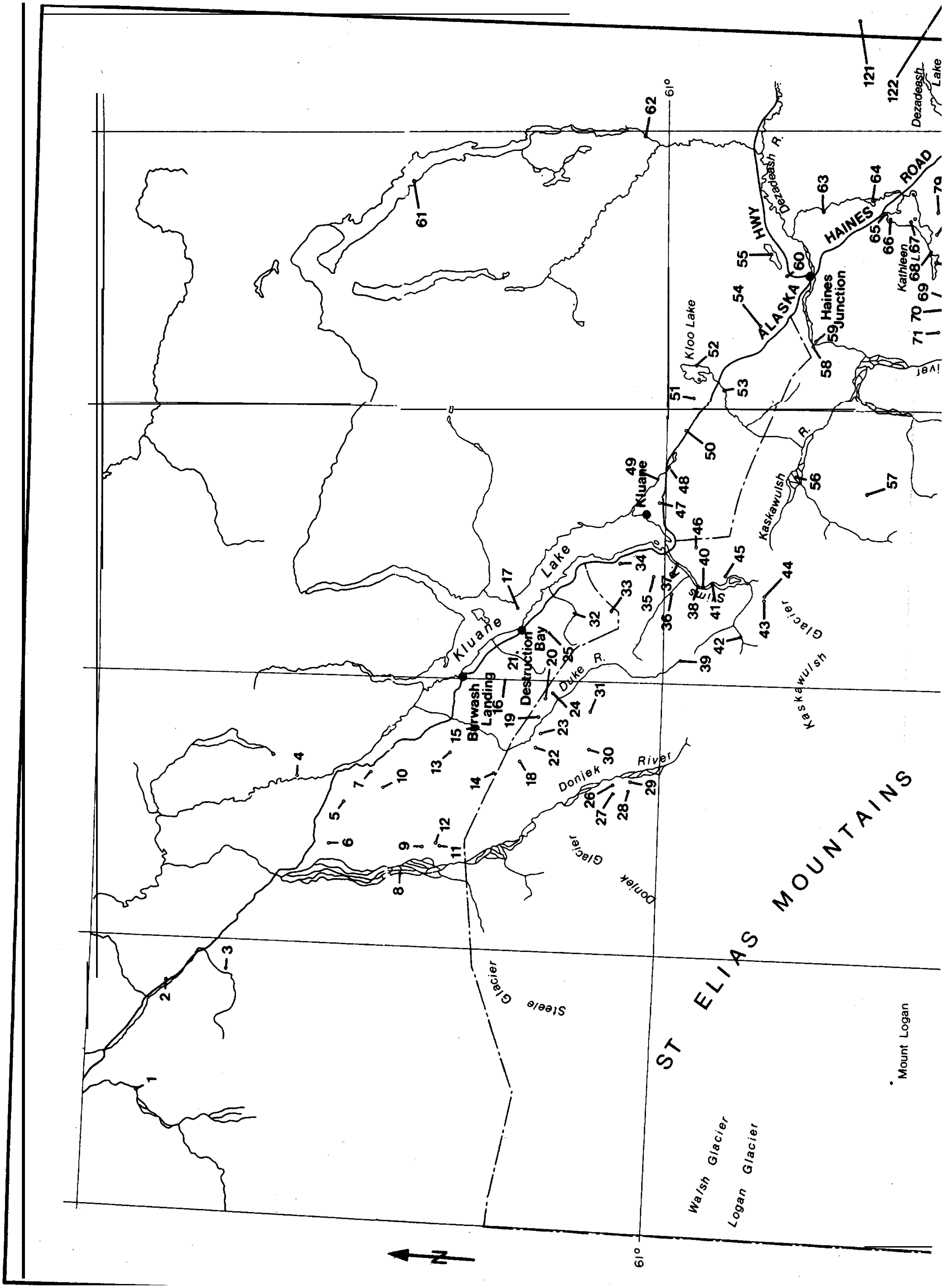
FOOTNOTES:

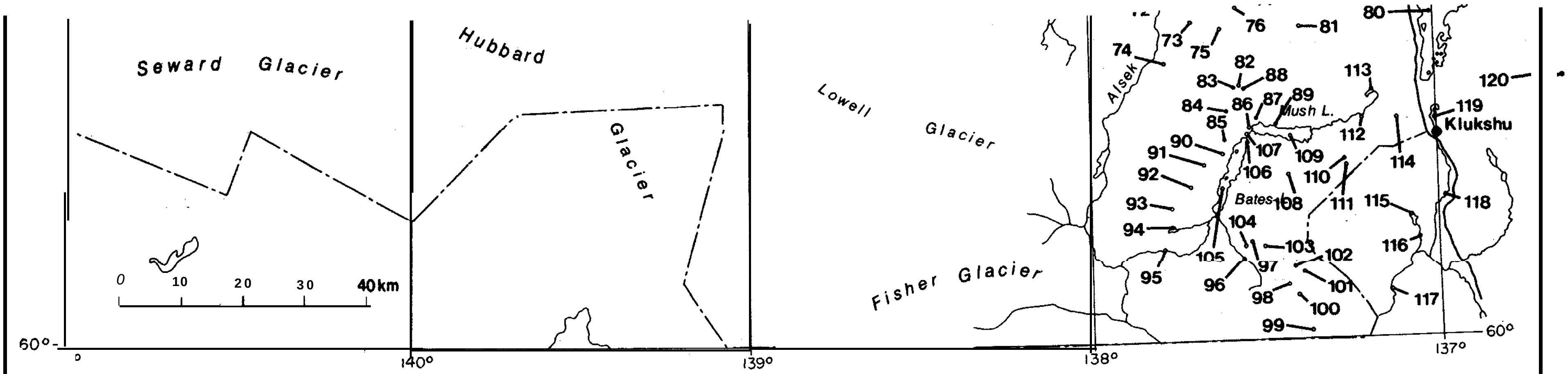
1. Source : Wickstorm 1978.
2. Area includes all land and water area contributing.
3. Stream Order - relation of stream magnitude measured by its hierarchy of tributaries. First-order streams are those which have no tributar ies; second-order streams are those which have only first-order tributaries. When two second-order streams meet they form one of thir order, and so on, with the proviso that acquisition of extra tributar ies of a lower order other than that of the receiving stream does not increase the order of that stream. A third-order stream may receive first - or second-order tributaries without becoming a fourth-order stream (Leopold et al, 1964; Hynes, 1974). Map scale determines relative measure; 1:250,000 used in above table.

Local name

peripheral to Kluane National Park

Includes one-half the value determined for the Kaskawulsh Glacier system.


Kluane Lake
Kluane
Burwash Landing
Destruction Bay
Duke R.
Donjek River
Donjek Glacier
Steele Glacier
Kaskawulsh Glacier
Kaskawulsh R.
ST ELIAS MOUNTAINS
Mount Logan
Walsh Glacier
Logan Glacier
Kloo Lake
Haines Junction
HAINES ROAD
ALASKA HWY
Dezadeash R.
Dezadeash Lake
Kathleen L.
61°
N



KLUANE NATIONAL PARK RESERVE

Figure 10.1 Location of standing and flowing waters in Kluane National Park.

LOCATION	NAME	POSITION LATITUDE N.	LONGITUDE W.
	White River a	63°11′	139°36′
2	Koidern River (Edith Creek) a	62°02′	140°29′
3	Ediih Creek (Koidern Rived a	61°48	140°02
4	Kluane River a	61°52	139°42′
5	Swede Johnson Creek 8	61°36	139°24′
6	Reed Creek a	61°36′	13941′
7	Glacier Creek a	61°31′40″	139°19′30′
8	Donjek River	62°36′	140°00′
9	Wade Creek a	61°27′30″x	1394225-X
10	Quill Creek (north) a	61°32′	139°19′
11	Phalarope Lake*a	61°23′25′	139°41′00′
12	Eagle Lake*a	61°23′30′	139°41′30′
13	Burwash Creek	61°30′	139°17
14	Granite Creek	61′17	139°15
15	Duke River	61°26′00″	139°06′25′
17	Kluane Lake a	61°15′	138°40′
16	Ship Creek*	61°15′15′	139°14′25′
[illegible]	[illegible]	[illegible]	[illegible]

LOCATION	NAME	POSITION LATITUDE N.	LONGITUDE W
69	Sockeye River*	60°32′	137°33′
70	Sockeye Lake	60°30′	137°37′
71	Trout Lake	60°31′15″	137°42′00″
72	Castle Lake*	60°29′30″	137°43′
73	Campsite Lake	60°28′	137°43′
74	Alsek River	59°27′	137°53′
75	Cottonwood Creek	60°29′30″	137°37′30″
76	Johobo Lake’	60°29′15″	137°35′30″
77	Upper Kathleen Lake*(Louise L.)	60°32′00″	137°28′00″
77	Louise Lake (Upper Kathleen L.*)	60°32′00″	137°28′000″
78	Clear creek-	60°32′20″	137°22′20″
79	Goat Creek	60°33″	137°20′
80	Dezadeash Lake a	60°28′	136°58′
81	Victoria Creek	60°33′	137°25′
82	Short Pond’	60°22′03″	137°34′37″
83	Cottonwood Lake’	60°[illegible]000″	137°34′45″
84	Shaft Creek	[illegible]	[illegible]

19	Bone Lake*	61°13'10"	139°08'45"
20	Halfbreed Lake*	61°12'30"	139°04'20"
21	Lewis Creek a	61°18	138°51'
22	Knob Creek*	61°13'45"	139°13'35"
23	Pool Creek'	61°13'45"	139°13'10"
24	Blueberry Pond*	61°12'00"	139°03'55"
25	Bock's Creek	61°13	138°45'
26	Middle Lake*	61°05'00"	139°22'30"
27	Middle Creek*	61°06'00"	139°22'45"
28	Slipping Creek*	61°04'35"	139°21'30"
29	Snipe Lake*	61°03'35"	139°22'25"
30	Bighorn Creek	61°09'05"	139°23'45"
31	Grizzly Creek	61°10	139°04'
32	Nines Creek	61'13	138°33'
33	Congdon Creek	61°09	138°33'
34	Williscroft Creek	61°05	138°32'
35	Sheep Creek	60°58'55" x	138°34'35" x
36	Bullion Creek	60°57'30"	138°37'40" x
37	Coin Creek	60°58'55"	138°34'35"
38	Spring pond*	60°54'35"	138°37'15"
39	Duke Glacier Melt Pool No. 1*	60°56'50"	138°53'45"
40	Slims River	60°59'25"	138°33'00"
41	Slims River Marsh*	60°55'30"	138°39'10"
42	Canada Creek	60°51'	138°37'
43	Fruit Creek'	60°50'50"	138°37'05"
44	Kaskawulsh Melt Pool No. , •	60°50'	138°37'
45	Rain Creek*	60°53'35"	138°37'25"
46	Vulcan creek	60°58'05"	138°34'35"
47	Silver Creek (north) a	61°02'	138°24'
48	Hungry Lake a	60°59'	138°10'
49	Christmas Creek a	61°03'	138°23'
50	Sulphur Creek a	60°53'	138°02'
51	Sulphur Lake a	60°57'	137°59'
52	Kloo Lake a	60°58'	137°52'
53	Jarvis River	60°46'	138°08'
54	Bear Creek (north)	60°45'25" x	137°40'30"
55	Pine Lake a	60°49'	137°27'
56	Kaskawulsh River	60°40' x	137°47' x
57	Airdrop Lake	60°39'	138°17'
58	Rita Pond*	60°44'45"	137°45'30"
59	Lynx Lake*	60°44'30"	137°44'50"
60	Pine Creek	60°46'	137°36'
61	Aishihik Lake a	61°25'	137°15'
62	Aishihik River a	60°51'	137°05'
63	Kathleen River	60°46'05"	137°23'20"
64	Rainbow Lake a	60°38'	137°15'
65	Cathie Lake*	60°37'00"	137°16'45"
66	Hectare Lake*	60°36'45"	137°17'25"
67	Kathleen Lake	60°35' x	137°18'
68	Duck Creek*	60°32'20"	137°26'00"
		[illegible] x	137°34' x
85	Bates Lake Creek No. 10*	60°17'20"	137°35'30"
86	Red Creek*	60°18'25"	137°33'25"
87	Bear Creek* (south)	60°19'00"	137°31'00"
88	Quaking Pond*	60°22'000"	137°34'35"
89	Mush Lake Creek No. 12*	60°19'45"	137°27'55"
90	Cranberry Lake*	60°16'40"	137°37'30"
91	Plum Creek*	60°14'40"	137°37'30"
92	Field Creek - upper station*	60°12'00"	137°46'00"
92	Field Creek - lower station	60°12'05"	137°38'35" x
93	Field Lake'	60°11'55"	137°46'45"
94	Upper Suspended Lake*	60°10'	137°47'
94	Lower Suspended Lake'	60°10'	137°44'
95	Bates River	60°06'	137°57'
96	Wolverine Creek	60°11'	137°39'
97	Jutland Lake*	60°08'50"	137°33'15"
98	Onion Lake	60°05'45" x	137°25'00"
99	Bridge River	60°00'	137°13'
100	Climbing Lake*	60°30'45"	137°24'15"
101	Climbing Creek*	60°06'00"	137°23'15"
102	Hiking Creek*	60°08'55"	137°24'45"
103	Lichen Lake*	60°08'30"	137°29'20"
104	Ptarmigan Pond*	60°08'45"	137°33'45"
105	Bates Lake	60°15'	137°36'
106	Mush River*	60°17'	137°33'
107	Scud Lake*	60°17'55"	137°33'15"
108	Mush Creek	60°18'05"	137°29'20"
109	Mush Lake	60°18'	137°26'
110	Fraser Creek	60°18'30" x	137°19'45" x
111	Missing Lake*	60°14'25"	137°16'45"
112	Alder Creek	60°18'15"	137°21'45"
113	Cyclops Lake* (Lake Ray)	60°21'20"	137°21'45"
113	Lake Ray (Cyclops Lake*)	60°21'20"	137°11'30"
114	St. Elias Lake	60°19'	137°07'
115	Nesketaheen Lake a	60°10'30"	137°04'30"
116	Village Creek a	60°07'25"	137°04'30"
117	Tatshenshini River	60°00'	137°12'
118	Klukshu River a	60°07'	137°02'
119	Klukshu Lake a	60°19'	136°59'
120	Frederick Lake a	60°24'	136°40'
121	Dezadeash River	60°40'	137°47'
122	Kusawa Lake a	60°20'	136°13'

Source: Wickstrom 1978.

1 Unless otherwise noted, positions are those described by the Canadian Permanent Committee on Geographical Names in the Gazetteer of Canada, Yukon, Provisional Edition, 1971, and the Cumulative Supplement. Additions and Corrections to 31 December, 1973. Energy, Mines and Resources Canada. Gazetteer co-ordinates given to minutes only; further, position to seconds estimated from topographical map.

* Not official names; used here for reference only. Position determined from 1:50,000 topographical charts where available, otherwise from 1:250,000.

x Differs from position shown in Gazetteer of Canada, which is suspected to be in error.

a Water entirely outside Park boundary.

temperatures are cold and the streams support only a few aquatic invertebrates; no fish were ever found. Victoria, Bighorn, Canada, Vulcan, and Grizzly creeks are typical; Map 6.2 shows Canada Creek and some higher unnamed tributaries. These creeks are 1st, 2nd, or 3rd order streams at 1:250,000.

3. Alpine streams. These high elevation streams originate from annual snowmelt, precipitation, or other hillside drainages and temporary ponds. They are dry in autumn and winter. Stream channels and banks are comprised of boulders, coarse gravel, or other unconsolidated material. The channels wander across the hillsides at time of high discharge. Riparian vegetation is limited but invertebrate fauna were present sometimes in large numbers ; a few fish, usually slimy sculpin or Arctic grayling, were occasionally found. Alpine tributaries of Victoria Creek are examples.

4. Woodland streams. Montane or subalpine wetlands and ponds are the sources of these streams. They are often seasonal. Water temperatures reflect daily means and the streams characteristically have low silt loads and good cover from overhanging and emergent riparian vegetation. Some display humic colouring. The streams are productive for invertebrates, and fish were present in the premanent streams.

5. Outflow type streams. Outflow streams such as the Kathleen, Bridge, Jarvis, and Bates rivers and Mush Creek originate as drainage from the major lakes in Kluane. They have year round flow and are clear-running as most sediment settles out in the lake basins. Stream beds are alluvial gravel or cobbles and water temperature usually reflects that of the lake. Epilithic (growing on stones) flora is conspicuous and riparian vegetation is well established. The same fish species occurring in the source lake are usually resident in these rivers. Stream order ranges from 2nd to 4th at 1:250,000.

6. Precipitation type streams. These streams carry water only during and immediately after freshets. They flow in gullies and ravines on steep hillsides, carrying high suspended loads. They do not support aquatic life.

Wickstrom (1978) recorded few springs during his study but attributed this more to their small size and inconspicuous nature than any rarity. Springs were always very cold and calcareous. Some provided water to small ponds which were considerably warmer and supported high standing crops of flora and fauna. Arctic grayling and slimy sculpin were found in such ponds along Dezadeash River. Dezadeash River is different than other streams in this sytem of classification as it is the only large river in the Park which is not directly glacier-fed. It drains Aishihik, Dezadeash, and Kathleen lakes.

10.3.1.4 Standing Waters

There are six major Lakes and 40 smaller ones in Kluane, ranging in size from Kathleen at 3375 ha to ponds of less than 0.5 ha. Table 10.2 summarizes physical data on all standing waters including an index describing the irregularity of the shoreline. By this measure, a circular lake has a shoreline development factor of 1.00; higher values indicate a more irregular shoreline and the possible presence of shallow water areas important to aquatic life. The usefulness cf this factor as a productivity index declines with lake size as the smaller lakes tend to be more regular in shape and shallower overall.

Most of the large lakes basins in Kluane were formed by glacial scour in areas of weakness in bedrock or unconsolidated material. These lakes include Mush, Bates, Onion, Louise, and Kathleen lakes, Kathleen and Louise were once a single basin but subsequent deposition of an alluvial fan by Victoria Creek across the basin ha; completely separated them.

Alpine tarns such as Lichen, Climbing, and Airdrop lakes now occupy the basins of former cirque glaciers at high elevation. Field Lake is an example of small shallow basins formed by glacial erosion on mature rolling plateau areas.

Most of the medium-sized lakes in the Park, such as Halfbreed, Cottonwood, Sockeye, and Trout, were formed in irregular depression:; in ground moraine. Kettle lakes are also present in the major valleys, formed by the in situ melting of ice blocks following glacier retreat.

Lakes and ponds formed on or in contact with glacier ice occur on several of the major glaciers. These may form between the ice and the valley wall, in the terminus area, or on the ice surface itself, Examples up to 0.5 ha in area occur on the Kaskawulsh and Donjek glaciers. These features can be seen on Map 6.2 showing the terminus of Kaskawulsh Glacier.

Small glacier-dammed lakes occur throughout Kluane today; most are temporary, draining and reforming annually or every few years. Much larger glacier-dammed lakes existed in the hlsek and Donjek valleys in historic times, and could reform if the Lowell and Donjek glacier: were to advance significantly (see section 6.3.7.7).

Many ponds, such as Rita and Spring, have formed throughout Kluane in irregular depressions in modern floodplains. Lynx Lake has formed between a levee and the scarp defining the edge of the Dezadeash River floodplain. Beaver dams have caused the formation of Lake Ray and Missing Lake.

Nickstrom (1978) produced bathymetric charts of 17 of the Park's lakes and found few bottom irregularities, probably due to heavy deposition of silt during glacial recession. He consistently found

Table 10.2 Physical characteristics of standing waters in and near Kluane National Park.

Water	Ref. No. (Fig. 10.1)	Elevation m	rainage Area km^2	Lake Surface Area ha	Maximum Depth m	Mean Depth m	Volume 105 m^3	ength of horeline km	Development of Shoreline	Secchi Disc Transparency m
Airdrop Lake	57	1585	5.5	21.1						
Bates Lake	105	680	960.5	1,815.2	56.0	30.1	,461.6	34.70	2.30	22.5
Blueberry Pond*	24	1539	0.6	0.6	1.6					to bottom
Bone Lake*	19	1189	1.1	2.4	0.6					to bottom
Campsite Lake	73	792	5.8	13.4				1.90	1.46	
Cathie Lake*	65	731	2.8	48.2	1.8	1.0	4.7	3.32	1.35	to bottom
Climbing Lake*	100	1211	1.4	22.3	19.5	6.1	13.7	2.15	1.29	7.0
Cottonwood Lake*	83	1036	2.5	28.2	10.5	2.2	6.3	3.97	2.11	8.0
Cranberry Lake*	90	792	1.4	5.1	2.75	1.9	1.0	0.85	1.06	to bottom
Cyclops Lake' (Lake Ray)	113	799	5.4	82.5	5.5	1.5	12.6	8.86	2.15	to bottom
Dezadeash Lake [a]	90	702	,084.2	7,949.5	7.63			63.80	2.02	2.1 to 4.03
Duke Glacier Melt Pool #1*	33	1943		2.3	-1.5					to bottom
Eagle Lake' [a]	12	884	0.1	1.1						
Field Lake*	93	1463	3.7	24.4	6.1	2.2	5.4	4.32	2.47	to bottom
Frederick Lake [a]	120	716	391.0	508.1	23.53					6.1[3]
Halfbreed Lake*	20	1478	1.8	2.0	1.8					1.0
Hectare Lake*	66	731	0.2	2.2	1.75					to bottom

TABLE 10.2 Physical characteristics of standing waters in and near Kluane National Park (Continued).

Water	Ref. No. (Fig. 10.1)	Elevation m	Drainage Area km^2	Lake Surface Area ha	Maximum Depth m	Mean Depth m	Volume 10^5 m^3	Length Shoreli km	Development of Shoreline	hi spa m
Hungry Lake [a]	48	909	125.2	67.9	.	.	.	.	.	.
Johobo Lake*	76	823	4.3	26.0	.	.	.	2.12	1.18	.
Jutland Lake*	97	1189	4.2	16.3	10.5	3.3	5.4	3.53	2.47	7.5
Kaskawulsh Melt Pool #1*	44	884	0.04	0.1	.	.	.	.	.	bot m
Kaskawulsh Melt Pool #2*	-	884	0.04	0.1	.	.	.	.	.	bot m
Kaskawulsh Melt Pool #3*	-	884	0.04	0.1	. .	.	. .	.	.	bot m
Kathleen Lake	67	731	641.4	3,375.8	111.0	55.2	18,619.1	42.73	2.07	8.5
Kloo Lake [a]	52	876	743.9	1,266.8	12[3]	.	.	.	.	2.4
Kluane Lake [a]	17	781	5,790.0[2]	40,906.6	~82[3]	.	.	279.53	3.90	3.4
Klukshu Lake [a]	119	704	101.9	157.4	.	-	.	13.36	2.98	.
Kusawa Lake [a]	122	671	4,060.6	14,089.4	.	-	.	173.14	4.11	.
Lake Ray (Cyclops Lake*)	113	799	5.4	82.5	5.5	1.5	12.6	8.86	2.75	bot
Lichen Lake*	103	1341	3.7	12.7	4.0	-	.	2.24	1.77	bot
Louise Lake (Upper Kathleen L.*	77	739	437.0	490.3	76.5	47.6	2,334.0	12.93	1.65	.
Lower Kathleen Lake [a]	-	728	681.9	119.8	.	-	.	.	.	.
Lower Suspended Lake*	94	881	12.8	70.5	.	-	.	7.44	2.59	
Lynx Lake*	59	572	0.01	1.6	8.7	2.8	1.2	0.91	1.26	4

TABLE 10.2 Physical characteristics of standing waters in and near **Kluane** National Park (Continued).

water	**Ref.** *No.* (Fig. 10.1)	**Eleva-tion m**	**rainage Area km^2**	Lake Sur-face Area ha	Maximum Depth **m**	Mean Depth **m**	volume **10^5 m^3**	**ength of horeline** km	**Develop-**ment of Shoreline	**Secchi** Disc Transparency m
Middle Lake*	26	1183	0.01	14.7	~ 2.0		2.28	2.28	1.68	to bottom
Missing Lake*	111	777	1.1	17.3	2.0	1.1	2.0	2.53	1.66	to bottom
Mush Lake	109	686	613.1	1,830.5	61.5	39.2	7,176.9	31.06	2.05	13.0
Nesketaheen Lake [a]	115	861	22.5	68.2						
Onion Lake	98	846	65.1	189.0	28.5	17.4	328.4	8.97	1.84	16.25
Phalarope Lake* a	11	899	0.05	0.8						
Pine Lake [a]	55	663	78.6	613.8	273			13.19	1.59	6.7 to 12.8[3]
Ptarmigan Pond*	104	1192		2.3	-1.0					to bottom
Quaking Pond*	88	1040		0.05	-1.5					to bottom
Rainbow Lake [a]	64	720	733.8	142.7						
Rita Pond'	58	580		2.3						to bottom
St. Elias Lake	114	890	4.2	20.5				3.44	2.14	
Scud Lake*	107	739	0.4	3.9				1.08	1.54	
Short Pond*	82	1039		0.05						to bottom
Slims River Marsh*	41	780		4.6						to bottom
Snipe Lake*	29	1272	2.4	9.4	6.5	2.9	2.1	1.59	1.46	4.2
Sockeye Lake	70	789	175.8	172.8	27.4	17.3	298.6	7.34	1.58	5.25

TABLE 10.2 Physical characteristics of standing waters in and near Kluane National Park (Concluded).

Water	Ref. No. (Fig. 10.1)	Elevation m	Drainage Area km^2	Lake Surface Area ha	Maximum Depth m	Mean Depth m	Volume 10^5 m^3	Length of Shoreline km	Development of Shoreline	Secchi Disc Transparency m
Spring Pond*	38	780	•	6.1	~ 1.5	•	•	•	•	to bottom
Sulphur Lake [a]	50	847	12.5	148.2	23	•	•	•	•	to bottom[3]
Prout Lake	71	159	29.4	40.1	.	•	•	3.85	1.72	
Upper Kathleen Lake* (Louise L.)	77	739	437.0	490.3	76.5	47.6	,334.0	12.93	1.65	3.25
Upper Suspended Lake*	94	884	6.4	53.7	.	.	,	5.12	2.01	

Source : Wickstrom 1978.

* Local name.

a Water peripheral to Kluane Park.

1. Includes all land and water area contributing.

2. Drainage area includes one-half the value determined for the Kaskawulsh Galcier System.

3. Data from Bodaly, R.A., 1977, Personal communication to R.D. Wickstrom.

bottom sediments to be almost entirely silt, with little organic matter present. Islands are relatively rare, again because of glacial scouring. Basins formed in till have more irregular bottoms.

The temperature, length of open water season, and consequently productivity of Kluane's lakes, depend largely on elevation. Lakes in Kluane range from 572 m to 1585 m asl, with meltwater pools existing at even higher elevations. Wickstrom (1978) sampled lakes from 676 m (Bates L.) to 1585 m (Airdrop L.).

Secchi disc readings are used to define the euphotic zone, the depth of light penetration into a lake or other waterbody. This has a direct relationship to the primary productivity of algae. Wickstrom (1978) indicates that dissolved and colloidal material producing humic colouring in the water as well as turbidity caused by suspended sediment are important in reducing light penetration.

By this measure, Bates Lake is the clearest of the Park's large lakes with a reading of 22.5 m. Kathleen is next at 18 m. Input of sediment from Victoria Creek markedly reduces the clarity of Louise Lake producing a reading of only 3.3 m. Sockeye Lake is similarly affected by sediment from Cottonwood Creek. For comparison, Kluane Lake gave a reading of 3.4 m near the south end of the lake where the Slims River discharges. Many of the smaller lakes are very clear and the disc could be seen to the bottom. Secchi disc readings are included in Table 10.2.

The instantaneous and annual variation of water temperature in a lake is an important characteristic, affecting aquatic life of all kinds. Most of the small shallow alpine, subalpine, and montane lakes freeze to the bottom every winter and they consequently do not support fish. Overwintering habitat for fish requires not only water, but sufficient dissolved oxygen and food to sustain life beneath the ice cover. No data on winter oxygen depletion are available for lakes in Kluane so for planning and construction purposes, it could be assumed that some lakes not freezing to the bottom may support overwintering fish.

During the winter and spring, under an ice and snow cover, temperatures in the larger lakes will vary from near 0°C immediately beneath the ice to a temperature of +4°C or slightly less at depth. As surface water reaches its maximum density at this temperature and tends to fall to the bottom and collect there. Following spring break-up, the phenomenon of 'spring turnover' occurs as the surface waters warm from 0° to +4°C, reach their maximum density and fall, displacing water at depth and causing water to mix throughout the lake. At this time, light surface winds can circulate the entire lake causing deep mixing of the lake water because it is all at a relatively similar density. Later in spring and summer, rapid warming of the surface water layers above 4°C occurs, spring turnover ceases, and a characteristic temperature - depth profile develops. The warmed layer - the epilimnion - attains a relatively uniform temperature through circulation and turbulence. The lower layer - the hypolimnion - remains cold, stable and undisturbed. The interface (mixing) area between these two layers where temperature changes rapidly with depth is called the metalimnion.

Within this zone, the plane at which temperature decreases most rapidly with depth is called the thermocline. The thermocline is a narrow zone of discontinuity between water masses of difference temperatures and therefore different densities, and is subject to vertical movements due to wind action. Warming continues through the summer but in autumn heat loss begins to exceed radiative input and the epilimnion will cool and thicken as heat is transferred downward. Eventually the thermocline dissappears and the lake becomes isothermal again at 4°C or slightly above. Further cooling allows the ice cover to be reestablished.

This pattern is complicated by the physical and thermal disruption caused by streamwater input to the lake. The temperature of streamwater may be higher or lower than that which the lake would develop in isolation; the physical movement of the water causes currents, mixing, and heat input through friction.

On the basis of thermal structure, Wickstrom (1978) classified Kluane's lakes as lst, 2nd, or 3rd order according to Hutchinson (1957). First and second order lakes have thermal stratification: the former with hypolimnia temperatures near 4°C, the latter with hypolimnia temperatures significantly above 4°C. Third order lakes show no thermal stratification.

Mush, Sockeye, and onion lakes are examples of first order lakes. The low hypolimnion temperature indicates that thermal stratification is established soon after spring turnover. These lakes are located in sheltered valleys at low elevation where wind conditions do not encourage mixing. Depending on the meterorological conditions (temperature and wind) after break-up in a given year, subalpine and alpine lakes such as Jutland and Climbing may also show first order characteristics.

Bates, Louise, Cottonwood, and Kathleen are second order lakes, with hypolimnia temperatures significantly above 4°C. This indicates that spring turnover and mixing probably continued for several weeks after break-up allowing bottom temperatures to warm up to 6-8°C. Cool windy weather after break-up is conducive to development of this pattern. The lakes mentioned above all experience windy conditions. only Bates Lake showed good thermal stratification in the year studied although the hypolimnion was evaluated. Kathleen, renowned for its strong winds, had a gradient of 2°C or less from the surface to hypolimnion, an elevated hypolimnion temperature of 8°C, and very weak stratification. Louise had a gradient of 5°C (10°C at the surface; 5°C at depth) but very weak stratification (Wickstrom 1978). Wickstrom (1978) states that meteorological conditions after break-up rather than size or depth are the factors which determine lake temperature under these circumstances.

Most other lakes in Kluane are third order. Lakes less than 10 m deep do not stratify and have gradients of only about 1°C, probably due to continual mixing by the wind. Snipe, Field, and Lynx lakes all showed surface and bottom temperatures between 11° and 12°C. very shallow lakes (less than 3 m) like Missing, Bone, and some high elevation lakes may stratify during the day and cool, mixing again at night.

Lakes are efficient heat sinks, storing energy in proportion to their volume. In low temperate latitudes, this heat source actually prevents some lakes from freezing over in winter. However, in the Kluane area, all lakes develop a thick, complete ice cover. Ice is thickest on small lakes in the northern part of the Park were snowfall is least and where wind keeps the surface blown free of snow. Table 3.7 gives ice thickness data for several lakes in the Park. No data are available on freeze-up and break-up. Louise, Mush, Bates, and Kathleen are the last lakes to freeze because of their large volume and stored heat. An uncharacteristically long open water season occurred in 1976 when Kathleen did not freeze over until the second week in December. For comparison, the earliest Kluane Lake has frozen over is November 7 and the latest December 6 (1966-1974 data; see Table 3.6); in this same period, the earliest the lake has been clear of ice is May 25 and the latest June 20.

During his summer field program, Wickstrom (1978) found oxygen saturation of 16 mg/l in the epilimnion, metalimnion, and hypolimnion of most lakes. The extent of winter oxygen depletion is unknown.

10.3.2 Chemical Characteristics

Wickstrom (1978) collected midsummer water samples for chemical analysis from selected waterbodies listed in Appendix 10.1. These data represent baseline information collected to allow characterization and description of the waters of Kluane; more detailed studies of individual parameters or seasonal variation are needed before statistically significant quantitative analysis and comparisons can be done.

10.3.2.1 Factors Affecting Water Chemistry

The chemical constituents in Kluane's lake and streamwater are derived from:

1. solution of minerals and other constituents from underlying bedrock and sediments during run-off and groundwater flow through the drainage basin; and

2. the composition of precipitation originating from sources outside the basin.

Minerals and nutrients are dissolved as run-off and groundwater pass over and through the local bedrock. Kluane's geological setting is complex but the majority of the bedrock is sedimentary and calcareous (limestone, dolomite). This is reflected in generally high pH and alkaline pH values but varies for each water with the geological makeup of its specific basin and associated drainage.

Streamflow and groundwater introduce to the waterbody the characteristics of their source areas, reflecting the terrain they have passed over in the interim, and any foreign substances they carry. This aspect is of most concern when dealing with pollution sources and harmful substances, such as sewage, oil spills, road salt or unnaturally high levels of herbicide, insecticide, or phosphate entering the system as run-off from agricultural areas. Some of these harmful sources have the potential to affect Park waters and they are discussed in greater detail in section 10.8.

10.3.2.2 Characteristics

Appendix 10.1 presents chemical analyses of water samples from lakes and streams in Kluane. These data reflect most closely their source areas.

Small lakes, ponds, and streams fed directly by precipitation or meltwater, commonly at high elevations, have low concentrations of major exchangeable cations (Ca - calcium, Mg - magnesium, Na - sodium, K - potassium), low values of total dissolved solids, low alkalinity, relatively neutral pH, and low concentrations of nutrients such as orthophosphate and nitrogen. Lichen, Field, and Climbing lakes are typical examples. Water in these lakes closely ressembles the composition of precipitation itself and with few industrial sources of airborne pollutants, rainwater and snow in this region are chemically very pure.

On the larger waterbodies, streams generally show higher concentrations of major cations, total dissolved solids and nutrients than standing waters, particularly the turbid high energy streams tributary to the Slims, Donjek, and Duke rivers which drain through friable bedrock and loose unstable unconsolidated material. Nutrient concentrations are higher in streams because they usually have fewer sources of organic uptake (plants, aquatic invertebrates and fish) . Nitrogen content was unusually high in Missing Lake (200 ug/l), a shallow low elevation lake supporting relatively large amounts of aquatic vegetation. The waters of Lake Ray, a physically similar lake, measured only 10 ug/l.

Wickstrom (1978) measured heavy metal concentrations on several streams and lakes and found high concentrations of copper, iron and nickel in streams passing through bedrock areas rich in these metals.

Exceptions to most of the above statements occur in spring-fed ponds, such as Slims River marsh, which exhibit the highest values for all parameters measured, reflecting their groundwater source and its typically higher concentrations of chemcial constituents.

10.4 Aquatic Flora

1014.1 Periphyton

Periphyton are aquatic algae which grow attached to other living or non-living elements on the submerged substrate. They usually grow in shallow water ponds or in the shallows of lakes where they are able to attach themselves and where light reaches the bottom. Species which grow in streams have evolved special methods of attaching themselves securely to the substrate be secreting large amounts of gelatinous material. The presence.of nitrogen, phosphorus, and of course light are necessary for the growth of algae.

Species belonging to three divisions of **algae** were in found in Kluane's lakes: Chrysophyta (golden algae) of which diatoms were the most abundant; Chlorophyta (green algae) forming net-like filmentous colonies; and Cyanophyta (blue-green algae) also filamentous and colonial. Appendix 10.2 lists the 102 species of periphytic algae collected in nine selected lakes in Kluane.

10.4.2 Phytoplankton

Phytoplankton are free-floating algae inhabiting the euphotic of lakes. The depth to which light penetrates, as well as levels of available nutrients, controls algal growth. If the lake is clear, photosynthesis can occur down to 15 m (Jensen & Salisbury 1972). If not, or if algae are so numerous near the surface that they absorb most of the light and shade the lower levels, growth will be. concentrated in the upper few metres. The growth cycle of algae is tied to spring turnover. Some species of algae can overwinter in the zone of light penetration directly below the ice. It is not known if this occurs in Kluane, although it is presumably possible on lakes which are blown free of snow. Spring turnover brings nutrient-rich water from the bottom into the euphotic zone and stimulates growth. Once thermal stratification is established, mixing and nutrient enrichment stops and the algae grow through the summer on the nutrients available in the epilimnion. In fall, their numbers decrease because the nutrient supply is nearly exhausted and because of lowered light levels. Decay of algae is one source of nutrient enrichment of the lower levels of the lake, but depletion of oxygen during the decay process may significantly lower oxygen levels for overwintering fish.

Wickstrom (1978) collected 137 species of planktonic algae including: 35 species of Chlorophyta (green algae): 15 Cyanophyta (blue-green algae); 79 Chrysophyta, including 44 diatoms; 5 Cryptophyta; and 3 Pyrrophyta (dinoflagellates). The Chrysophyta were dominant. These are listed in Appendix 10.3.

Aquatic algae occupy a diverse range of habitats and provide food for protozoa, aquatic invertebrates, and fish. They are the primary producers upon which the productivity of the higher trophic levels depends. Sufficient information is not available at the present time to discuss the ecological significance of phytoplankton in Kluane's waters in any more specific terms.

10.4.3 Aquatic Macrophytes

Aquatic macrophytes are vascular plants which grow either totally submerged, emergent, or free-floating on the surface. Wickstrom (1978) collected 91 species representing 26 families (see Appendix 10.4). One liverwort and 12 mosses were also collected (see Appendix 10.5). The vascular plants included sedges, grasses, pondweed, rushes, and horsetails. The most common species were Carex aquatilis, Calamagrostis canadensis, Juncus arcticus, Potamogeton filifonnis, Equisetum arvense, and E. fluviatile. Of the mosses collected Drepanocladus sp. was the most common, occurring in a variety of habitats from shallow littoral to deep benthic zones and in lakes of all sizes and at all elevations. Lack of suitable shallow water habitat and windy exposures of Kluane's larger lakes limit the growth of aquatic macrophytes. Only a few areas, such as Alder-Fraser creek, Sockeye-Trout lake marshes, Missing Lake and Cranberry Lake, support extensive well-established aquatic vegetation. At higher elevations, only small isolated communities occur.

10.5 Zooplankton

Zooplankton comprise the animal forms of free-living plankton including small crustaceans and small insects. Wickstrom (1978) recorded 26 species in lakes and ponds from the montane to alpine zones. These included 13 species of Cladocera, 10 species of Copepods (crustaceans), as well as amphipods, and the larval forms of Diptera (flies and mosquitoes). These species and their distribution and relative abundance are indicated in Appendix 10.6. Abundance is expressed as numbers of individuals per litre of water sampled.

Rluane appears to have fewer zooplankton species than other mountainous areas but greater populations than expected from northern oligotrophic lakes. Usually only 3 or 4 species occurred in any one lake - the greatest number of species was 6. Cyclops scutifer and Diaptomus pribilofensis were most common and one or the other of these two species dominated all the large lakes in the Park.

Wickstrom (1978) noted that the presence or absence of fish in a lake could be predicted on the basis of the zooplankters collected. The presence of Anostracoda, Chaborus, and the larger zooplankters indicated the absence of fish. These species occur in Field and Snipe lakes, which while appearing to be able to support fish, in fact do not.

10.6 Benthic, Littoral, and Terrestrial Invertebrates

Wickstrom (1978) presented a preliminary list of the aquatic and terrestrial invertebrates of Rluane (Appendix 10.7). This list is not complete because the limited time available precluded sampling of all life cycle phases. Identification of some samples to species was beyond the scope of his report.

Studies have recently been undertaken by the Biosystematics Research Institute of Agriculture Canada, the National Museum of Natural sciences, and the Royal Ontario Museum which should provide more detailed information in the future. The importance of some of these invertebrates to lake productivity and fish management is recognized from the literature but no assessment within Kluane has been made.

10.7 Fish

10.7.1 General

The waters of Kluane National Park proper support only 10 species of fish - pygmy whitefish, round whitefish, Arctic grayling, kokanee, rainbow trout, Dolly Varden, lake trout, northern pike, burbot, and slimy sculpin. All ten species are found in the Alsek drainage while the Yukon drainage in the Park support only round whitefish, Arctic grayling, and slimy sculpin. However, a total of twenty-one species occur in waters adjacent to the Park. This relatively poor Park species diversity probably reflects recent deglaciation and lack of time for dispersal, and the restricted occurrence of suitable habitat for fish. Most waterbodies are cold, have a short open water season, and high silt loads. Additionally there are simply few lakes in Kluane, particularly in the northern parts of the Park.

Some differences in species diversity between areas within and adjacent to the Park are due to the disruption of drainage patterns experienced in Kluane since deglaciation. Wickstrom (1978) states that deep glacial scouring of lake basins prevented fish surviving within the glaciated areas during the Kluane Glaciation. Most species now present in Kluane dispersed to their current habitat in post-glacial times from the Bering Refugium - a large area of unglaciated terrain in central Yukon and Alaska. Dispersal occurred along waterways carrying meltwater from the retreating glaciers.

This dispersal began in early post-glacial times via Glacial Lake Champagne formed by the extensive ponding of glacier melt water in the Dezadeash and Kathleen valleys. The Kluane Ranges and Coast Mountains were still ice-covered at this time and Glacial Lake champagne drained northeastward via the Yukon system opening what is now the upper Alsek basin to in-migration by Yukon system fish species, such as northern pike, lake trout, lake, round, and pygmy whitefish, burbot, Arctic grayling, longnose sucker, and slimy sculpin.

Ultimately, continued deglaciation opened an outlet to the Pacific southward via the present Alsek River and Lake Champagne drained, disconnecting waterbodies in the areas from the Yukon drainage. This new connection to the Pacific however probably allowed Coho, Chinook, chum, and sockeye salmon and steelhead trout to enter the system.

None of these sea-run species are present within the Park proper but occur further south in the Alsek system. However, the land-locked forms of kokanee and rainbow trout do occur.

Similarly, Kluane Lake experienced drainage changes which have affected the species composition. Initially, after deglaciation Kluane Lake drained southward via the Slims River to the Alsek, and would have been populated by fish from that system. About 450 years ago, Kaskawulsh Glacier advanced and blocked southward drainage of the Slims, raising the level of Kluane Lake until a northward outlet to the Yukon River system became available and flow through the lake reversed. The northern waters of the Park then became part of the Yukon system. Ten fish species, all from the Yukon system, are present in Kluane Lake - lake and round whitefish, inconnu, Arctic grayling, lake trout, northern pike, longnose sucker, burbot, and Slimy sculpin of Bering Refugium origin; chum salmon are coastal migrants up the Yukon River, and lake chub have dispersed inward from the Mississippian refuge (McPhail & Lindsey 1970). Rainbow trout and Dolly Varden are present in the Alsek system, but not in Kluane Lake and northern Park drainages, perhaps because they were not able to find suitable habitat in the lake following reversal or because the catastrophic changes accompanying reversal may have broken their life cycle (Lindsey 1975; Wickstrom 1978).

Least cisco, broad whitefish, and inconnu are found in the Yukon system but appear not to have moved into Glacial Lake Champagne and are absent today from the Alsek system.

In general, northern subarctic lakes are not productive. Kluane's lakes have been classified as oligotrophic - they are characteristically fairly deep, rich in oxygen, have little macrophyte vegetation around their margins, are poor in dissolved nutrients, and have low rates of fish production. In cold alpine lakes, food sources are limited and lake trout, for example grow very slowly and remain small (maximum 1.6 kg) throughout their life. Lake trout tend to grow to a much larger size (13 kg) in the larger lower elevation lakes, which are warmer and support more productive lower trophic levels (Wickstrom 1980).

The potential fish productivity of Kluane's lakes has not been evaluated by actual study. Wickstrom (1978) developed preliminary estimates, based on application of Ryder's Morphoedaphic Index (MEI), an empirically based measure derived from correlation of mean water depth and total dissolved solids with fish productivity. The MEI represents a theoretical fish yield if the lakes were moderately fished. Table 10.3 presents a summary of ME1 data for Kluane lakes. All values represent low fish productivity rates compared with more temperate waters (Wickstom 1978). Large lakes are the least productive.

Wickstrom (1978) used actual round whitefish growth rates as an alternative measure of productivity in these lakes. Round whitefish are entirely lake dwelling, pelagic in habit, and primarily

Table 10.3 Morphoedaphic Index values, fish productivity estimates, and fish growth rates for lakes in Kluane National Park.

Lake	Lake Surface Area (km²)	Mean Depth (m)	TDS* (mg/L)	M.E.I.	Fish Production* (kg/ha/yr)	Fish Growth[4] Rate (mm/yr)
Kathleen Lake (1)	33.75	55.2	124.2	2.25	1.45	29.4
Louise Lake (2)	4.90	47.6	113.5	2.38	1.49	27.6
Mush Lake (3)	18.30	39.2	96.0	2.45	1.51	32.0
Bates Lake (4)	18.15	30.1	89.0	2.96	1.66	39.9
Onion Lake (5)	1.89	17.4	62.0	3.56	1.82	-
Sockeye Lake (6)	1.72	17.3	96.1	5.55	2.28	-
Field Lake + (7)	0.244	2.2	16.5	7.5	2.65	-
Climbing Lake (8)	0.223	6.1	18.8	3.08	1.70	-
Cottonwood Lake (9)	0.282	2.2	35.3	16.05	3.87	-
Snipe Lake + (10)	0.094	2.9	154.3	53.0	7.03	-
Jutland Lake (11)	0.163	3.3	27.9	8.45	2.81	-
Missing Lake (12)	0.173	1.1	83.2	75.63	8.40	-
Ray Lake (13)	0.825	1.5	129.4	86.27	8.97	-

Source: Wickstrom 1978.

* TDS - Total Dissolved Solids

\+ Fishless Lakes

planktonic feeders, and therefore serve as a good indication of lake productivity. The rates of growth were found to be:

Louise L.	27.4	mm/year
Kathleen L.	29.4	mm/year
Mush L.	32.0	mm/year
Bates L.	19.9	mm/year.

Wickstrom (1978) believes these figures correlate well with the MEI information and support its applicability to Kluane.

MEI data on smaller lakes in Kluane are also included in Table 10.3 These are not as reliable as the lakes do not meet the criteria established by Ryder for use of the Index. In these smaller lakes which contain fish (Cottonwood, Climbing, Jutland, Middle) the major limits to productivity are high elevation, (cold water, short season), possible winter oxygen depletion, and poor invertebrate production. Other alpine and subalpine lakes which do not contain fish probably freeze to the bottom. Small lakes at lower elevations may also be fishless because of winter kill due to shallow depth or oxygen depletion through good organic production. Anomalies occur in Missing Lake and Lake Ray which are shallow (2.0 and 5.5 m respectively), support good organic growth, and have populations of Dolly Varden (Wickstrom 1978).

The following sections discuss the individual species found in Kluane. Table 10.4 lists these species and indicates their distribution in and adjacent to the Park. Scott and Crossman (1973) provide detailed life cycle information.

10.7.2 Kokanee (*Oncorhyncus nerka*)

Kokanee is the premanent freshwater form of sockeye salmon. It is morphologically identical to anadromous or sea-running sockeye and populations are thought to arise from anadromous stocks which have been denied access to the sea. The only populations of kokanee in the southwest Yukon are found in the Kathleen lakes chain and in Frederick Lake (outside the Park), both tributary to the Alsek system. Anadromous sockeye utilize the Tatshenshini River drainage, spawning in Klukshu lake and river and Village Creek. Wynne-Edwards (1947) cites information from local natives stating that sea-running salmon once migrated to the headwaters of Kathleen and Dezadeash rivers to spawn. Today, no sea-running sockeye occur in the Park. This unusual distribution is one of the most intriguing aspects of the aquatic biology of Kluane.

During his field investigations, Wickstrom (1978) documented an apparent significant decline in the kokanee population in Kathleen Lake. It was decided at that time to institute special management practices in view of the species unique status, and to undertake a more detailed study when it was felt the population had recovered sufficiently. A draft report of this study was completed in 1982 (Wickstrom In prep. a).

Table 10.4 Fish distribution in Kluane National Park and vicinity by drainage basin.

Waters by Drainage	Location No. on Fig. 10.1	Data Source	least cisco	lake whitefish	broad whitefish	pygmy whitefish	round whitefish	inconnu	Arctic grayling	chum salmon	coho salmon	sockeye salmon	kokanee	chinook salmon	steelhead trout	rainbow trout	Dolly Varden	lake trout	northern pike	lake chub	longnose sucker	burbot	slimy sculpin
ALSEK RIVER DRAINAGE		L		+		+	+		+	+	+	+	+	+	+	+	+	+	+		+	+	+
Alsek River	74																						
Kaskawulsh River	56																						
Jarvis River	53	W							+								+						+
Kloo Lake	52	B		+																			+
Dezadeash River	121																						
Lynx Lake*	59	W							+										+				
Pine Creek	60	W					+		+														+
Pine Lake	55	W		+			+		+									+	+			+	+
Aishihik River	62	S		+			+		+							+		+	+		+	+	●
Aishihik Lake	61	S		+			+		+									+	+		+	+	+
Kathleen River	63	W,C					+		+				+			+	+	+					
Rainbow Lakes	64	W,C					+									+		+					
Kathleen Lake	67	W				+	+		+				+			+	+	+				?	+
Goat Creek	79	W					+		+														+
Clear Creek*	78	W					+		+														+
Cathie Lake*	65																						
Louise Lake	77	W				+	+		+				+					+				?	●
Victoria Creek	81																						
Sockeye River*	69	W											+										
Sockeye Lake	70	W,E				+	+		+				+					+				+	+
Cottonwood Creek	75																						
Cottonwood Lake*	83	W							+									+					?
Johobo Lake*	76																						
Dezadeash Lake	80	B		+			+		+								+	+	+		+	+	+
Frederick Lake	120	B							+				+					+	+			+	?
Bates River	95																						
Suspended Lakes*	94																						
Wolverine Creek	96																						
Bates Lake	105	W				+	+		+								?	+					+
Field Creek	92	W																					+
Field Lake*	93	W																					
Shaft Creek	84	W																					+
Cranberry Lake*	90	W																					
Mush River*	106	W					+		+									+					+
Mush Lake	109	W				+	+		+								+	+					+
Scud Lake*	107																						
Red Creek*	86	W																					?
Mush Creek	108	W																					+

\+ present
? suspected
* local name
See last page of table for data source key.

Table 10.4 Fish distribution in Kluane National Park and vicinity by drainage basin (continued).

Waters by Drainage	Location No. on Fig. 10.1	Data Source	Species																				
			least cisco	lake whitefish	broad whitefish	pygmy whitefish	round whitefish	inconnu	Arctic grayling	chum salmon	coho salmon	sockeye salmon	kokanee	chinook salmon	steelhead trout	rainbow trout	Dolly Varden	lake trout	northern pike	lake chub	longnose sucker	burbot	slimy sculpin
ALSEK RIVER DRAINAGE continued		L	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*	-	-
Lichen Lake*	103	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jutland Lake*	97	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Alder Creek	112	W	-	-	-	-	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyclops Lake* (Lake Ray)	113	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
St. Elias Lake	lld	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fraser Creek	110	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Missing Lake*	111	W	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-
Tatshenshini River	117	D	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Bridge River	W	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Onion Lake	98	W	-	-	-	-	+	-	*	-	-	-	-	-	-	-	-	+	-	-	-	-	+
Hiking Creek*	102	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Climbing Creek*	101	W	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
Climbing Lake*	100	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	-	-	-	-	-
Village Creek	116	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neshketaheen Lake	115	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Klukshu River	118	D	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
Klukshu Lake	119	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YUKON RIVER DRAINAGE		L	+	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Upper Yukon River		L	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
White River	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Koidern River	2	W	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	*	+	+
Donjek River	8	E,W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Reed Creek	6	W	+	+	+	+	?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Middle Creek*	27	W	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Lake*	26	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slipping Creek*	28	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snipe Lake*	29	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bighorn Creek	30	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Wade Creek	9	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eagle Lake*	12	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kluane River	4	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swede Johnson Creek	5	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glacier Creek	7	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quill Creek	10	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Burwash Creek	13	W	-	-	-	-	-	-	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Duke River	15	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Granite Creek	14	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Knob Creek*	22	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grizzly Creek	31	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

+ present
? suspected
* local name
See last page of table for data source key.

Table 10.4 Fish distribution in Kluane National Park and vicinity by drainage basin. (concluded).

Waters by Drainage	Location No. on Fig. 10.1	Data Source	least cisco	lake whitefish	broad whitefish	pygmy whitefish	round whitefish	inconnu	Arctic grayling	chum salmon	coho salmon	sockeye salmon	kokanee	chinook salmon	steelhead trout	rainbow trout	Dolly Varden	lake trout	northern pike	lake chub	longnose sucker	burbot	slimy sculpin
			Species																				
YUKON RIVER DRAINAGE continued		L	+	+	+	+	+	+	+	+	+	•	[illegible]	[illegible]	[illegible]	[illegible]	•	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Kluane Lake	17	E,W	[illegible]	•	[illegible]	[illegible]	•	•	•	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	•	•	•	+
Halfbreed Creek	[illegible]	W	•	•	•	•	•	•	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Halfbreed Lake*	20	W																					
Blueberry Pond*	24	W																					
Lewis Creek	21	W																					
Williscroft Creek	34	W																					
Nines Creek	32	W																					
Bock's Creek	25	W																					
Congdon Creek	33	W																					
Silver Creek	47	W																					
Slims River	40	W					•	•	+												•	•	+
31 ims River Marsh*	41	W					•	•	+														*
Sheep Creek	35	W					•	•	+												•	•	+
Coin Creek	37	W					•	•	+	•	•	•	•	•	•	•	•	•	•	•	•	•	+
Vulcan Creek	46	W																					
Bullion Creek	36	W																					
Canada Creek	42	W																					
Chr I stmas Creek	49	W																					
Hungry Lake	48	W																					
Sulphur Creek	S 0	W																					
Sulphur Lake	51	B																*					

Data sources: W - R.D. Wickstrom; E - V.C. Wynne-Edwards 1947, 1952:
L - C.C. Lindsey 1975; C - Scott & Crossman 1973; S - Schouwenburg 1974;
D - Fisheries & Marine Service 1977: B - R.A. Bodaly 1977.

Source: Wickstrom 1978.

+ present
? suspected
* local name.

10.7.2.1 Present Distribution and Habitat Use

Within the Park, kokanee occupy a chain of three lakes formed by Sockeye, Louise, and Kathleen and their connecting streams (see Figure 10.1). Each lake supports a resident population. Apparently the fish do not utilize the upstream tributaries and lakes above Sockeye Lake although strays are occasionally seen in Cottonwood creek. Similarly only strays are found in the Kathleen River downstream of Kathleen Lake.

As described in previous section, Kathleen Lake is the largest and deepest lake in the Park. Constant downvalley winds encourage mixing in the lake, thermal stratification is poorly developed, and the hypolimnion has an elevated temperature approaching 8°C by mid-summer.

Louise Lake is only about an eighth the size of Kathleen, but is the second deepest lake in the Park. Sockeye Lake is considerably smaller again. Both lakes experience thermal stratification.

Wickstrom (In prep. a) describes the life cycle of kokanee as follows:

> "Kokanee usually migrate to the upper waters of their habitat drainage and spawn in the autumn, depositing their eggs in g-ravel substrate in stream riffles or along similar substrate along lake shores. The eggs incubate over the winter and hatch in early spring, but the tiny kokanee with their yolk sacs, called alevins, remain in the gravel for several more weeks, emerging from the gravel beds about May. The free-swimming, feeding fry may linger in the stream...but eventually swim downstream. ..and commence living pelagically in the lake, feeding on plankton. Growth continues for five years in the Kathleen drainage until the fifth summer when they migrate upstream to their natal spawning grounds to spawn and then die."
>
> (Wickstrom In prep. a)

Fish from all three lakes spawn in the waters of Sockeye Lake or its outlet stream. Fish from Kathleen and Louise lakes begin their upstream spawning migration in mid-July. In early August, fish in sockeye Lake move downstream into the outlet. The actual time of spawning occurs about the third week of August.

Spawning occurs in only two restricted areas:

1. in shallow reaches of the outlet stream about 200 m below Sockeye Lake; and

2. along the north shore of Sockeye Lake.

This distribution caused Wickstrom (In prep. a) to speculate that the two spawning areas may be used by different subpopulations - possibly some of the Sockeye Lake population spawn along the north shore of the lake, while fish from the lower lakes use the outlet stream. Further study and tagging could clarify this question.

Table 10.5 presents recent counts of spawning kokanee. Wickstrom (In prep. **a)** speculates that the prime spawning grounds are reaching their capacity and that this may account for increasing observations of spawners in uncustomary locations along the east and west shores of the lake. These data illustrate a 7-fold increase in adult population over the study period. Wickstrom (In prep. a) attributes this increase to management decisions taken in 1975 to protect the population by closing Sockeye Lake and its outlet stream to fishing and lowering the possession limits on Kathleen and Louise lakes from 10 to 2. This prevented disturbance to the spawning areas by anglers wading into the water and protected part of the pre-spawning and spawning population. Results of a creel census done in 1980 and 1981 indicate **that** the present level of angling is not detrimental and appears to satisfy anglers. The population may also experience cyclical variations similar to those of anadromous sockeye. Further years of spawning enumeration would verify this.

10.7.2.2 Origin of the Kokanee Population

Two theories have been proposed to explain the presence of kokanee in southwest Yukon. The most widely accepted theory is tied to the blockage of the Alsek River during the most recent major advance of the Lowell Glacier and subsequent formation of Neoglacial Lake Alsek (see Section 6.3.7.7 and Figure 6.11). This blockage would have prevented spawning migrations of anadromous sockeye on the Alsek and isolated an upstream population. The Alsek now discharges freely to the Pacific but anadromous stocks have not reutilized the upper part of the system and the kokanee have not returned to anadromous behaviour. Wickstrom (In prep. a) considers there to be no impassable physical barriers along the lower Alsek to prevent return of anadromous sockeye.

The second explanation was first suggested by Clarke in Wynne-Edwards (1947). He considered that headwater capture between the Klukshu Lake and Dezadeash Lake watersheds may have allowed anadromous sockeye access to Dezadeash Lake and thence Kathleen Lake. The narrow height of land separating the two watersheds contains several ponds and marshes whose drainage is conspicuously uncertain, and the theory is advanced that fish may have found their way through this area to the Dezadeash basin in times of high water. Both theories remain unverified.

10.7.3 Dolly **Varden (<u>Salvelinus malma</u>)**

Within the Park, Dolly Varden char are restricted to the Alsek drainage. The largest populations are found in the Alder-Fraser creek drainage where they spawn in the creeks, and in St. Elias, Cyclops, and Missing lakes areas, all tributary to Mush Lake. These

Table 10.5 Kokanee utilization of spawing areas in Sockeye Lake and outlet.

year	Maximum Spawners Lake and Streams		Total in outlet pools and lake narrows		Spawning Flats		Along Lakeshore	
	#	%	#	%	#	%	#	%
1976	2360	100	792	34	576	24	545	23
1977								
1978	3872	100	1626	34	1346	35	567	15
1979	3684	100	1617	44	1283	35	443	12
1980	4217	100	2283	54	1331	32	432	10
1981	7110	100	3225	45	2253	32	953	13

Source: Wickstrom In prep. a

three lakes have obstructions at their outlets preventing in- or outward migration of fish, so these populations must be captive, reproducing within the lakes. Strays have been taken in Mush Lake and they are suspected but not proven in Bates and Dezadeash lakes. They have also been caught in the Kathleen lakes chain and Jarvis River.

10.7.4 Rainbow Trout/Steelhead Trout (Salmo gairdneri)

Rainbow trout are found only in the Rainbow Lakes, Kathleen River, and Klukshu River (all outside the Park). Strays are reported from Kathleen Lake and unverified occurrences are reported from Bear creek. These are thought to be the only naturally occurring native populations in Yukon (Scott & Crossman 1973). Steelhead trout are the anadromous form of the species and are confined to the Tatshenshini drainage, again outside the Park.

10.7.5 Lake Trout (Salvelinus namaycush)

Lake trout are common throughout the Alsek drainage, occurring even in high elevation alpine lakes with impassable outlets. They do not occur in the northern region of the Park drained by the Yukon River tributaries. Lake trout are the principle sport fish in Kluane's standing waters, particularly Kathleen and Mush lakes. Wickstrom (In prep. b) reported the results of a recent 2 year creel census on Kathleen Lake and concluded that the lake is now moderately to moderately heavily fished. Given the relatively unproductive nature of the lake and the long time to maturity for lake trout in these conditions (15 years), he warns that active management may be necessary in the near future to sustain the population if angler pressure continues at current levels or increases. Mush Lake is less accessible and less heavily fished at the present time. No creel census information is available for this lake, but efforts should be made to obtain quantitative data if the Mush-Bates area is opened up to further development.

10.7.6 Round Whitefish (Prosopium cylindraceum)

Round whitefish are common throughout in the southern areas of the Park, inhabiting most relatively deep lakes and the clearer streams, such as Jarvis River and Pine Creek. They occur in Kluane Lake but not in the northern drainages of the Park.

10.7.7 Arctic Grayling (Thymallus arcticus)

Arctic grayling is very common and a popular sport fish in all the standing and flowing waters in Kluane, including those in St. Elias - Kluane ranges and the Sockeye-Kathleen and Mush-Bates chains. Even the usually silty tributaries of the Slims, Donjek, and Duke rivers contain grayling when the silt load declines in the summer or between freshets.

10.7.8 Pygmy Whitefish (Prosopium coulteri)

Pygmy whitefish are an unusual species of small size which at maturity are less than half the size of round whitefish with which they coexist. They have a scattered, discontinuous distribution across the continent. Wynne-Edwards (1947) first captured the species in sockeye lake in 1945 and it was not caught there again until 1975 (Wickstrom 1978). In 1976 it was found in Kathleen, Mush, and Bates lakes, and it is felt that its distribution may be more widespread in the area than initially thought (Wickstrom 1978). The only other Yukon occurrence is Squanga Lake near Whitehorse; other reports are from widely separated drainages in Alaska, B.C., western Alberta, and recently Lake Superior. This unusual post glacial dispersal is a continuing puzzle.

10.7.9 Northern Pike (Esox lucius)

Within in Park, northern pike occur only in Lynx Lake, a small pond adjacent to the Dezadeash River below Bear Creek. They are however found in waters of both the Alsek and Yukon drainages around the periphery of the Park.

10.7.10 Lake Chub (Couesius plumbeus)

Lake chub occur in a tributary of the Donjek River within the Park, and in Kluane Lake but have not yet been found in streams tributary to Kluane Lake.

l.o.7.11 Burbot (Lota lota)

Burbot (or freshwater cod) have been reported only from Sockeye Lake but probably occur in Louise and Kathleen lakes as well. They are relatively common in waters peripheral to Kluane.

10.7.12 Slimy Sculpin (Cottus cognatus)

Slimy sculpin is a small inconspicuous fish which is virtually ubiquitous in Kluane's waters.

10.7.13 Chum Salmon (Oncorhynus keta), Coho Salmon (Oncorhynus kisutch), and Chinook Salmon (Oncorhynus tshawytscha)

Chum salmon do not occur within the Park area although there are unverified reports from Kluane Lake and spawning runs occur in the White and Kluane rivers. Coho and chinooks occur in the lower Alsek drainage and spawn in the headwaters of the Tatshenshini River. They are harvested annually along Klukshu River. Both species also occur in the Yukon drainage but not within the Park area.

10.7.14 Longnose Sucker (Catostomus catostomus)

Longnose sucker is not present in the Park but occurs in adjacent waters such as Dezadeash, Aishihik, and Kluane lakes.

10.8 Evaluation

1018.1 Interpretation

Two unique species, kokanee and pygmy whitefish, occur in Kluane. Discussion of their unusual distribution and life histories provides an interesting topic for interpretation. The *occurrence* of **a** kokanee population has been tied to formation of Neoglacial Lake Alsek. This event greatly influenced many aspects of the biotic and abiotic environment of Kluane and could be developed as an important part of the interpretation program of the Park, bringing together events in the glacial history, the human element through the catastrophic drainage of the lake and subsequent flooding, primary vegetation succession, wildlife use of the former floodplain area and its vegetation, fisheries, and agriculture and soils - the former Pine Creek Experimental **Farm** is on lake bottom sediments. The Bering Refugium and post glacial dispersal of fish could also be discussed, and perhaps integrated with description of the concurrent dispersal of plants.

10.8.2 Sensitive Resources and Future Study and Monitoring Requirements

Parks Canada Policy (Parks Canada 1979) states that "controlled sports fishing of naturally regenerating populations of native species will be permitted" and Management Guideline 4.4.1 (Parks Canada 1981) directs each Park to manage fish populations on a sustained yield basis using a resource management plan to identify streams open to fishing and specific objectives on population maintenance. The Kluane Park Conservation Plan (Parks Canada 1984) sets out a programme for interim management of resources and defined the objective of a Fish Management Plan for the Park. The plan requires the Park to manage the total aquatic environment and all species present. Immediate general objectives are:

- to expand the present data base of Mush, Bates, St. Elias, and Kathleen lakes to increase the reliability of present productivity estimates; and

- to conduct ongoing assessments of angler pressure and harvest, a regular creel census program, and a period test netting program for the above lakes to compare harvest data with productivity estimates and species composition data (Parks Canada 1984).

The kokanee population of Kluane has been identified as a rare resource. Its critical spawning habitat in Sockeye Lake and its outlet stream have been designated a Class I or Special Preservation Area and fishing areas and limits have been reduced. Three of the objectives of the proposed Fish Management Plan relate to continued successful maintenance of this population.

1. Maintain unrestricted movement of kokanee salmon spawners and fry through the Kathleen lakes chain. This includes in part

preventing beaver activity on the outlet stream from blockir.3 free upstream migration of fish to Sockeye Lake.

2. **Monitor** kokanee salmon spawning activity to obtain:

- long term trends in population,
- changes in spawning area utilization,
- verify the relationship between redd density and spawning success.

3. Verify suspected presence of resident kokanee populations in each of Kathleen, Louise, and Sockeye lakes and identify spawning areas used by each.

Lake trout are one of the most highly prized sport fish in Kluane. In Kathleen Lake they comprise 65-75% of the total sport fisher, harvest (Wickstrom In prep. b). Given the generally low fish productivity of Kluane's lakes and the concentration of angling pressure on Kathleen Lake, active management of the lake trout population may be necessary in the near future (Wickstrom In prep. b). The proposed fish management plan identifies the following as important objectives related to the maintenance of the population:

identify trout spawning areas in Mush, Bates, Kathleen, and St. Elias lakes; and

prepare and sign a cooperative agreement with Department of Fisheries and Oceans and the Yukon Territorial Government for management of the Kathleen River lake trout spawning areas (Parks Canada 1984).

Within the requirement to manage the total aquatic environment is the need to maintain and monitor water quality. The wilderness character of Kluane has ensured pure water throughout the Park for many years. Increasing pressure for development of facilities within the Park, more intensive use of existing facilities, and increasing threats from pollution sources outside but adjacent to the Park make it necessary to plan for active management of Kluane's water resources.

Most rivers in Kluane have their sources but not their entire drainage basin within the Park and the Park is therefore responsible for maintenance of water quality for downstream users. In contrast, the Alsek River has its source outside and upstream of the Park and water quality in the Alsek and Dezadeash rivers within the Park are subject to external influences. These influences include potential pollution sources such as effluent from the new Haines Junction sewage lagoon and lodges along the Alaska Highway, and siltation from upstream construction activities. Jarvis River is influenced by placer mining activity on Telluride and Kimberley creeks and by fecal coliform and possible oil spill pollution from the native settlement at Kloo Lake. In 1978, water quality samples taken from the day-use area at Kathleen Lake indicated a public health hazard, and measures were taken to control the situation. Since that time, however, monitoring has not continued. Future developments should be screened through the EAR Process to ensure adequate water quality protection measures.

The Park Conservation Plan (Parks Canada 1984) recommended that a long term water quality monitoring program be undertaken to identify any deterioration of water quality, to protect drinking water supplies, and to protect fish and wildlife populations. The initial steps are: collection of baseline water quality data to provide a standard against which future changes can be measured; identification of potential pollution sources and problem areas; and establishment of a sampling network.

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APPENDIX

Appendix 10.1 Chemical characteristics of selected lakes and streams in and near Kluane National Park.

	Temp. of Testing (°C)	pH	Sp. Conductance (μmho/cm)	Colour (Hazen units)	Turbidity	Chlorophyll a (μg/L)	Silica: Reactive (mg/L SiO_2)	Alkalinity: Total (mg/L $CaCO_3$)	Hardness: Total (mg/L $CaCO_3$)	Calcium: Diss. (mg/L)	Phosphorus: Ortho Phosphate (μg/L)	Phosphorus: Total (μg/L)	Sulphate: Diss. (mg/L SO_4)	Nitrogen: Diss. NO_3 + NO_2 (μg/L)	Chloride: Diss. (mg/L)	Magnesium: Diss. (mg/L)	Manganese: Ext. (μg/L)	Potassium: Diss. (mg/L)	Sodium: Diss. (mg/L)	Copper: Ext. (μg/L)	Iron: Ext. (mg/L)	Lead: Ext. (μg/L)	Zinc: Ext. (μg/L)	Arsenic: Diss. (μg/L)	Cadmium: Ext. (μg/L)	Nickel: Ext. (μg/L)
Alder Creek 18-08-74	15.2	8.2	271	<5	1.1	<5	6.5	110	135	44	<3	-	35	30	0.2	-	10	0.7	3.0	1	0.13	<4	1	<0.5	3	6
Bates Lake 26-08-73	18.4	8.0	154	<5	0.23	-	4.7	69.5	77.5	24.2	5	-	11.9	39	0.3	4.2	<10	0.2	1.6	1	0.005	<1	1	<5	<1	<1
Bates Lake 18-08-74	14.5	8.2	162	<5	0.2	<5	5.0	72	77	25	<3	-	12	40	0.2	-	<10	0.4	1.7	<1	<0.04	5	3	<0.5	3	6
Bates Lake Creek #10* 18-08-74	15.3	8.0	241	<5	0.1	<5	4.1	113	123	41	<3	-	18	60	0.1	-	<10	0.7	1.1	<1	0.18	6	2	<0.5	2	6
Bates Lake Creek #15* 18-08-74	14.2	8.2	282	<5	0.3	<5	7.2	145	147	53	<3	-	6.6	170	1.2	-	<10	0.4	2.5	<1	0.04	<4	2	<0.5	2	5
Bear Creek* (south) 26-08-73	18.3	7.7	104	<5	0.09	-	5.7	46.1	51.6	16.5	7	-	7.2	28	0.2	2.4	<10	0.3	1.1	2	<0.005	<1	2	<5	<1	<1
Bighorn Creek 24-08-75	21.8	8.0	330	<5	42	<5	4.4	74.9	169	51.4	-	134	89	90	0.3	9.8	110	3.0	1.6	8	3.3	<4	8	<0.5	<1	6
Bone Lake* 24-08-75	21.7	8.3	410	5	2.1	<5	12.8	213	206	36.5	-	12	23	<10	0.1	27.8	20	1.9	17.1	2	0.18	<4	59	<0.5	<1	<2
Campsite - Marsh Creek* 29-07-73	21.5	7.8	195	10	1.3	-	5.8	94.5	99.6	30.8	4	-	8.5	9	0.8	5.5	20	0.3	2.3	<1	0.24	<1	<1	<5	<1	<1
Canada Creek 28-07-74	24.5	8.1	213	5	100	10	3.0	66	105	31	<3	-	53	60	0.2	-	4500	5.8	0.8	160	38.0	24	430	<0.5	6	290
Clear Creek* 29-07-73	21.4	7.9	142	5	3.9	-	2.5	50.3	66.1	20.2	2	-	18.5	44	0.6	3.8	<10	0.1	2.1	<1	0.27	<1	<1	<5	<1	<1
Climbing Creek* 13-08-73	18.2	7.4	101	<5	0.22	-	5.7	46.6	51.3	17.4	2	-	5.6	13	0.2	1.9	<10	0.1	1.0	<1	0.02	<1	<1	<5	<1	<1
Climbing Lake* 05-08-75	21.5	7.5	33	<5	1.3	<5	3.0	12.2	15.6	5.4	-	3	1.2	20	0.2	0.5	30	0.4	0.5	4	0.09	<4	1	-	-	
Cottonwood Creek 29-07-73	21.5	8.0	151	5	1.7	-	5.3	67.3	74.4	21.4	6	-	11.2	28	0.8	5.1	10	0.1	2.1	<1	0.17	<1	<1	<5	<1	<1
Cottonwood Lake* 05-08-75	21.3	7.8	62	<5	1.0	<5	2.8	27.2	28.2	8.3	-	<3	1.9	10	<0.1	1.8	10	0.1	1.2	4	0.09	7	6	-	-	-
Duck Creek* 29-07-73	21.6	7.8	128	<5	0.43	-	3.7	51.3	62.9	20.9	3	-	12.6	83	0.7	2.6	<10	0.1	1.0	<1	0.02	<1	<1	<5	<1	<1
Duke Glacier Melt Pool* 28-07-74	24.6	8.2	193	<5	3.5	28	1.6	61	93	26	<3	-	35	40	0.4	-	18	0.8	0.5	1	0.09	<4	2	<0.5	2	9
Duke River 28-07-74	24.2	8.2	297	5	100	24	6.5	88	145	41	<3	-	67	60	0.5	-	230	2.0	1.6	10	4.5	5	13	0.5	<1	15
Eagle Lake*a 21-08-74	23.2	7.7	180	80	1.2	5	3.2	88	100	32	<3		5.0	<10	0.9			1.8	1.0					<0.5		

* local name
a peripheral to Kluane National Park.

Appendix 10.1 Chemical characteristics of selected lakes and streams in and near Kluane National Park. (continued).

	Temp. of Testing (°C)	pH	Sp. Conductance (µmho/cm)	Colour (Hazen units)	Turbidity	Chlorophyll a (µg/L)	Silica: Reactive (mg/L SiO_2)	Alkalinity: Total (mg/L $CaCO_3$)	Hardness: Total (mg/L $CaCO_3$)	Calcium: Diss. (mg/L)	Phosphorus: Ortho Phosphate (µg/L)	Phosphorus: Total (µg/L)	Sulphate: Diss. (mg/L SO_4)	Nitrogen: Diss. $NO_3 + NO_2$ (µg/L)	Chloride: Diss. (mg/L)	Magnesium: Diss. (mg/L)	Manganese: Ext. (µg/L)	Potassium: Diss. (mg/L)	Sodium: Diss. (mg/L)	Copper: Ext. (µg/L)	Iron: Ext. (mg/L)	Lead: Ext. (µg/L)	Zinc: Ext. (µg/L)	Arsenic: Diss. (µg/L)	Cadmium: Ext. (µg/L)	Nickel: Ext. (µg/L)
Field Creek 26-08-73	18.3	8.1	183	'5	0.17	-	3.6	16.7	99.1	JJ.5	3	•	15.b	14	0.2	4.4	<10	01	0.7	<1	0.01	<1	'I	'5	<1	<1
Field Lake* 18-08-74	14.2	7.8	a9	•5	0.1	•I	1.6	16	12	5.0	<3	•	0.1	IO	<0.1	•	<10	<0.1	0.3 ●	I	0.06	4	2	'05	2	3
Fraser Creek 18-08-74	13.4	8.2	159	<5	5	<5	5.7	72	78	23			12	50	0.1	•	<10	0.2	1.6	2	0.15	1	1	<0.5	2	6
Fraser Creek 05-08-75	21.3	7.9	146	<5	7.2	<5	4.2	61.5	75.9	20.0	<3	10	10.1	IO	0.3	5.J	51	0.1	1.7	5	0.50	7	2	•	•	-
Goat Creek 29-07-73	21.4	7.9	149	5	4.5	•	3.6	49.2	b9.9	11.9	2	.	22.9	37	0.7	3.1	10	0.3	1.8	<1	0.53	<1	<1	'5	<1	<1
Granite Creek 28-07-74	24.2	8.1	207	IO	35	IO	5.9	92	91	II	<3	-	21	70	I I	•	74	1.4	8.0	4	I.5	5	7	'05	2	10
Hiking Creek* 13-08-73	18.3	7.9	119	<5	0.21	•	5.4	58.8	60.7	10.7	2	.	4.9	7	0.2	2.2	10	0.1	09	<1	0.006	<1	<1	'5	<1	<1
Jutland Lake* 05-08-75	21.4	7.6	59	<5	I.1	<5	3.6	19.8	23.1	8.1	•	<3	3.4	<10	0.1	0.7	<10	0.1	0.6	1	0.05	<4	3	'		-
Kaskawulsh Glacier Melt Pool #2* 28-07-74	24.8	8.1	173	5	3.5	17	I.0	57	83	27	<3	•	JO	J0	0.3	•	1200	2.0	0.6	25	II.0	8	J9	<0 5	<1	23
Kathleen Lake 29-07-73	II.5	8.1	218	'5	0.49	•	4.1	88 4	110	32.8	2	•	23.4	27	0.8	6.8	<10	05	2 6	<1	0 018	<1	<1	<5	<1	<1
Kathleen Lake 21-08-74	23.3	8.2	223	<5	I.5	5	4.1	130	110	34	<3	•	28	20	0.2	•	•	0.4	2.9	-	•	-	-	<0 5	•	-
Kluane L.-near mouth of Slims R.[a2] 31-08-76	II.7	8.0	235	<5	1.3	•	3.2	76.8	114	32.6	•	II	42.0	II	0.4	7.9		2.4	2.0	<1	0.042	<1	7	0.3	<0.2	1
Kluane L.-opp. Destruction Bay[a2] 01-09-76	II.,	8.0	230	<5	0.58	•	1.5	/b	411	32.0	•	7	38 5	<2	0 4	7.b		2.3	2.0	3	0.014	1	70	0.2	<0.2	<1
Kluane L.-near outlet[a2] 01-09-76	21.7	8.1	226	'5	0.47	•	3.5	74.8	109	31.3		6	JI.5	8	0.5	7.5	•	2.3	2.0	1	0.031	<1	70	0.3	<0.2	<1
Knob Creek* 28-07-74	24.0	7.9	486	<5	280	I5	5.5	70	231	68	<3		170	60	0.5		I700	2.9	2 8	43	42.0	10	88	0.5	3	63
Lake Ray (Cyclops L.*) 21-07-74	23.6	8.1	227	0	I.0	'I	5.6	/b	lob	28	<3	<3	J9	20	0.5	•	<10	1.6	4.2	8	0.09	<4	2	<0.5	<1	<2
Lichen Lake* 05-08-75	21.4	7.5	25	<5	1.8	<5	1.4	9.3	10.9	J.7	•	10	I.7	10	0.1	0.4	21	<0.1	0.5	3	0.08	<4	3	-	-	-
Louise Lake (Upper Kathleen L.*) 29-07-73	II.5	8.0	201	'5	1.3	•	5.9	86.4	102	18.9	7	•	16.6	4	0 8	1.1	<10	0.7	2.4	<1	0.05	<1	<1	<5	<1	<1
Missing Lake* 05-08-75	11.5	8.1	146	<5	1.3	<5	8.6	69.0	17.9	lJ.I	•	6	4.0	200	0.3	b.9	16	0.4	1.2	2	0.05	<4	3	-	-	-

* local name

Appendix 10.1 Chemical characteristics of selected lakes and streams in and near Kluane National Park (Concluded).

	Temp. of Testing (oC)	pH	Sp. Conductance (µmho/cm)	Colour (Hazen units)	Turbidity	Chlorophyll a (µg/L)	Silica: Reactive (mg/L SiO_2)	Alkalinity: Total (mg/L $CaCO_3$)	Hardness: Total (mg/L $CaCO_3$)	Calcium: Diss. (mg/L)	Phosphorus: Ortho Phosphate (µg/L)	Phosphorus: Total (µg/L)	Sulphate: Diss. (mg/L SO_4)	Nitrogen: Diss. NO_3 + NO_2 (µg/L)	Chloride: Diss. (mg/L)	Magnesium: Diss. (mg/L)	Manganese: Ext. (µg/L)	Potassium: Diss. (mg/L)	Sodium: Diss. (mg/L)	Copper: Ext. (µg/L)	Iron: Ext. (mg/L)	Lead: Ext. (µg/L)	Zinc: Ext. (µg/L)	Arsenic: Diss. (µg/L)	Cadmium: Ext. (µg/L)	Nickel: Ext. (µg/L)
Mush Creek 26-08-73	18.2	8.0	132	5	0.23	-	6.3	62.9	67.7	20.2	3	-	9.6	14	0.3	4.2	<10	0.3	1.6	<1	0.009	<1	<1	<5	<1	<8
05-08-75	21.3	7.7	72	<5	1.8	<5	3.6	29.2	41.1	13.5	-	<3	4.5	20	<0.1	1.8	<10	0.1	1.0	2	0.07	<4	1	-	-	-
Mush Lake 26-08-73	18.2	8.1	165	<5	0.32	-	5.1	74	83.3	26.1	3	-	13.3	37	0.3	4.4	<10	0.4	1.8	1	0.014	<1	<1	<5	<1	<1
Mush Lake Creek #12* 18-08-74	14.5	8.0	192	<5	0.1	<5	7.0	81	95	29	<3	-	16	340	0.1	-	<10	0.4	1.1	1	<0.04	5	1	<0.5	3	6
Onion Lake 13-08-73	18.3	7.8	104	<5	0.47	-	4.8	49.7	52.5	19.9	5	-	5.2	6	0.3	0.7	<10	0.4	0.8	<1	0.008	<1	1	<5	<1	<1
Plum Creek* 26-08-73	18.3	8.2	205	<5	0.51	-	4.2	94.8	110	35.1	3	-	17.8	9	0.2	5.4	<10	0.2	0.8	<1	0.016	<1	<1	<5	<1	<1
Pool Creek* 28-07-74	24.2	7.7	169	40	0.3	13	9.6	76	98	29	<3	-	7.5	180	0.9	-	<10	2.5	1.0	4	0.05	<4	2	<0.5	2	7
Quaking Pond* 05-08-75	21.4	7.3	57	<5	0.5	-	1.0	7.1	9.2	3.2	-	11	1.0	<10	0.2	0.3	100	<0.1	0.2	3	0.20	<4	3	-	-	-
Rain Creek* 28-07-74	24.4	8.0	393	5	250	17	2.4	64	191	59	<3	-	130	50	0.2	-	130	2.0	0.8	21	24.5	10	300	<0.5	3	66
Shaft Creek 26-08-73	18.4	7.8	69	<5	0.32	-	4.7	30.4	29.7	9.0	<2	-	2.6	6	0.2	1.8	<10	0.2	1.6	<1	0.031	2	3	<5	<1	<1
Ship Creek* 28-07-74	24.1	8.2	275	<5	3.5	22	4.4	82	158	44	<3	-	61	80	0.5	-	10	0.9	0.4	<1	0.25	<4	3	0.8	<1	6
Slims River 21-08-74	23.0	8.1	241	<5	600	<5	3.1	81	113	33	<3	-	45	30	0.4	-	-	3.0	2.6	-	-	-	-	2.3	-	-
Slims River Marsh* 28-07-74	24.2	7.8	901	<5	1.5	15	8.9	225	468	119	<3	-	340	50	0.4	-	110	16	5.6	-	0.15	<4	2	0.5	<1	9
Slipping Creek* 24-08-75	21.8	8.0	292	<5	10	<5	7.8	66.1	142	47.3	-	24	75	200	0.2	5.9	29	3.6	2.2	3	0.96	<4	3	<0.5	<1	<2
Snipe Lake* 24-08-75	22.0	8.1	271	5	1.3	5	6.5	98.:	139	44.7	-	12	42	10	0.2	6.7	16	3.9	1.1	3	0.06	<4	1	<0.5	<1	<2
Sockeye Lake 29-07-73	21.6	8.0	170	5	0.80	-	5.5	77.4	85.4	25.2	3	-	10.2	16	0.0	5.5	<10	0.3	2.1	1	0.07	<1	2	<5	<1	<1
Victoria Creek 29-07-73	21.3	8.0	144	5	3.4	-	4.0	56.3	70.3	20.4	2	-	15.9	15	0.6	4.7	<10	0.3	1.7	<1	0.26	<1	<1	<5	<1	<1
Wade Creek* 21-08-74	23.4	8.1	210	10	2.0	10	3.2	88	100	33	<3	-	27	30	0.6	-	-	1.8	4.5	-	-	-	-	<0.5	-	-

Source: Wickstrom 1978.

*-local name.
a-peripheral to Kluane National Park.

1 Analyses performed by DOE Water Quality Branch, Calgary, according to J.P. Lively (ed) 1975. Analytical Methods Manual. Inland Waters Directorate.

Appendix 10.2 Periphytic algae of Kluane National Park.

	Alder Creek 12-VIII-74	Bates Lake 16-VIII-73	Bone Lake* 21-VIII-75	Cottonwood Lake* 30-VII-75	Field Lake* 17-VIII-74	17-VIII-74	Jutland Lake* 29-VII-75	Kathleen Lake 17-VII-73	17-VII-73	Onion Lake 12-VIII-73	Snipe Lake* 23-VIII-75
Chlorophyta											
Chara vulgaris				A							
Chara spp.				C							
Coelochaeta divergens											C
Bulbochaete sp.				O							
Oedogonium sp.					A		R				
Rhizoclonium cf. *hieroglyphicum*							A				
Spirogyra spp.		C			C						
Stigeoclonium nanum						O					
Zygnema sp.		A			A				A		
Cyanophyta											
Anabaena spp.			R								
Lyngbya spp.			C								
Nostoc linckia											A
Nostoc pruniforme							C			A	C
Nostoc verrucosum										C	
Oscillatoria agardhii	A										
Oscillatoria spp.			C								
Tolypothrix tenuis							O				
Rivularia compacta						A					
Rivularia dura											C
Rivularia spp.						C					
Chrysophyta (Class Diatomeae)											
Achnanthes flexella	R										
Achnanthes linearis				O							
Achnanthes lanceolata				R							
Achnanthes minutissima	A				O	O					
Achnanthes spp.		O		C		O					
Amphipleura pellucida	O										O
Amphora ovalis				O							
Cocconeis placentula	R			O		R	C			A	
Cocconeis sp.											R
Caloneis ventricosa var. *subundulata*	R										
Cymatopleura solea				R							
Cyclotella antiqua	R	O		O							
Cyclotella comta											R
Cyclotella kuetzingiana	C										

A abundant; C common: R rare.
* local name.

Appendix 10.2 Periphytic algae of Kluane National Park [Continued].

	Alder Creek 12-VIII-74	Bates Lake 10-VIII-73	Bone Lake* 21-VIII-75	Cottonwood Lake 30-VIII-75	Field Lake* 17-VIII-74	17-VIII-74	Jutland Lake* 23-VII-75	Kathleen Lake 17-VII-73	17-VII-73	Onion Lake 12-VIII-73	Snipe Lake* 23-VIII-75
Chrysophyta (Class Diatomeae)											
Cymbella affinis	R	.	.	.	.	.	.		.	•	
Cymbella angustata	0	0	.	.	.	.	.	.		•	
Cymbella cistula	0	C				R	R				
Cymbella cymbiformis											
var. *nonpunctata*	.	C	.	.	.	.	.			•	
Cymbella hustedtii	.	.	.	.	.	.	R	.			
Cymbella mexicanum		.	.	0	.		C	.	.	•	
Cymbella muelleri	.			.	.	.	R	.			
Cymbella microcephala	.	.	.	.	.	0	.		R		
Cymbella minuta	0	C	.	0	C	O	.		0	•	
Cymbella naviculiformis	.	R	.	.	.	.	.				
Cymbella sinuata	R	.	.	.	R	.	.			•	
Cymbella spp.	C		R	.	.	C		.	C		
Diatoma hiemale											
var. *mesodon*		A		.		.		A	A	•	
Diatoma hiemale	.	.	.	.		.		A	A	•	
Diatoma tenue											
var. *elongatum*	R	.	.	.	.	.	.	.	.	•	
Didymosphenia geminatum	0	R	.	.	.	.	.	.	.	•	
Diploneis finnica	.		.	R	.	.	.	.	.		
Diploneis elliptica	.	.	.	.	.	R	.	.	.	•	
Diploneis oblongella	.	.	.	.	R	.	R		.	•	
Diploneis puella	R	.	.	.	.	.	.	.		•	
Epithemia sorex	.	.	.	0	.	.	R	.		•	
Epithemia turgida		.		0	R	R	0			•	
Epithemia spp.	.			.	R	.	.		.	•	
Eunotia adnata											
var. *minor*			.	.			.		.		
Eunotia naegeli		.	.	R	.	.	.	.		•	
Eunotia praerupta	.		.	R		R			.	•	
Eunotia spp.		.		.	R	.	.	.	.	•	
Fragilaria construens	.	.		0	.	.	.	.	.		
Fragilaria crotonensus	.	0	.		0	.	.	.	.	•	
Fragilaria pinnata	0	0	.	A	.	0	R	.	A	•	
Fragilaria vaucheriae	.	.	.	.	.	.	.		R	•	
Fragilaria spp.	3	.	0	.	.	.	.	.	.	•	
Gomphonema acuminatum	R	.	.	0	0	R	.	.	.	•	
Gomphonema angustatum	.	.	.	.	R	.	.		.	•	
Gomphonema brebissonii	.	.	.	.	.	R	.	.	.		

A abundant; C common; O occasional; R rare.
* Local name.

Appendix 10.2 Periphytic algae of Kluane National Park [Concluded].

	Alder Creek 12-VIII-74	Bates Lake 16-VIII-73	Bone Lake* 21-VIII-75	Cottonwood Lake* 30-VII-75	Field Lake* 17-VIII-74	17-VIII-74	Jutland Lake* 29-VII-75	Kathleen Lake 17-VII-73	17-VII-73	Onion Lake 12-VIII-73	Snipe Lake* 23-VIII-75
Chrysophyta (Class Diatomeae)											
Gomphonema clevei	R			.	.	.	R	.	.	.	.
Gomphonema gracile	•	.			.	.	.	.	.	.	R
Gomphonema instabilis-quadri-punctulatum?	.	.	.	.	R	.	.	.	.	.	.
Gamphantma lanceolatum	.	.	.	.		R	.	.	.	.	.
Gomphonema montanum var. *acuminatum*	.	.	.	R	.	.	.	.	.	.	.
Gomphonema truncatum var. *capitatum*	.	.	.	.	R	.	.	.	.	.	.
Gomphonema truncatum var. *elongata*	.	.	.	R	.	.	.	.	.	.	.
Gomphonema subtile var. *sagitta*	.	.	.	R	.	.	.	.	.	.	.
Gomphonema spp.	C	c	•	c	•	c	0	•	c	•	•
Gyrosigma spp.	.	.	.	R	.	.	.	.	.	.	.
Hannaea arcus	.	.	.	.	C	.	.	.	0	•	•
Meridion circulare	R	.	.	•	.	.	.	.	.	.	.
Navicula arenaria	.	.	.	.	.	.	.	.	.	.	R
Navicula aurora	.	.	.	.	O	.	.	.	.	.	R
Navicula elginensis	.	.	.	R	.	.	.	.	.	.	.
Navicula pupula	.	.	.	O	.	.	.	.	•	.	.
Navicula radiosa	O	.	.	.	.	.	.	.	.	.	.
Navicula tuscula	.	R	.	.	.	.	.	.	.	.	.
Navicula spp.	C	O	•	[illegible]	[illegible]	•	•	•	•	•	[illegible]
Neidium affine	.	.	.	R	.	.	.	.	.	.	.
Neidium iridis var. *ampliatum*	R	.	.	.	.	.	.	.	.	.	.
Neidium spp.	.	.	.	R	.	.	.	.	.	.	.
Nitzschia acicularis	.	.	O	.	.	.	.	.	.	.	.
Nitzschia denticula	.	.	.	R	.	.	.	.	.	.	.
Nitzschia dissipata	.	.	.	.	.	.	.	.	R	•	•
Nitzschia sigmoidea	R	.	.	.	.	.	.	.	.	.	.
Nitzschia sinuata	R	.	.	.	.	.	.	.	.	.	•
Pinnularia biceps	R	.	.	.	.	.	.	.	.	.	.
Pinnularia major	.	.	.	O	.	.	.	.	.	.	.
Rhopalodia gibba	R	•	0	O	.	.	.	.	.	.	A
Synedra ulna	O	.	.	.	C	0	•	•	0	•	•
Synedra spp.	.	.	.	O	.	.	.	c	0	•	O
Stauroneis phoenicenteron	.	.	.	O	.	.	.	.	.	.	.
Tabellaria fenestrata	0	•	•	0	•	O	.	.	.	.	.
Tabellaria flocculosa	.	.	.	•	A	C	.	.	.	.	•
o. of species	32	16	7	35	20	21	15	3	13	3	15

A • [illegible] common; [illegible] occasional; R [illegible]

* local name.

Source: Wickstrom 1978.

Appendix 9.3 Phytoplankton occurrence in lakes and pond: Kluane National Park.

Taxon		Bates Lake 20-VIII-73	13-VIII-74	Blueberry Ponds 11-VIII-76	Bone Lakes 21-VIII-75	Climbing Lakes 27-VII-75	Cottonwood Lakes 30-VII-75	Cranberry Lakes 14-VIII-74	Duck Glacier Melt Pool #1* 28-VII-74	Eagle Lakes 20-VIII-74	Field Lakes 17-VIII-74	Halfbreed Lakes 10-VIII-76	Jutland Lakes 29-VII-75	Kaskawulsh Melt Pool #1* 16-VII-74	Kathleen Lake 19-VIII-73	24-VIII-74
CYANOPHYTA	% of total	7	0	0	0	0	0	17.2	0	1.4	1.2	0	0	0.2	0.4	3.0
Anabaena flos-aquae																
Anabaena cf. *solitaria* var. *planctonica*																
Anabaena variabilis																
Anabaena spp.										♦	♦					
Aphanizomenon flos-aquae											♦					
Aphanizomenon spp.																♦
Aphanocapsa sp.		♦													♦	
Aphanothece sp.		♦														
Chroococcus dispersus											♦			♦		
Chroococcus limneticus								♦		♦						
Gloeocapsa rupestris										♦						
Gloeocapsa spp.										♦						
Gomphosphaeria aponina								♦								
Gomphosphaeria lacustris		♦													♦	
Gomphosphaeria sp.																
Lyngbya perelegans																
Merismopedia glauca														♦		
Merismopedia tenuissima																
Microcystis aeruginosa								♦								
Microcystis cf. *flos-aquae*		♦														
Oscillatoria lacustris								♦								
Oscillatoria nigra																
Oscillatoria tenuis										♦						
Synechococcus sp.																
Small blue-greens																♦
CHLOROPHYTA	% of total	7	29.8	0.7	2.3	1.1	14.9	21.1	27.3	0.9	8.9	47.0	6.1	5.4	4	3.0
Ankistrodesmus cf. *acicularis* (*Monoraphidium*)															♦	
Ankistrodesmus convolutus													♦			
Ankistrodesmus falcatus										●						
Ankistrodesmus spp.																
Arthrodesmus incus															♦	
Carteria klebsii								♦								
Chlamydomonas spp.			●			●	●	♦					♦			
Coelastrum microporum		♦														
Cosmarium bioculatum					●		♦	●								
Cosmarium meneghinii												♦				

Taxon		Lake Ray (Cyclops L.*) 21-VII-74	Lichen Lakes 29-VII-75	Louise Lake (Upper Kathleen L.*) 22-VII-73	Lynx Lakes 07-VIII-74	Middle Lakes 12-VIII-76	Missing Lakes 26-VII-75	Mush Lake 09-VIII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 29-VII-75	Quaking Ponds 30-VII-75	Red Creek 15-VIII-74	Scud Lakes 15-VIII-74	Slims River Marshes 28-VII-74	Snipe Lakes 23-VII-75	Sockeye Lake 27-VII-73
CYANOPHYTA	% of total	12.5	14.5	0.4	0	0	0	6	0	2.8	0.1	2.4	0.5	2.1	0	0.2
Anabaena flos-aquae		♦														
Anabaena cf. *solitaria* var. *planctonica*												♦		♦		
Anabaena variabilis			●											♦		♦
Anabaena spp.			♦							♦			♦			
Aphanizomenon flos-aquae		♦														
Aphanizomenon spp.																
Aphanocapsa sp.																♦
Aphanothece sp.				♦												
Chroococcus dispersus																
Chroococcus limneticus																
Gloeocapsa rupestris																♦
Gloeocapsa spp.																♦
Gomphosphaeria aponina																
Gomphosphaeria lacustris																♦
Gomphosphaeria sp.		♦														
Lyngbya perelegans											♦			♦		
Merismopedia glauca																
Merismopedia tenuissima								♦								
Microcystis aeruginosa																
Microcystis cf. *flos-aquae*																♦
Oscillatoria lacustris																
Oscillatoria nigra														♦		
Oscillatoria tenuis		♦														
Synechococcus sp.								♦								
Small blue-greens		♦														
CHLOROPHYTA	% of total	3.8	11.7	23	6.6	0	10.1	5	30	0	99.9	9.8	11.4	94.1	50.6	6
Ankistrodesmus cf. *acicularis* (*Monoraphidium*)				♦												
Ankistrodesmus convolutus					♦											♦
Ankistrodesmus falcatus							♦				♦					
Ankistrodesmus spp.							♦									
Arthrodesmus incus																
Carteria klebsii																
Chlamydomonas spp.					♦				♦		♦					
Coelastrum microporum															●	
Cosmarium bioculatum																
Cosmarium meneghinii																

* Local name

Appendix 10.3 Phytoplankton occurrence in lakes and ponds of Kluane National Park [Continued].

	Bates Lake 20-VIII-73	13-VIII-76	Blueberry Ponds 11-VIII-76	Bone Lakes 21-VIII-75	Climbing Lakes 27-VIII-75	Cottonwood Lakes 30-VII-75	Cranberry Lakes 14-VIII-76	Duck Glacier Melt Pool #1* 28-VII-74	Eagle Lakes 26-VIII-74	Field Lakes 17-VIII-74	Mallfored Lakes 10-VIII-76	Jutland Lakes 29-VII-75	Kaskawulsh Melt Pool #1* 16-VII-74	Kathleen Lake 19-VIII-73	24-VIII-74	Lake Ray (Cyclops L.*) 21-VII-74	Lichen Lakes 29-VII-75	Louise Lake (Upper Kathleen L.*) 22-VII-73	Lynx Lakes 07-VIII-74	Middle Lakes 12-VIII-76	Missing Lakes 26-VII-75	Mush Lake 09-VIII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 25-VII-75	Quaking Ponds 30-VII-75	Red Creeks 15-VIII-74	Scud Lakes 15-VIII-74	Slims River Marshes 28-VII-74	Snipe Lakes 23-VIII-75	Sockeye Lake 27-VII-73
CHLOROPHYTA (Continued)																														
Cosmarium phaseolus var. *achondrum*	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cosmarium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crucigenia quadrata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	♦	.
Crucigenia rectangularis	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.
Dictyosphaerium ehrenbergianum	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elakatothrix gelatinosa	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	♦	.	.	.	.	.	.	♦
Gloeococcus schroeteri	♦	.	.	.	.	.	.	.	.	♦	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦
Gloeocystis planctonica	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.
Heterotrophic multiflagellate green	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦
Monoraphidium setiforme	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Monoraphidium spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	♦	.	.	.
Mougeotia spp.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.
Nephrocytium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oocystis borgei	.	♦	.	.	♦	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	♦	.	.	.	♦	.	.	.	♦	.
Oocystis crassa	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oocystis gigas	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.
Oocystis parva	.	♦	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	♦	.	♦	.	.	.	♦	.	.	♦	♦	.
Oocystis pusilla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.
Oocystis solitaria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oocystis submarina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oocystis cf. *submarina*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.
Oocystis submarina var. *variabilis*	♦	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.
Oocystis spp.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pediastrum boryanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.
Pediastrum duplex	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.
Pediastrum tetras	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Planktosphaeria gelatinosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Quadrigula lacustris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.
Scenedesmus bijuga	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	♦	.
Scenedesmus brevispina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.
Scenedesmus cf. *quadricauda*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scenedesmus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Schroederia setigera	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.
Sphaerocystis schroeteri	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.
Spirogyra sp.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.
Spondylosium planum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	♦	.	.	.
Staurastrum sp.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tetraedron minimum	.	♦	.	.	♦	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	♦	.
Tetraedron muticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	♦	.	.	.	.	.	.	.	.	.	.	.	.	.

* Local name

Appendix 3 Phytoplankton occurrence in lakes and ponds of Kluane National Park [Continued].

	Bates Lake 26-VIII-73	13-VIII-74	Blueberry Ponds 11-VIII-76	Bone Lakes 21-VIII-75	Climbing Lakes 27-VII-75	Cottonwood Lake 30-VII-75	Cranberry Lakes 16-VIII-74	Duck Glacier Melt Pool #1[a] 28-VII-74	Eagle Lakes 20-VIII-74	Field Lakes 17-VIII-74	Hallbread Lakes 10-VIII-76	Jutland Lakes 29-VII-75	Kaskawulsh Melt Pool #1[a] 16-VII-74	Kathleen Lake 19-VIII-73	24-VIII-76	Lake Rey (Cyclops L.[a]) 21-VII-74	Lichen Lakes 29-VII-75	Louise Lake (Upper Kathleen L.[a]) 22-VII-73	Lynx Lakes 07-VIII-74	Middle Lakes 12-VIII-76	Missing Lakes 26-VII-75	Mush Lake 09-VIII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 29-VII-75	Quaking Ponds 30-VII-75	Red Creeks 15-VIII-74	Scud Lakes 15-VIII-74	Slims River Marshe 28-VII-74	Snipe Lakes 23-VIII-75	Sockeye Lake 27-VII-73
CHLOROPHYTA (Continued)																														
Zygnema spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
small greens	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	+	.	.	.
EUGLENOPHYTA % of total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0
Trachelomonas sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
CHRYSOPHYTA																														
Class Chrysophyceae % of total	52	10.5	9.0	11.7	15.3	13.6	.1	72.7	0.9	72.3	.0	21.4	94.2	3	39.1	58.	17.8	15	.0	4.6	4.1	50	63	69.7	0	84	73.2	0.5	34.1	83
Bitrichia chodatii	+	+	.	.	.	.	.	.	+	.	.	+	.	+	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Botryococcus braunii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	+
Chromulina spp.	+	+	+	.	+	+	+	.	+	+	.	.	+	+	+	+	+	+	+	.	+	+	+	+	.	.	.	.	.	+
Chrysochromulina parva	.	.	.	.	+	+	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Chrysochromulina cf. *parva*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Chrysococcus rufescens	+	.	.	+	+	.	+	.	.	.	+	.	.	+	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	+
Chrysococcus spp.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	+	+	.	+	.	.	.	+	+	.	.	.	.	.	.	+
Chrysoikos skujae	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chrysolykos planctonicus	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.
Chrysopyxis bipes	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dinobryon acuminatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Dinobryon attenuatum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dinobryon bavaricum	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Dinobryon crenulatum	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Dinobryon divergens	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+	.
Dinobryon njakajaurense	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Dinobryon cf. *saccatum*	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.
Dinobryon sertularia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.
Dinobryon sociale	.	.	.	.	.	+	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Dinobryon sociale var. *americanum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Dinobryon suecicum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dinobryon tabellaria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Epipyxis cf. *borealis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.
Epipyxis gracilis	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epipyxis tubulosa	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epipyxis utriculus	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epipyxis spp.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Erkenia subaequiciliata	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+
Erkenia spp.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gloeobotrys limneticus	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kephyrion littorale	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	+
Kephyrion spp.	.	.	.	.	+	.	.	.	.	.	+	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	+	+	.

[a] Local name.

Appendix 10.3 Phytoplankton occurrence in lakes and ponds of Kluane National Park [Continued].

	Bates Lake 20-VIII-73	13-VIII-74	Blueberry Ponds 11-VIII-76	Bone Lakes 21-VIII-75	Climbing Lake 27-VIII-75	Cottonwood Lake 30-VII-75	Cranberry Lake 16-VIII-74	Duck Glacier Melt Pool #1a 28-VII-74	Eagle Lake 20-VIII-74	Field Lake 17-VIII-74	Hallbread Lake 10-VIII-76	Jutland Lake 29-VII-75	Kaskawulsh Melt Pool #1a 16-VII-74	Kathleen Lake 19-VII-73	26-VIII-74	Lake Bay (Cyclops L.e) 21-VII-74	Lichen Lake 29-VII-75	Louise Lake (Upper Kathleen L.e) 22-VII-73	Lynx Lake 07-VII-74	Middle Lake 12-VIII-76	Missing Lake 26-VII-75	Mush Lake 09-VII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 25-VII-75	Quaking Ponds 30-VII-75	Red Creek 15-VIII-74	Scud Lake 15-VIII-74	Slims River Marshes 28-VII-74	Snipe Lake 23-VIII-75	Sockeye Lake 27-VII-73
Class Chrysophyceae (Continued)																														
Kephyriopsis gracilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.
Kephyriopsis spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.
Mallomonas pumilio	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	•	.	.	.	.
Mallomonas pumilio var. *canadensis*	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•
Mallomonas spp.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Monosiga varians var. *vagans*	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ochromonas spp.	•	.	•	.	•	•	•	.	•	•	.	.	•	•	•	.	•	.	.	.	•	•	•	.	.	.	.	.	.	•
Pseudokephyrion pseudospirale	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	•	.
Pseudokephyrion striatum	.	.	.	•	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.
Pseudokephyrion undulatissimum	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.
Pseudokephyrion spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	•
Pseudopedinella sp.	.	•	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.
Stenocalux densata	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stenocalux klarnetii	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stenocalux monilifera	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.
Stenocalyx spp.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
small chrysophyceae	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	•	•	.	.	.
large chrysophyceae	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	•	•	.	.	.
Class Diatomeae % of total	3	17.2	10.8	86.0	16.4	42.8	56.4	0	81.1	0.6	45.2	31.2	0.2	3	49.2	2.8	29.1	60	83.5	25.8	83.6	21	3	27.5	0	1.6	2.6	.3	12.3	6
Achnanthes lanceolata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.
Achnanthes microcephala	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achnanthes minutissima	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.
Achnanthes spp.	.	•	•	.	.	•	.	.	•	.	•	•	.	.	.	.	•	.	•	.	•	.	.	•	.	.	.	.	•	.
Amphora ovalis	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asterionella formosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	•	.
Cyclotella antiqua	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.
Cyclotella comta	•	•	.	.	.	.	.	.	.	.	.	.	.	•	.	•	.	•	.	.	.	•	.	.	.	.	.	.	.	•
Cyclotella glomerata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclotella kuetzingiana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.
Cyclotella ocellata	•	•	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	•	.	.	.	•	•	.	.	.	.	.	.	•
Cyclotella stelligera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.
Cyclotella spp.	.	•	.	.	.	•	•	.	.	.	.	.	.	.	.	•	.	.	.	.	•	.	.	.	.	.	•	.	•	.
Cymbella angustata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.
Cybella cymbiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.
Cymbella microcephala	.	.	.	.	.	•	.	.	•	.	.	.	.	.	.	.	.	.	•	•	•	.	.	•	.	.	.	.	.	.
Cymbella minuta	.	.	.	.	.	•	•	.	•	.	.	•	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.
Epithemia sorex	.	.	.	.	.	.	•	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eunotia arcus																														
Fragilaria pinnata																														

Appendix 10.3 Phytoplankton occurrence in lakes and ponds of Kluane National Park [Continued].

		Bates Lake 20-VIII-73	13-VIII-76	Blueberry Ponds 11-VIII-76	Bona Lakes 27-VIII-75	Climbing Lakes 27-VII-75	Cottonwood Lakes 30-VII-75	Cranberry Lakes 16-VIII-76	Duck Glacier Melt Pool #1* 28-VII-76	Eagle Lakes 20-VIII-76	Field Lakes 17-VIII-76	Hellbroad Lakes 10-VIII-76	Jutland Lakes 29-VII-75	Kaskawulsh Melt Pool #1* 16-VII-76	Kathleen Lake 19-VII-73	26-VIII-76	Lake Ray (Cyclops L.*) 21-VII-76	Lichen Lakes 29-VII-75	Louise Lake (Upper Kathleen L.*) 22-VII-73	Lynx Lakes 07-VIII-76	Middle Lakes 12-VIII-76	Missing Lakes 26-VII-75	Mush Lake 09-VIII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 29-VII-75	Quaking Ponds 30-VII-75	Red Creeks 15-VIII-76	Scud Lakes 15-VIII-76	Silver River Marshes 28-VII-76	Snipe Lakes 23-VIII-75	Sockeye Lake 27-VII-73
Class Diatomeae (Continued)																															
Fragilaria spp.		.	.	.	.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.			.	.	.	.	.	ı	•	•
Gomphonema angustatum		.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	ı	ı	ı
Gomphonema gracile		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		◆	.	◆	.	.	.	ı	•	•
Gomphonema lanceolatum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	•	[illegible]	[illegible]
Gomphonema parvulum		.	.	.	.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.		.	.	.	.	.	[illegible]	•	[illegible]
Gomphonema spp.		.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	◆	.	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Hannaea arcus		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Navicula cryptocephala		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Navicula pupula var. *rectangularis*		.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	•	[illegible]	[illegible]
Navicula radiosa		.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Navicula rhynchocephala		.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Navicula spp.		.	◆	.	◆	.	.	◆	.	◆	.	.	◆	◆	.	.	.	.	.	◆	.	◆		.	.	.	.	.	ı	[illegible]	•
Nitzschia acicularis		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	◆		.	.	.	.	.	◆	ı	[illegible]
Nitzschia amphibia var. *genuina*		.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Nitzschia dissipata var. *media*		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	ı	◆	[illegible]
Nitzschia palea		.	.	.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	ı	[illegible]	[illegible]
Nitzschia spp.		.	.	.	.	◆	◆	◆	.	◆	.	.	◆	.	.	.	.	◆	.	.	◆	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Pinnularia major		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Pinnularia mesolepta		.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	◆	.	.	.	[illegible]	[illegible]	[illegible]
Pinnularia spp		.	.	.	◆	.	.	.	.	◆	◆	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
[illegible]		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	.	.		.	.	.	.	.	[illegible]	[illegible]	[illegible]
Synedra acus		◆	.	.	.	.	.	.	.	.	.	.	.	.	◆	◆	.	.	◆	.	.	.	◆	.	.	.	.	.	[illegible]	[illegible]	[illegible]
Synedra cf. *acus*		.	.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	[illegible]	[illegible]	[illegible]
Synedra spp.		.	.	.	.	.	.	.	.	.	.	.	◆	.	.	.	◆	.	.	.	.	.	.	.	◆	.	◆	.	[illegible]	[illegible]	[illegible]
Stauroneis phoenicenteron		.	.	.	.	.	.	◆	.	◆	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[illegible]	[illegible]	[illegible]
Tabellaria fenestrata		.	.	.	.	.	◆	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	◆	.	.	.	.	◆	[illegible]	•	[illegible]
Tabellaria flocculosa		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	[illegible]	[illegible]	[illegible]
Tetracyclus rupestris		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	ı	ı	[illegible]
large diatoms		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	[illegible]	[illegible]	[illegible]
Class Xanthophyceae[1]																															
Tribonema spp.		.	.	.	.	.	.	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	.	.	.	.	.	[illegible]	[illegible]	[illegible]
PYRROPHYTA																															
Class Cryptophyceae	% of total	15	13.6	79.5	0	55.2	28.8	3.3	0	15.6	17.0	0	28.4	0	0.3	2.1	15.0	6.9	0	1.5	69.6	1.9	5	3	0	0	1.2	0.4	0	3.0	1
Cryptomonas erosa		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	◆	.	.	.
Cryptomonas marssonii		.	.	.	.	.	.	◆	.	◆	.	.	.	.	.	.	◆	.	.	.	.	.	.	.	.	.	◆	ı	ı	ı	◆

* Local name.
1 Xanthophyceae percentage composition is included with Class Crysophyceae.

Appendix 10.3 Phytoplankton occurrence in lakes and ponds of Kluane National Park [Concluded].

	Gates Lake 20-VIII-73	13-VIII-74	Blueberry Ponds 11-VIII-76	Bone Lakes 21-VIII-75	Climbing Lakes 27-VIII-75	Cottonwood Lakes 30-VIII-75	Cranberry Lakes 14-VIII-74	Duck Glacier Melt Pool #1a 28-VII-74	Eagle Lakes 20-VIII-74	Field Lakes 17-VIII-74	Halfbreed Lakes 10-VIII-76	Jutland Lakes 29-VII-75	Kaskawulsh Melt Pool #1a 16-VII-74	Kathleen Lake 19-VII-73	24-VIII-74	Lake Ray (Cyclops L.o) 21-VII-74	Lichen Lakes 29-VII-75	Louise Lake (Upper Kathleen L.o) 22-VII-73	Lynx Lakes 07-VIII-74	Middle Lakes 12-VIII-76	Missing Lakes 26-VII-75	Mush Lake 09-VIII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 29-VIII-75	Quaking Ponds 30-VII-75	Red Creeks 15-VIII-74	Scud Lakes 15-VIII-74	Slims River Marshs 28-VII-74	Snipe Lakes 23-VIII-75	Sockeye Lake 27-VII-73
Class Cryptophyceae (Continued)																														
Cryptomonas ovata	–	–	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Cryptomonas rostratiformis	–	–	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Cryptomonas spp.	–	–	·	·	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Katablepharis ovalis	–	–	·	·	·	·	·	·	·	+	·	·	·	+	+	+	·	·	·	·	·	+	+	·	·	·	·	·	·	+
Rhodomonas minuta	–	–	+	·	+	·	+	·	+	+	·	·	·	·	+	+	+	·	·	+	+	+	+	·	·	·	+	·	·	+
Rhodomonas minuta var. *nannoplanctica*	–	–	·	·	·	+	·	·	·	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	+	·
Class Peridineae % of total	5	29.0	0	0	5.3	0	1.0	0	0	0.1	0	12.9	0	0.1	16.3	7.6	0	2	0	0	0	12	1	0	0	0	11.8	0	0	3
Ceratium hirundinella	·	–	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·
Glenodinium spp.	–	–	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Gymnodinium helveticum	–	–	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	+	+	·	·	·	·	·	·	+
Gymnodinium III	–	–	·	·	·	·	·	·	·	+	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Gymnodinium spp.	–	–	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	+	·	·	·	+	+	·	·	·	·	·	·	+
Peridinium inconspicuum	–	–	·	·	+	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Peridinium willei	–	–	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·
Peridinium III	–	–	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·
Peridinium spp.	–	–	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Total biomass (mg/m3)	76	55	176	77	105	76	1145	1	825	301	20	135	15161	270	274	413	29	176	90	70	456	98	379	34	549	26	693	6360	402	433
No. of species	21	8	10	9	16	18	29	2	28	18	6	20	12	23	16	28	12	15	18	10	22	15	16	11	10	6	17	14	23	27

Source: Wickstrom 1978.

Appendix 10.4 Aquatic macrophyte occurrence in Kluane National Park.

	Alder Creek	Bates Lake	Blueberry Pond*	Cathie Lake*	Climbing Creek*	Coin Creek	Cranberry Lake*	Dezadeash River	Duke River	Eagle Lake*a	Field Lake*	Halfbreed Lake*	Jutland Lake*	Kaskawulsh Melt Pool #1*	Kathleen Lake	Lake Ray (Cyclops L.*)	Lichen Lake*	Louise Lake (Upper Kathleen L.*)	Lynx Lake*	Missing Lake*	Mush Lake	Onion Lake	Phalarope Lake*a	Quaking Pond*	Rita Pond*	Scud Lake*	Short Pond*	Slims River	Slims River Marsh*	Snipe Lake*	Sockeye Lake	Spring Pond*
CALLITRICHACEAE																																
Callitriche																																
verna L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
CARYOPHYLLACEAE																																
Stellaria																																
sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
COMPOSITAE																																
Aster																																
alpinus L.	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Petasites																																
frigidus (L.) Fries																																
var. *nivalis* (Greene) Cronq.	·	·	·	·	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
sagittatus (Banks) Gray	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
sp.	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Senecio																																
pauciflorus Pursh	·	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CRASSULACEAE																																
Sedum																																
rosea (L.) Scop.	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
CRUCIFERAE																																
Descurainia																																
pinnata (Walt.) Britt.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Rorippa																																
islandica (Oed.) Borbas	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
CYPERACEAE																																
Carex																																
aquatilis Wahl.	+	+	·	·	·	+	+	·	·	+	·	+	+	·	+	+	·	·	+	+	·	+	+	+	+	+	·	+	+	·	+	·
aurea Nutt.	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
buxbaumii Wahl.	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
canescens L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
crawfordii Fern.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
diandra Schrank	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
lasiocarpa Ehrh.	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
lenticularis Michx.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·
maritima Gunn.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
media R. Br. ex Richards	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·		·	·	·	·	·
rhyncophysa C.A. Mey.	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
rostrata Stokes	·	[illegible]	[illegible]	[illegible]	·	·	+	·	·	·	·	·	·	·	+	+	·	+	·	+	+	+	+	·	·	+	·	·	·	·	+	·
saxatilis L.	·	+	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+	·	·	+	·	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
spp.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+	·	+	·	+	·	·	·	·	+	·	·	·	+	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* Local name; a Peripheral to Park; + Present.

Appendix 10.4 Aquatic macrophyte occurrence in Kluane National Park [Continued]

	Alder Creek	Bates Lake	Blueberry Pond*	Cathie Lake*	Climbing Creek*	Coin Creek	Cranberry Lake*	Dezadeash River	Duke River	Eagle Lake*[a]	Field Lake*	Halfbreed Lake*	Jutland Lake*	Kaskawulsh Melt Pool #1*	Kathleen Lake	Lake Ray (Cyclops L.*)	Lichen Lake*	Louise Lake (Upper Kathleen L.*)	Lynx Lake*	Missing Lake*	Mush Lake	Onion Lake	Phalarope Lake*[a]	Quaking Pond*	Rita Pond*	Scud Lake *	Short Pond*	Slims River	Slims River Marsh*	Snipe Lake*	Sockeye Lake	Spring Por
CYPERACEAE																																
Eleocharis																																
palustris (L.) Roem. & Schult.	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·
Eriophorum																																
angustifolium Honck.	+	·	+	·	·	+	·	·	·	·	+	+	+	·	·	·	·	·	+	·	·	·	·	+	+	·	+	·	+	·	·	·
branchyantherum Trautv. & Mey.	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·
chamissonis C.A. Mey	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
scheuchzeri Hoppe	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Scirpus																																
caespitosus L.	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
EMPETRACEAE																																
Empetrum																																
nigrum L.	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
EQUISETACEAE																																
Equisetum																																
arvense L.	·	·	·	·	·	+	·	·	·	·	+	·	·	·	+	+	·	·	+	·	·	·	·	·	+	·	·	·	+	·	·	·
fluviatile L.	+	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	+	·	+	+	·	·	·	·	·	·	·	·	+	+	·
palustre L.	+	·	·	·	·	·	+	·	·	·	·	·	+	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·
scirpoides Michx.	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
variegatum Schleich.	·						·	·	+	·	+	·	·	+	·	·	·	·	+	·	·	+	·	·	·	·	·	·	+			
ERICACEAE													·	·	+																	
Andromeda																																
polifolia L.	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·
GRAMINEAE																																
Agropyron																																
yukonense Scribn. & Merr.	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Arctagrostis																																
latifolia (R. Br.) Griseb.	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Arctophila																																
fulva (Trin.) Anderss.	·	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	·	·
Calamagrostis																																
canadensis (Michx.) Beauv.	·			·	·	+	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	+	+	·	+	+						
inexpansa Gray					·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+									
neglecta (Ehrh.) Gaertn., Mey., Schreb.																							·	·	+	·	+					
nutkaensis (Presl) Steud.									·	·	+																					
spp.										·	·	+	·	·	+	·	·	·	·	·	+											

* Local name; [a] Peripheral to Park; + Present.

Appendix 10.4 Aquatic macrophyte occurrence in Kluane National Park [Continued].

	Alder Creek	Bates Lake	Blueberry Pond*	Cathie Lake*	Climbing Creek*	Coin Creek	Cranberry Lake*	Dezadeash River	Duke River	Eagle Lake*a	Field Lake*	Halfbreed Lake*	Jutland Lake*	Kaskawulsh Melt Pool #1*	Kathleen Lake	Lake Ray (Cyclops L.*)
GRAMINEAE																
Deschampsia																
caespitosa (L.) Beauv.	•	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
elongata (Hook.) Munro ex Benth.	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•	•
Festuca																
ovina L.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Glyceria																
grandis Wats. ex Gray	•	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Phleum																
alpinum L.	•	+	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Poa																
sp.	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•
Polypogon																
monspeliensis (L.) Desf.	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•	•
HALORAGACEAE																
Hippuris																
vulgaris L.	+	+	•	•	•	•	•	•	•	•	•	+	•	•	+	+
Myriophyllum																
spicatum L.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	+
JUNCACEAE																
Juncus																
alpinus Vill.	•	[illegible]	[illegible]	•	•	+	•	•	•	•	•	•	•	•	+	•
arcticus Willd.	[illegible]	[illegible]	[illegible]	•	•	+	•	•	•	•	•	+	•	+	+	•
castaneus J.E. Smith	[illegible]	[illegible]	[illegible]	[illegible]	•	•	+	•	+	•	+	•	+	•	•	•
drummondii E. Meyer in Ledeb.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
mertensianus Bong.	•	•	•	•	•	•	•	•	•	•	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
triglumis L.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	•	•	+	[illegible]	[illegible]	[illegible]	[illegible]
JUNCAGINACEAE																
Triglochin																
maritima L.																
palustris L.																
LENTIBULARIACEAE																
Utricularia																
intermedia Hayne ex Schrad.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
vulgaris L.	•	•	•	+	•	•	•	•	•	+	•	•	•	•	•	•
MENYANTHACEAE																
Menyanthes																
trifoliata L.	•	•	•	•	•	•	+	•	•	+	•	•	•	•	•	•

	Lichen Lake*	Louise Lake (Upper Kathleen L.*)	Lynx Lake*	Missing Lake*	Mush Lake	Onion Lake	Phalarope Lake*a	Quaking Pond*	Rita Pond*	Scud Lake *	Short Pond*	Slims River	Slims River Marsh*	Snipe Lake*	Sockeye Lake	Spring Pon
GRAMINEAE																
Deschampsia																
caespitosa (L.) Beauv.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
elongata (Hook.) Munro ex Benth.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Festuca																
ovina L.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Glyceria																
grandis Wats. ex Gray	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Phleum																
alpinum L.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Poa																
sp.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Polypogon																
monspeliensis (L.) Desf.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
HALORAGACEAE																
Hippuris																
vulgaris L.	•	•	+	+	+	+	•	•	+	•	+	+	•	•	+	•
Myriophyllum																
spicatum L.	•	•	•	•	+	•	•	•	•	+	•	•	•	•	+	•
JUNCACEAE																
Juncus																
alpinus Vill.	•	•	+	•	•	•	•	•	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
arcticus Willd.	•	•	+	•	•	•	•	•	•	•	•	•	+	[illegible]	[illegible]	[illegible]
castaneus J.E. Smith	•	•	•	•	•	•	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
drummondii E. Meyer in Ledeb.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
mertensianus Bong.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
triglumis L.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JUNCAGINACEAE																
Triglochin																
maritima L.																
palustris L.			+	•	•	•	•	•	•	•	+	•	•	•	•	•
LENTIBULARIACEAE																
Utricularia																
intermedia Hayne ex Schrad.	•	•	•	•	+	•	•	•	•	•	•	•	•	•	+	•
vulgaris L.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
MENYANTHACEAE																
Menyanthes																
trifoliata L.	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•

* Local name; a Peripheral to Park; + Present.

Appendix 10.4 Aquatic macrophyte occurrence in Kluane National Park [Conti:'ued].

	Alder Creek	Bates Lake	Blueberry Pond*	Cathie Lake*	Climbing Creek*	Coin Creek*	Cranberry Lake*	Dezadeash River	Duke River	Eagle Lake*#	Field Lake*	Halfbreed Lake*	Jukland Lake*	Kaskawulsh Melt Pool #1*	Kathleen Lake	Lake Ray (Cyclops L.*)	Lichen Lake*	Louise Lake (Upper Kathleen L.*)	Lynx Lake*	Missing Lake*	Mush Lake	Onion Lake	Phalarope Lake*#	Quaking Pond*	Rica Pond*	Scud Lake*	Short Pond*	Slims River	Slims River Marsh*	Snipe Lake*	Sockeye Lake	Spring Pond*
ORCHIDACEAE																																
Habenaria																																
sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
POLYGONACEAE																																
Polygonum																																
amphibium L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·
Rumex																																
arcticus Trautv. ex Middend.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·
sp.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·
POTAMOGETONACEAE																																
Potamogeton																																
alpinus Balbis																																
var *tenuifolius* (Raf.) Ogden	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
filiformis Pers.	·	+	·	·	·	·	+	·	·	+	·	+	·	·	+	+	·	·	+	+	+	+	·	·	+	·	+	+	·	·	+	·
friesii Rupr.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
gramineus L.	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
pectinatus L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
praelongus Wulf.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
pusillus Rupr.	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
richardsonii (Benn.) Rudb.	·	·	·	+	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	+	+	·
vaginatus Turcz.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·
RANUNCULACEAE																																
Caltha																																
biflora DC.	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
leptosepala DC.	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Ranunculus																																
aquatilis L.	·	·	+	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
flammula L.	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
hyperboreus Rottb.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
repens L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
ROSACEAE																																
Geum																																
macrophyllum Willd.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Potentilla																																
fruticosa L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·
palustris (L.) Scop.	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·	+	+	·	·	+	+	·	·	·	·	·	·	·
SALICACEAE																																
Salix																																
spp.	·	·	·	·	+	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+	·	·	·	·	+	·	+	·	·	·	·	·

*Local name, # Peripheral to Park, + Present.

Appendix 10.4 Aquatic macrophyte occurrence in Kluane National Park [Concluded].

	Alder Creek	Bates Lake	Blueberry Pond*	Cathie Lake*	Climbing Creek*	Coin Creek	Cranberry Lake*	Dezadeash River	Duke River	Eagle Lake*ª	Field Lake*	Halfbreed Lake*	Jutland Lake*	Kaskawulsh Melt Pool #1*	Kathleen Lake	Lake Ray (Cyclops L.*)	Lichen Lake*	Louise Lake (Upper Kathleen L.*)	Lynx Lake*	Missing Lake*	Mush Lake	Onion Lake	Phalarope Lake*ª	Quaking Pond*	Rita Pond*	Scud Lake*	Short Pond*	Slims River	Slims River Marsh*	Snipe Lake*	Sockeye Lake	Spring Pond*
SAXIFRAGACEAE																																
Saxifraga																																
lyallii Engler	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SCROPHULARIACEAE																																
Pedicularis																																
sudetica Willd.	.	.	.	.	.	.	..l....	.	.	.	.	.	.	.	.	.							.	.	+	.	.	.	.	.	.	.
SPARGANIACEAE																																
Sparganium																																
hyperboreum Laest.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
minimum Fries	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
spp.	●	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	☒	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.	.	+	.	.	.	.	.	.	.
VALERIANACEAE																																
Valeriana																																
sitchensis Bong.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ZANNICHELLIACEAE																																
Zannichellia																																
palustris L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.

* Local name. ª Peripheral to Park. + Present.

Source: Wickstrom 1978.

Appendix 10.5 Occurrence of aquatic hepatics and mosses in Kluane National ?ark.

Taxon	Alder Creek	Bates Lake	Blueberry Pond[1]	Cathie Lake[1]	Climbing Creek[1]	Coin Creek	Cranberry Lake[1]	Dezadeash River	Duke River	Eagle Lake[1,a]	Field Lake[1]	Halfbreed Lake[1]	Jutland Lake[1]	Kaskawulsh Melt Pool #1[1]	Kathleen Lake	Lake Ray (Cyclops L.[1])	Lichen Lake[1]	Louise Lake (Upper Kathleen L.[1])	Lynx Lake[1]	Missing Lake[1]	Mush Lake	Onion Lake	Phalarope Lake[1,a]	Quaking Pond[1]	Rita Pond[1]	Scud Lake[1]	Short Pond[1]	Slims River	Slims River Marsh[1]	Snipe Lake[1]	Sockeye Lake	Spring Pond
HEPATICAE																																
Jungermannia																																
cordifolia Hook.						*						*																				
MUSCI																																
Bryum																																
pallescens Schleich. ex Schwaegr.									*																							
pseudotriquetrum (Hedw.) Gaertn.											I																					
sp.																												*		*		
Calliergon																																
giganteum (Schimp.) Kindb.																																
Drepanocladus																																
aduncus (Hedw.) Warnst.																																
var. *capillifolius* (Warnst.) Rienm.																																
exannulatus (B.S.G.) Warnst.																																
var. *exannulatus*																																
fluitans (Hedw.) Warnst.																			+													
cf. *revolvens*																																
revolvens (Sw.) Warnst.							+						+		+		+	+				+		+	+		+				+	
Fontinalis																																
hypnoides C.J. Hartm.																																
var. *duriaei* (Schimp.) Husn.																																
Philonotis																																
fontana (Hedw.) Brid.																																
var. *fontana*																												*				
Pohlia																																
cruda (Hedw.) Lindb.															*																	
Scorpidium																																
scorpioides (Hedw.) Limpr.										+																						
turgescens (T. Jens.) Loeske																															*	

Source: Wickstrom 1978.

[1] Local name; [a] Peripheral to Park; + Present.

Appendix 10.6 Zooplankton species occurrence in lakes and ponds of Kluane National Park.

	Bates Lake 20-VIII-73	15-VIII-74	Blueberry Ponds 11-VIII-76	Bone Lake 20-VIII-75	Climbing Lake 27-VII-75	Cottonwood Lake 30-VII-75	Cranberry Lake 16-VIII-74	Field Lake 16-VIII-76	Halfbreed Lake 10-VIII-76	Jutland Lake 29-VII-75	Kathleen Lake 19-VIII-73	24-VIII-74	Lake Ray (Cyclops L.?) 21-VII-74	Lichen Lake 29-VII-75	Louise Lake (Upper Kathleen L.?) 22-VII-73	Lynx Lake 07-VIII-74	Middle Lake 12-VIII-76	Missing Lake 26-VII-75	Mush Lake 09-VIII-73	Onion Lake 13-VIII-73	Ptarmigan Ponds 29-VII-75	Quaking Ponds 30-VII-75	Red Creek 15-VIII-74	Scud Lake 15-VIII-74	Snipe Lake 23-VIII-75	Sockeye Lake 27-VII-73	Spring Ponds 15-VII-74
CLADOCERA																											
Sida crystallina (O.F. Müller)	.	.	.	.	.	.	0.004	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Daphnia longispina hyalina Leydig var. *microcephala* Sars	2.4	1.61	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	2.4	.	.	.	.	.	.	.
Daphnia middendorffiana Fischer	.	.	0.51	.	.	0.18	0.004	.	0.87	.	0.07	0.05	0.008	.	.	.	.	0.08	.	.	.	2.22	.	.	.	.	.
Daphnia pulex Leydig	.	.	.	.	.	.	.	0.721	.	.	0.07	0.10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Daphnia schødleri Sars	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.50	2.40	.	.
Daphnia species (immature)	.	.	.	.	0.17	.	.	.	.	.	.	.	.	0.10	.	.	.	.	.	.	.	.	.	.	.	.	.
Scapholeberis kingi Sars	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.02	.	.	.	.	.
Bosmina longirostris (O.F. Müller)	.	.	.	.	0.101	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bosmina coregoni longispina Leydig	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.0	.	.	.	.	.	.	.
Eurycercus lamellatus (O.F. Müller)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.02	.	.	.	.
Camptocercus rectirostris Schödler	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.22	.	.	.	.	.
Acroperus harpae Baird	.	.	.	.	.	.	0.002	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alona affinis Leydig	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chydorus sphaericus (O.F. Müller)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.02	.	.	.	.	2.20	0.04	.	.	.	.
COPEPODA																											
Senecella calanoides Juday	0.16	0.17	.	.	.	.	.	.	.	.	0.18	0.13	.	.	0.01	.	.	.	0.05	.	.	.	.	.	.	0.05	.
Heterocope septentrionalis Juday & Muttkowski	.	.	0.04	.	.	.	0.01	.	0.04	1.25	.	.	0.15	.	.	0.06	0.13	0.10	.	.	.	.	.	.	.	.	.
Epischura nevadensis Lilljeborg	.	.	.	.	.	0.11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epischura species (immature)	.	.	.	.	.	.	.	.	.	.	.	.	.	0.77	.	.	.	.	.	.	.	.	.	.	.	.	.
Diaptomus arcticus Marsh	.	.	.	.	.	.	.	0.75	0.16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diaptomus pribilofensis Juday & Muttkowski	2.8	3.59	.	1.94	.	.	3.73	.	.	.	23.9	10.27	15.49	.	6.9	19.02	39.28	14.66	2.9	2.9	.	.	.	29.21	18.56	1.8	.
Diaptomus tyrrelli Poppe	.	.	0.65	.	.	.	.	12.61	24.36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diaptomus species (immature)	.	.	.	.	6.03	3.41	.	.	.	7.43	.	.	.	.	.	.	.	.	.	.	.	26.07	.	.	.	.	.
Eucyclops speratus (Lilljeborg)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.75	.	.	.
Cyclops scutifer Sars	7.7	26.64	.	0.24	46.65	130.44	0.33	.	.	22.44	15.4	16.11	.	10.51	5.4	4.17	.	.	6.1	43.1	.	15.08	.	.	.	24.4	.
Cyclops vernalis Fischer	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.16	.	.	.	.
Cyclops capillatus Sars	.	.	0.05	.	0.005	.	.	.	.	.	.	.	.	0.01	.	.	2.22	.	.	.	.	1.15	.	.	.	.	.
Cyclops species	.	.	.	.	.	.	.	.	.	.	.	.	92.92	.	.	.	.	.	.	.	.	.	0.004	.	.	.	.
Cyclops species (immature)	.	.	0.01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.62	.	.	.	.	.	.	179.64	.	.
OTHER																											
Anostraca species	.	.	0.01	.	.	.	.	+	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amphipoda species (cf. *Gammarus*)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.04	.	.	.
Gammarus species	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.006	.	.
Chaoborus species	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	0.02	.	0.06	0.26	.	.
Total Individuals /ℓ	13.1	32.01	1.27	2.18	52.96	134.14	4.08	14.08	25.47	86.12	39.6	26.66	108.57	11.39	12.3	23.25	41.65	15.46	10.2	49.4	.	46.98	0.22	31.56	200.89	26.3	.
Total Individuals /cm^2	65.5	160.1	1.02	1.09	97.94	134.14	3.70	7.8	17.81	86.12	198.0	133.3	48.0	4.56	61.5	19.5	24.97	9.27	51.0	128.4	.	10.82	0.11	22.3	130.66	69.2	.

Appendix 10.7 Aquatic and semi-aquatic invertebrate occurrence, exclusive of zooplankton, in waters of Kluane National Park.

Taxon	Alder Creek	Bates Lake	Bates Lake Creek	Bear Creek*	Bighorn Creek*	Blueberry Ponds	Lura Lake*	Bullion Creek	Canada Creek	Climbing Lake*	Climbing Creek (Upper)*	Climbing Creek (Lower)*	Colin Creek	Cottonwood Lake*	Cottonwood Creek	Cranberry Lake*	Dezadeash River	Donjek River	Duke Glacier Melt Pools	Duke River	Eagle Lake*	Field Lake*	Field Creek	Fraser Creek	Fruit Creek*	Granite Creek	Halfbreed Lake*	Hiking Creek*	Jarvis River	Jutland Lake*	Kaskawulsh Melt Pools	Kathleen Lake	Knob Creek*	Lake Bay	Lichen Lake*	Louise Lake	Lynx Lake*	Middle Lake*	Missing Lake*	Mush Lake	Mush Creek (Upper)	Mush Creek (Lower)	Mush Lake Creek #12*	Onion Lake	Phalarope Lake*	Pine Creek	Plum Creek*	Pool Creek*	Quaking Ponds	Rain Creek*	Red Creek*	Rica Ponds*	Mud Lake*	Shaft Creek	Sheep Creek	Short Ponds	Slims River	Slims River Marsh*	Slipping Creek*	Snipe Lake*	Sockeye Lake	Spring Ponds	Vulcan Creek	Wade Cr.
Porifera																																																																
Coelenterata																																																																
Hydrozoa *Hydra* sp.																																																																
Platyhelminthes																																																																
Turbellaria																																																																
Tricladida																																																																
Trematoda																																																																
Cestoda																																																																
Aschelminthes																																																																
Nematoda																																																																
Nematomorpha																																																																
Gordioidea																																																																
Gordius sp.																																																																
Annelida																																																																
Oligochaeta																																																																
Hirudinea																																																																
PISCICOLIDAE																																																																
Piscicola																																																																
milneri																																																																
Theromyzon																																																																
rude																																																																
Mollusca																																																																
Gastropoda																																																																
LYMNAEIDAE																																																																
Lymnaea spp.																																																																
arctica Lea																																																																
athabascensis Baker																																																																
elodes ? (Say)																																																																
modicella (Say)																																																																
Physa spp.																																																																
jennessi jennessi																																																																
PLANORBIDAE																																																																
Gyraulus spp.																																																																
circumstriatus (Tryon)																																																																
parvus (Say)																																																																
VALVATIDAE																																																																
Valvata spp.																																																																
sincera helicoidea Dall																																																																
Pelecypoda																																																																
SPAERIIDAE																																																																
Pisidium spp.																																																																
casertanum (Poli)																																																																
idahoense Roper																																																																
lilljeborgi Clessin																																																																
nitidum Jenyns																																																																
Sphaerium spp.																																																																
lacustre (Muller)																																																																
nitidum Clessin																																																																
securis ? (Prime)																																																																
Arthropoda																																																																
Crustacea																																																																
Brachiopoda Anostraca																																																															
Ostracoda																																																																
Malacostraca																																																																
Amphipoda																																																																
Gammarus sp.																																																																
lacustris Sars																																																																
Hyalella sp.																																																																
Arachnida																																																																
Hydracarina																																																																
Araneae																																																																

Appendix 10.7 Aquatic and semi-aquatic invertebrate occurrence, exclusive of zooplankton, in waters of Kluane National Park [Continued].

	Alder Creek	Bates Lake	Bates Lake Creeks	Bear Creeks	Bighorn Creeks	Blueberry Ponds	Bone Lakes	Bullion Creek	Canada Creek	Climbing Lakes	Climbing Creek (Upper)*	Climbing Creek (Lower)*	Cola Creek	Cottonwood Lakes	Cottonwood Creek	Cranberry Lakes	Dalzdeash River	Donjek River	Duke Glacier Melt Pool*	Duke River	Eagle Lakes	Field Lakes	Field Creek	Fraser Creek	Fruit Creeks	Granite Creek	Halfbread Lakes	Hiking Creeks	Jarvis River	Jutland Lakes	Kaskawulsh Melt Pools	Kathleen Lake	Kaw Creeks	Lake Bay	Lichen Lakes	Louise Lake	Lynx Lakes	Middle Lakes	Missing Lakes	Mush Lake	Mush Creek (Upper)	Mush Creek (Lower)	Mush Lake Creek #13*	Onion Lake	Phalarope Lakes	Pine Creek	Plum Creeks	Pool Creeks	Quaking Ponds	Rain Creeks	Red Creeks	Rita Ponds	Scud Lakes	Shaft Creek	Sheep Creek	Sport Ponds	Slims River	Slims River Marshes	Slipping Creeks	Snipe Lakes	Sockeye Lake	Spring Ponds	Vulcan Creek	Wade Creek
Insecta																																																																	
Ephemeroptera																																																																	
SIPHLONURIDAE																																																																	
Ameletus sp.																																																																	
Siphlonurus sp. Eaton																																																																	
HEPTAGENIIDAE																																																																	
Heptagenia sp. Walsh																																																																	
Cinygmula sp. McDonnough																																																																	
BAETIDAE																																																																	
Pseudocloeon sp. Klapalek																																																																	
EPHEMERELLIDAE																																																																	
Ephemerella sp.																																																																	
invaria group Walsh																																																																	
walkeri group																																																																	
Odonata																																																																	
Anisoptera																																																																	
CORDULIIDAE																																																																	
Somatochlora sp.																																																																	
albicincta (Burmeister)																																																																	
AESHNIDAE																																																																	
Aeshna sp.																																																																	
juncea L.																																																																	
COENAGRIIDAE																																																																	
Enallagma sp.																																																																	
cyathigerum (Charpentier)																																																																	
boreale Selys.																																																																	
Zygoptera																																																																	
LESTIDAE																																																																	
Lestes sp.																																																																	
disjunctus disjunctus Selys.																																																																	
COENAGRIIDAE																																																																	
Enallagma sp.																																																																	
cyathigerum																																																																	
boreale																																																																	
Plecoptera																																																																	
CHLOROPERLIDAE																																																																	
Alloperla																																																																	
Hastaperla																																																																	
PERLODIDAE																																																																	
Isogenus																																																																	
Isoperla																																																																	
Hemiptera																																																																	
HEBRIDAE																																																																	
Merragata sp.																																																																	
hebroides White																																																																	
MESOVELIIDAE																																																																	
Mesovelia sp.																																																																	
GERRIDAE																																																																	
Gerris																																																																	
pingreensis Drake & Hottes																																																																	
CORIXIDAE																																																																	
Trichoptera																																																																	
RHYACOPHILIDAE																																																																	
Rhyacophila Pictet																																																																	
pellisa Ross																																																																	
GLOSSOSOMATIDAE																																																																	
Glossosoma Curtis																																																																	
alascense Banks																																																																	
POLYCENTROPIDAE																																																																	
Polycentropus Curtis																																																																	
aureolus (Banks)																																																																	
flavus (Banks)																																																																	
ARCTOPSYCHIDAE																																																																	
Arctopsyche McLachlan																																																																	
HYDROPTILIDAE																																																																	
Agraylea Curtis																																																																	
multipunctata Curtis																																																																	
PHRYGANEIDAE																																																																	
Agrypnia Curtis																																																																	
straminea Hagen																																																																	
vestita (Walker)																																																																	

Appendix 10.7 Aquatic and semi-aquatic invertebrate occurrence, exclusive of zooplankton, in waters of Kluane National Park [Concluded].

Sites (column headings): Alder Creek; Bates Lake; Bates Lake Creek; Bear Creek; Bighorn Creek; Blueberry Ponds; Cap Lake; Bullion Creek; Canada Creek; Climbing Lakes; Climbing Creek (Upper); Climbing Creek (Lower); Coin Creek; Cottonwood Lakes; Cottonwood Creek; Cranberry Lakes; Dezadeash River; Donjek River; Duke Glacier Melt Pools; Duke River; Eagle Lakes; Field Lakes; Field Creek; Fraser Creek; Fruit Creeks; Granite Creek; Halfbreed Lakes; Hiking Creeks; Jarvis River; Jutland Lakes; Kaskawulsh Melt Pools; Kathleen Lake; Knob Creeks; Lake Bay; Lichen Lakes; Louise Lake; Lynx Lakes; Middle Lakes; Missing Lakes; Mush Lake; Mush Creek (Upper); Mush Creek (Lower); Mush Lake Creek #12; Onion Lake; Phalarope Lakes; Pine Creek; Plum Creeks; Pool Creeks; Quaking Ponds; Rain Creeks; Red Creeks; Rita Ponds; Scud Lakes; Shaft Creek; Sheep Creek; Short Ponds; Slims River; Slims River Marshes; Sluping Creeks; Snipe Lakes; Sockeye Lake; Spring Ponds; Vulcan Creek; Wade Creek

Taxon
Trichoptera (continued)
LIMNEPHILIDAE
Asynarchus McLachlan
aldinus (Ross)
curtis (Banks)
Apatania Kolenati
stigmatella (Zett.)
zonella (Zett.)
Chyranda Ross
centralis (Banks)
Clistoronia Banks
magnifica (Banks)
Dicosmoecus McLachlan
jucundus Banks
Ecclisomyia Banks
conspersa Banks
Grammotaulius Kolenati
betteni f Hill-Griffin
interrogationis Banks
Hesperophylax Banks
consimilis (Banks)
designatus (Walker)
incisus (Banks)
Lenarchus Martynov
vastus (Hagen)
Limnephilus Leach
externus Hagen
hageni Banks
hyalinus Hagen
kennicotti Banks
nigriceps (Zett.)
pallens (Banks)
pictoratus McLachlan
sansoni Banks
Onocosmoecus Banks
unicolor (Banks)
Mystacides Berthold
sepulchralis (Walker)
Coleoptera
DYTISCIDAE
STAPHYLINIDAE
HYDROPHILIDAE
GYRINIDAE
Diptera
TIPULIDAE
Tipula sp.
CHIRONOMIDAE
SIMULIIDAE
Prosimuliidae sp.
Simulium sp.
TABANIDAE
CULICIDAE
Aedes sp.
communis
Chaoborus sp.
RAGIONIDAE
SYRPHIDAE
DIXIDAE

Appendix 10.8 **Glossary**

alkalinity - excess of bases over strong acids; in most Canadian waters, alkalinity comes from hydrolysis of bicarbonate ions.

Amphipoda - an order of Crustacea; common in marine and freshwater environments; most frequently benthic or meroplanktonic; one of many groups called "freshwater shrimps".

Anostraca - a group of Crustacea commonly called fairy shrimps and most commonly occurring in temporary waters.

benthos - the association of species of plants and animals that live in or on the bottom sediments of a body of water.

biomass - mass units of organic matter per unit surface area or per unit volume ; mass of living material in an organism.

biota - the flora and fauna of a given habitat.

BOD - biological oxygen demand reduction of dissolved oxygen by bacterial breakdown of organic matter.

bryophytes - plants belonging to the mosses and liverworts.

catchment area or basin - the entire area from which drainage is received by a body of water; a watershed.

cation - a positively charged particle or ion.

Chironomidae - the chironomids or midges; Diptera; larval stages are aquatic.

Cladocera - small planktonic, meroplanktonic, or epibenthic Crustacea often known as water fleas (e.g. Daphnia, Bosmina).

Coelenterata - jellyfish and their relatives; Hydra is one of the few freshwater forms.

Coleoptera - the beetles; larvae and adults of many species are aquatic; often highly predaceous; frequent in lakes and often very common in ponds.

community - groups of organisms in a habitat, more closely related to each other ecologically than to other groups.

competition - effect of one organism (or group of organisms) on another in the struggle for food, nutrients, living space, or other common needs.

conductivity - (see specific conductance)

Copepoda - the copepods; an order of Crustacea having three main free-living groups (Calanoida, Cyclopoida, Harpacticoida) and some parasitic forms.

Corixdae - water boatmen; family or Hemiptera; both nymphs and adults aquatic, although adults can fly for dispersal; common inhabitants of shallow-water habitats.

depauperate - falling short of natural development or size.

detritus - finely divided settleable material suspended in the water; organic detritus = broken down remains or organisms.

dimictic - temperate lakes with spring and fall overturns; two periods of full circulation.

Diptera - two-winged insects, often with aquatic larvae; includes flies and mosquitoes (e.g. Chironomus, Aedes, Chaoborus).

effluent - the outflow; usually refers to sewage outflow after some form of treatment.

Ephemeroptera - an order of insects including the Mayflies; larvae are common inhabitants of lakes and rivers.

epilimnion - turbulent superficial layer of a lake above the metalimnion or thermocline.

epilithic - growing upon stone or stone like materials.

euphotic zone - total illuminated stratum of a lake, including limnetic and littoral zones.

eutrophic - water with a good supply of nutrients and, hence, a rich organic production.

eutrophication - enrichment of waters by nutrients either through man's activities or by natural means. Phosphorus and nitrogen are the two most important elements responsible for eutrophication.

food chain - transfer of food energy from the plant source through a series of organisms with repeated eating and being eaten; the shorter the food chain, the greater the efficiency.

Gastropoda - the common single-shelled mollusks of freshwater; the snails.

gradient - a change in a physical property related to a unit of length or height (e.g. temperature per metre).

hardness - anti-lathering (soap) and scale-forming quality of water due to alkaline earth salts, mainly carbonates and bicarbonates of magnesium and calcium (most commonly calcium bicarbonate).

heat budget - balance between heat content and uptake (absorption and tranfer) and heat loss (radiation, conduction, evaporation).

hectare - (ha) unit of square **measure,** 100 metres X 100 metres; approximately 2.47 acres.

Hemiptera - an order of insects; the true "bugs", including Corixidae and giant water bugs.

hepatic - a class of Bryophytes comprising the liverworts.

Hirudinoidea - leeches; members of phylum Annelida, the segmented worms.

holomictic - refers to lakes which circulate completely to the bottom, especially at the time of autumnal circulation.

homothermy - condition of uniform **temperatures** throughout, as at fall turnover which begins when water column uniform at 4°C.

Hydracarina - **water mites:** group of aquatic arachnids.

hypolimnion - deep layer of a lake lying below the metalimnion or thennocline and normally removed from surface influences.

ion - electrically charged particles in aqueous solution; anions are negatively charged ions which migrate to the anode; cations **are** positively charged ions which migrate to the cathode; molecules which dissociate in water form ions.

larvae - early form of an animal unlike the parent (i.e. as in complete metamorphosis in insects).

lentic - referring to standing water habitats (lake, swamp, pond or bog).

limnetic - open water zones to the depth of effective light penetration.

limnology - study of inland waters: from Greek limne = lake, and loggos = discourse.

littoral - the shoreward section of a body of water with light penetration to the bottom.

iotic - referring to running-water habitats (springs, streams, rivers) .

macrobenthos - benthic organisms clearly visible to the naked eye.

macrophytes - vascular aquatic plants which may grow either free-floating, totally submerged or emergent above the water surface.

metalimnion - (see **thermocline**).

micron - 1 one millionth of a metre.

Mollusca - the mollusks (snails and clams).

monomictic - a lake in which the water mass mixes or circulates completely once a year.

morphoedaphic index - a productivity index for lakes based on morphometric and soil (or sediment) related factors such as water chemistry.

nekton - powerful swimmers among freshwater animals that are capable of moving about voluntarily from place to place.

nematodes - unsegmented roundworms; many free-living forms in the benthos and many parasitic forms.

Notostraca - a group of epibenthic Crustacea commonly called tadpole shrimps; closely related to the Anostraca.

nymph - immature stage of insect which resembles the adult in many structural features; metamorphosis here involves gradual changes rather than radical morphological changes of "complete metamorphosis".

Odonata - the dragronflies and damselflies; usually highly predaceous both as aquatic nymphs and aerial adults.

Oligochaeta - a group of annelids mainly terrestrial and freshwater; segmented worms with relatively few chaetae or bristles per segment.

oligotrophic - descriptive term for lakes which are characteristically deep, rich in oxygen, have little macrophyte vegetation around margins, are poor in dissolved nutrients, and have low rates of production.

Ostracoda - the ostracodes; small bivalved crustaceans usually on or in the benthic sediments.

pelagic - refers to region of free water in seas or inland lakes; of the open-water or limnetic zone; usually refers to the ocean.

Pelecypoda - bivalved mollusks (freshwater clams); common inhabitants of relatively stable substrates free from pollution and excessive silting.

periphyton - minute organisms (both plant and animal) attached to submersed substrates (living or non-living) which project above the sediments; usually accepted as equivalent to German term. "Aufwuchs".

pH - a measure of hydrogen ion concentration; pH of 0 to 7 indicates excess of hydrogen ions over hydroxyl ions - acidity: pH *over* 7 to 14 indicates excess of hydroxyl ions over hydrogen ions - alkalinity; pH of 7 = neutrality.

photosynthesis - synthesis of organic matter from inorganic carbon (as CO, *or* bicarbonate) with the aid of radiant energy.

phytoplankton - plant portion of the plankton (see plankton).

plankton - the total community of the free water (or limnetic zone of lakes); in a strict sense, only the non-motile forms drifting passively, but now usually extended to include all living forms in free water except vertebrates, larger insects and larger **Crustacea.**

Plecoptera - the stoneflies; nymphs common inhabitants of swift, cool streams and shores of oligotrophic lakes.

pollution - contaminated, defiled, or degraded with unnatural material; degradation of a natural environment by the addition of foreign material.

polymictic - lakes with almost continuous circulation or very frequent overturns.

population - a group of individuals of one species closely associated with each other and forming a cohesive unit.

p.p.m. - parts per million = milligrams per litre (dissolved salts).

primary production - amount of *energy* stored as organic matter through photosynthetic activity of plants.

production - sum of growth increments of all individuals of a species population (survivors + non-survivors) in a discrete time period.

productivity - **trophic** nature of a water body or other habitats; a rate assessment often implying characteristics responsible for high or low productivity: approximately equivalent to "bioactivity".

profundal - of the deeper part of a lake; usually considered that deep zone beyond depth of effective light penetration.

protozoan - single-celled animal.

riffle - shallow section across the bed of a stream over which water flows quickly so that water surface is broken in waves; small wave or a succession of small waves.

riparian - one that lives **or** has it property on the bank of a river.

Rotifera - the rotifers or "wheel animalcules", so-called because of their apparently whirling ciliated structures; probably coenocytic; many epibenthic and planktonic forms.

secchi-disc transparency - a measure of water transparency utilizing a white or black-and-white disc lowered to the point at which it disappears from sight.

secondary production - quantity of food or energy stored as biomass by consumers of primary producers (i.e., plants and some bacteria); third trophic level.

seepage lakes - **a** lake into which ground water enters and from which water leaves by seeping through the lake basin walls; no consistent surface inlet or outlet.

seston - collectively, all particulte, free-floating matter, living or dead, and including zooplankton and phytoplankton.

shoreline development - ratio of the actual pereimeter of a lake to circumference of a circle having some area.

specific conductance - the amount of electrical current conducted by water depends on the amount and nature of dissolved salts (ions); measured in micro-mhos (umho), usually at 20 or 25°C.

stage - surface level of a water body with reference to a fixed mark.

standing crop - in limnology, the biomass present in a body of water at a particular time.

stratification - formation of layers exhibiting uniform and distinct physical or other qualities (e.g. thermal stratification in lakes).

substrate - the material on or in which a plant or animal lives; the material or substance acted upon by an enzyme or ferment.

succession - ecological succession is the orderly process of community change usually involving a sequence of change in a given area.

TDS - total dissolved solids.

thermocline - region of greatest slope of the temperature gradients in a lake; zone is called the metalimnion.

Trichoptera - caddisflies; larval stages of these insects are common in running and standing waters: larvae of many species build cases of sand, detritus, etc., some spin webs for trapping their food.

trophic level -	"trophic" refers to food or nourishment: a level at which all organisms' food formed with same number of steps from plants.
turbidity -	estimate of suspended matter density inhibiting passage of light.
turbulence -	unorganized movement in liquids or gasses.
water renewal - rate - (or flushing rate)	theoretical time required for total volume of water in a lake or its equivalent to be discharged via outlet stream or river.
yield -	the aggregate of products resulting from growth or cultivation.
zoobenthos -	animal portion of the benthic community.
zooplankton -	animal portion of the plankton (see plankton).

CHAPTER 11

Ecological **Interrelationships**

By: Bonnie J. Gray
Terrain Sciences Officer
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

Date of Preparation:. April 1985.

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11.1 Introduction

By definition, a Resource Description and Analysis is a thematic document, examining and evaluating the component resources of a Park. Its primary source is a database derived from thematic inventory studies usually conducted as part of the Park's Basic Resource Inventory. In addition, the Resource Description and Analysis contains a synthesis of component resource material into a decription of broader integrated ecological processes and interrelationships between the principle components. Material for this part of the Resource Description and Analysis is usually derived from an ecological or biophysical land classification (ELC) study.

Unfortunately, an integrated ELC does not exist for Kluane. Douglas (1980) undertook biophysical inventory studies aimed at producing an ELC but the document fell short of expectations. This was mostly due to an error in basic approach, allowing vegetation and soils to be mapped separately and failure to integrate geomorphological and wildlife information. Use of the document is complicated by an unwieldy map base and variable data quality.

Without a Park-wide ELC, problems of describing ecological interrelationships become daunting. Some of the interrelationships have been mentioned briefly in previous chapters. Overriding all is their complexity and the difficulty of drawing order and pattern from the web of interdependent elements. This difficulty arises in part because thematic studies seldom have a common map base or level of detail and the result is detailed information in one subject area produced in isolation from the rest of the ecosystem. An integrated ELC approach avoids this by starting with the whole and breaking the landscape down into homogeneous units on the basis of ecological similarity. The most stable and significant elements of the ecosystem form the basis of the classification (usually geomorphological features) and units are defined by their characteristic combinations of other elements, thus making the interrelationships between elements inherent in the definition of the units.

Resource management problems, issues and concerns, and their proposed solutions seldom affect only one component of an ecosystem and an appreciation of the broader implications of decisions is vital. Parks Canada recognizes that the ELC approach is preferable to a thematic one and that it produces the type of information needed for planning and management (Parks Canada 1980). Ecological Land Classification is flexible and, depending on the scale chosen, can be used for broad scale regional planning or site-specific situations.

Only two integrated studies have been done in Kluane. Blood (1975) examined five transportation corridors for proposed Park development. Lopoukhine (1983) prepared an ELC of the Slims Valley at the Ecosection level (1:125,000).

11.2 Pilot ELC for the Slims River Valley area

Parks Canada recognizes the continuing need for an ELC for Kluane but resurvey of the Park is prohibitively expensive. As part of an effort to bring the Natural Resource Management Process up to date in Kluane (Parks Canada 1983), a proposal was made to attempt a pilot ELC for the Slims River Valley area based on existing thematic information at a scale of 1:50,000 (the Ecosite level). This study was to comprise Chapter 11 of the Resource Description and Analysis and allow Parks Canada to evaluate the financial implications of extending this approach to the rest of the Park area. Unfortunately, manpower and time constaints have made it impossible to complete this proposed study at the present time and it has been deferred.

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CHAPTER 12

Cultural Resources of Kluane National Park

By: Margaret Burnip
Research Assistant
Parks Canada, Prairie Region

- and -

Peter Priess
Regional Archaeologist
Parks Canada, Prairie Region

In: Gray, Bonnie J. (Editor) 1985. Kluane National Park Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg.

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12.1 Introduction

Discoveries over the last 15 years in the Old Crow area of the northern Yukon indicate that man has been in the Yukon for at least 30,000 years (Irving & Cinq-Mars 1974). Evidence of occupation in the Kluane area dates only from about 8000 BP (before present), since the end of the Wisconsin glaciation (Workman 1974). Whether man inhabited the southwest Yukon prior to this in unknown. Glaciation may have destroyed evidence of his existence or the area may not have been occupied.

There is now consensus that the prehistoric inhabitants of North America arrived from Eurasia via the 'Bering land bridge', exposed as a land link between Asia and North America at various times in the Pleistocene when glacial maxima lowered sea levels substantially (Bonnischen & Young 1980). Theories propose that people first crossed to North America following the herds of animals which they hunted and that the movement continued back and forth between new and old areas of occupation over a long period. The extensive cold grasslands of northern North America were a rich environment for these hunting people. Southward migration continued when an ice-free corridor was open through the Yukon and northern British Columbia, probably during most of the Wisconsin glaciation (Rutter 1980), prompted by climatic warming and reduction of the rich grassland environment (Workman 1980). Intercontinental movements stopped when sea levels rose at the end of the glacial period. These theories are still the subject of investigation and refinement, particularly regarding the ethnographic origins of specific groups and smaller scale movements of people. Workman (1980) discusses these in more detail.

It is somewhat paradoxical that this area, through which North America's first inhabitants travelled, was also the last area of the continent to be explored by European man in the 1980's. These early explorers were the vanguard of several waves of people to pass through the Yukon in the next century - geologists, miners, fortune-seekers, fur traders, the road and pipeline builders, and latterly tourists trying to recapture the flavour of Canada's frontier and wilderness.

12.2 Data Sources and Limitations

Knowledge of the prehistory and history of the Kluane area is incomplete. Archaeological research in the Park proper dates only from 1978. Stevenson (1978, 1980, 1981, 1982) has reported on three seasons of field work and French (1980) on one season. Much of this work was concerned with the historic period, specifically gold mining operations. Considerable work still remains to be done in this area as many creeks for which gold mining was known through historic sources have not been examined for artifacts.

Archaeological study in 1978 was brief and was concentrated in the Airdrop Lake area; the 1980 work was not particularly successful in locating evidence of prehistoric use.

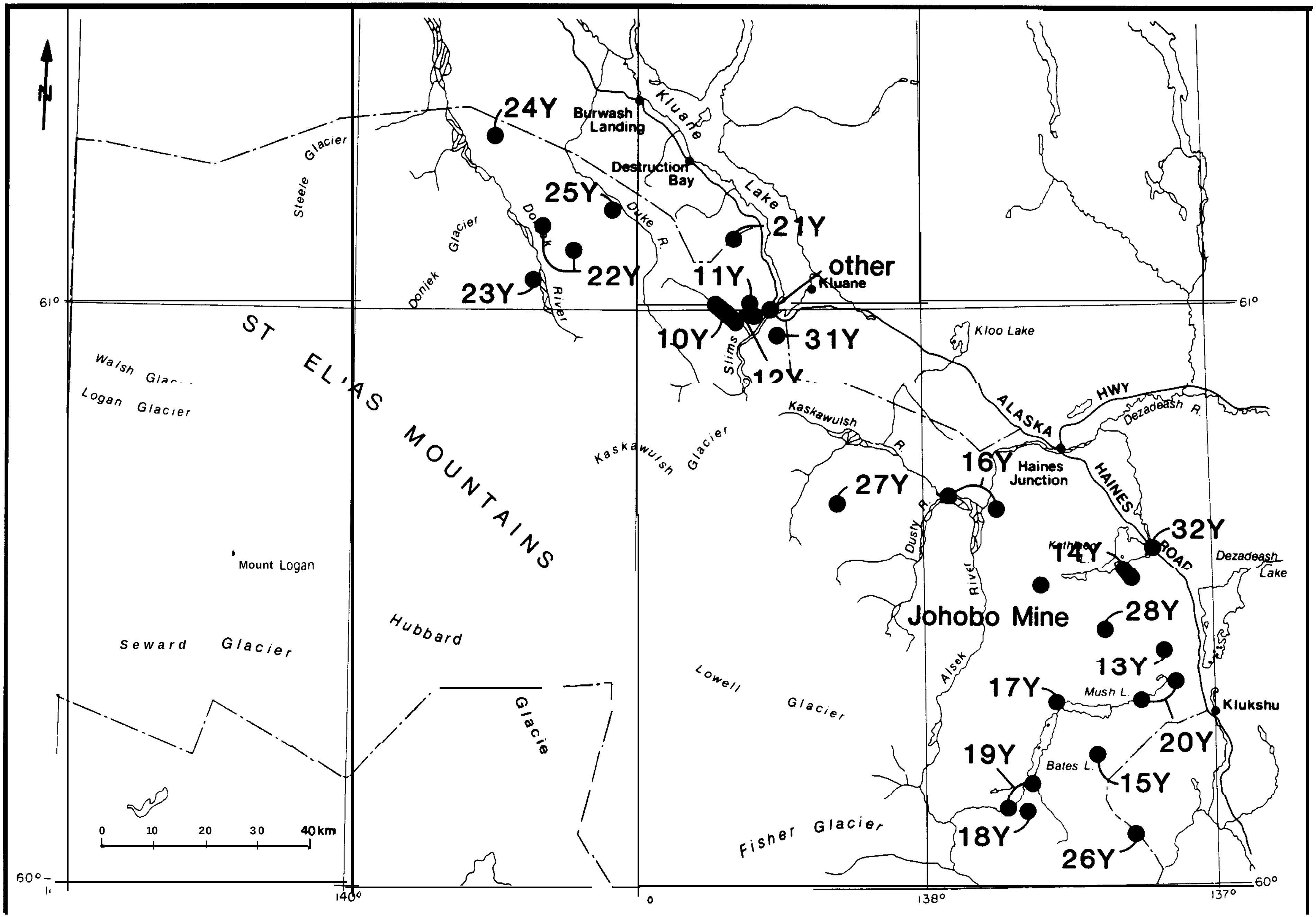
A prehistoric culture sequence has been suggested by Workman (1978) for an area to the east of the Park and this has provided the major source for the summary to follow.

Appendix I lists the historic and prehistoric sites identified to date within the Park and Figure 12.1 shows their location. An earlier listing of historic resources (Theberge 1972) is less complete, providing only general indications for site location, and occasionally offers unacceptable suggestions for site management.

The abundance and quality of material pertaining to the recorded history of Kluane National Park area varies considerably. The early exploration of the area and mountaineering in the Park have been extensively documented in geographical magazines and alpine journals. Descriptions of big game hunting are available in books written by the hunters, although they consist for the most part of inventories of animals killed. A good understanding of other themes such as mining, the North West Mounted Police, and the International Boundary Survey can be gained only by reading technical reports published yearly by the responsible government departments. The prehistory and history of man in the vicinity of the Park have been given brief treatment in John Theberge's Kluane: Pinnacle of the Yukon (1980). The only discussion of Indian use of the Park can be found in the incomplete "Kluane Park Study", prepared by the Council for Yukon Indians (1977).

Allen Wright (1980a) has attempted to provide the most comprehensive account of the history of the Kluane region. His detailed and lengthy manuscript centres upon the history of people of European descent, from the first coastal explorations to the declaration of the national park. This incomplete manuscript is arranged in a strict chronological format which limits its usefulness. Wright also presents the historical data in an overly subjective manner and is generally inconsistent in his treatment of the material.

The major ethnohistorical publication on the Kluane are is My Old People Say, by Catharine McClellan (1975). This study is exhaustive in many respects. Much of the information, however, describes the most heavily utilized parts of the Tutchone's territory. Even though her informants included Kluane in their description of hunting territories, few specific details of Tutchone activity in this part of their territory are mentioned. This leaves considerable uncertainty as to the degree to which the Tutchone used the area which is now Kluane National Park. McClellan (1975), Workman (1974), and Gates and Roback (1972) have all stressed the need for further human history studies in their publications.


N
24Y
Burwash Landing
Kluane
Destruction Bay
Lake
25Y
Steele Glacier
Donjek
Glacier
Duke R.
21Y
22Y
other
Kluane
11Y
23Y
Donjek River
61°
10Y
31Y
12Y
Slims
Kloo Lake
ST ELIAS MOUNTAINS
Walsh Glac
Logan Glacier
Kaskawulsh Glacier
Kaskawulsh R.
ALASKA HWY
Dezadeash R.
16Y
Haines Junction
27Y
HAINES ROAD
32Y
Dusty R.
Kathleen L.
14Y
Dezadeash Lake
Alsek River
Mount Logan
Johobo Mine
28Y
Hubbard Glacie
Seward Glacier
13Y
Lowell Glacier
17Y
Mush L.
Klukshu
20Y
19Y
Bates L.
15Y
0 10 20 30 40km
18Y
Fisher Glacier
26Y
60°
140°
138°
137°

KLUANE NATIONAL PARK RESERVE

Figure 12.1 Location of historic and prehistoric sites in Kluane National Park. ●

10Y	Bullion Creek	21Y	Congdon Creek
11Y	Sheep Creek	22Y	Bighorn Creek
12Y	Coin Creek	23Y	Donje k River
13Y	Shorty Creek	24Y	Hoge Creek
14Y	Goat Creek	25Y	Grizzly Creek
15Y	Mush Creek	26Y	Silver Creek
16Y	Kaskawulsh, Dezadeash, and Alsek rivers	27Y	Airdrop Lake
		28Y	Victoria Creek
17Y	Mush Lake	31Y	Vulcan Creek
18Y	Iron Creek	32Y	Kathleen Lake
19Y	Bates River	other	Slims River
20Y	Alder Creek	Johobo Mine	Sockeye Lake

Source : Stevenson . 1978, 1980.

12.3 Prehistory of the Kluane Area

Workman (19741, using a combination of analysis of materials from actual sites and review of available literature for the general area, has developed a synthesis of the prehistory of the south-westerm Yukon which is now used generally by other authors in discussing the area. This report also provides the basis of the summary to follow. According to Workman, prehistoric use or occupation of the southwest Yukon began approximately 8000 years ago, shortly after the end of the glacial period in the area. He divides the cultural sequence into four phases, the latter three being somewhat arbitrarily defined since they probably represent a continuum within similar groups of people. Table 12.1 outlines these four phases, and their characteristic artifacts and lifestyle traits.

Evidence of these culture phases becomes more rare as one goes back in time. The most ancient culture known in the Park area is the Little Arm (8000-4000 BP). The first site to be discovered was on a bluff overlooking the Alaska Highway crossing of the Aishihik River. Here, 2.5 m below the surface, a small camp and several artifacts, including spear points, bone tools, and stone flakes, left by ancient bison hunters was excavated. Only four other sites from this phase are known in southwest Yukon (Morlan & Workman 1980). The phase takes its name from a particularly rich site on the Brooks (or Little) Arm of Kluane Lake. The Little Arm Culture is characterized by the production of small, slender, parallel-sided, and sharp-edged obsidian flakes, called microblades. Spear points and knives are thin and well made but the bases are round, not notched, and could not easily be attached to a shaft. The bow and arrow would not appear in the area for thousands of years (Morlan & Workman 1980). In early postglacial times, the southwest Yukon was an area of extensive grassland and only very limited forest. The climate was gradually warming to temperatures higher than those of today. The lifestyle of prehistoric man was focussed on the exploitation of the large herds of mammals which utilized this grassland habitat. Bison, moose, and caribou were hunted by small groups of people constantly moving through the area. Evidence from one late Little Arm site indicates that pole and brush shelters may have been used; these were probably similar to structures built in their youth by the oldest native people living in the area today (Morlan & Workman 1980).

About 4500 BP, the Little Arm technology was abruptly replaced by a very different one associated with what is now called the Taye Lake culture phase (4500-1300 BP). Because of the great technological differences in the two cultures, it is believed that a new population moved into the area, and that the Little Arm people were either displaced or absorbed by the Taye Lake culture (Workman 1980). Subsequent cultures in the Kluane area, including the modern Tutchone Athapaskan people appear to have derived from the Taye Lake phase.

Table 12.1 Prehistoric culture sequence of the Kluane National Park area.

Phase Name	Time Period*	Characteristic Artifacts	Lifestyle Characteristics
Little Arm	8000 - 4000 BP	• microblade techology, including micro-blades, microcores, burins, geometric round-based projectile points.	• seasonal hunting with concentration on big game. • small groups occupied many sites for short periods.
Tayo Lako	4500 - 1300 BP	• chanqo in technology marked the beginning of Tayo Lsko phase and suggest a change in population. • absonco of microblade technology. • notched or lanceolate points, large bifaces, thick unifaces, a variety of ondscapers, a developed bone industry.	• hunting of caribou, moose and, in early times, bison and possibly somo now-extinct species. Big game hunting was supplemented by small mammals, birds, and fish. • society was comprised of small groups occupying a number of sites for short periods. • some sites were large enough to suggest seasonal reoccupation.
Aishihik	700 - 1800 AD	• increased use of native copper, decreased use of implements of flaked stone.	• similar hunting lifestyle, carried out by small groups ranging over a large area living in small ephemeral camps.
Bennett Lake	1800 - 1900 AD	• presence of European trade goods.	• big game hunting, fishing, birds, etc. • fur trade increased emphasis on furbearing game. • seasonal occupation of settlements but some buildings were constructed more permanently of logs. • ancestral to present native inhabitants.

source : Workman 1974; LeBlanc 1984.

• BP indicates years before the present; 1300 BP therefore represents about the same time as AD 700.

To date, Taye Lake is the best documented culture phase in the Kluane area (Morlan & Workman 1980) and collections have been made at several sites. Taye Lake people continued to be hunters, supplementing big game with small mammals and fish. Permanent dwellings were not established but certain favourable sites were seasonally reoccupied over many generations.

The climate during the Taye Lake phase was undergoing a significant cooling trend which, about 2800 BP, marked the beginning of the Neoglacial Climate Episode in southwest Yukon. This period was characterized by renewed glacier expansion and would culminate in the Little Ice Age about 500 BP. Grassland vegetation was giving way to expanding areas of spruce forest, and about 3000 BP, bison became extinct in the Kluane area (Morlan & Workman 1980).

Workman (1980) suggests that the southwest Yukon may have presented a particularly attractive and diverse environment at this time:

> "(presenting in addition to Boreal Forest)... upland tundra associated with mountain systems, substantial patches of relict grasslands and, in some places, access to salmon carried inland on the great river systems...."
> (Workman 1980: 130)

He postulates that, prior to their occupation of the southwest Yukon, the Taye Lake people were already inhabitants of the Boreal Forest further to the south and that they moved northward to exploit the expanding forest area and its associated diverse terrain.

The tools of the Taye Lake culture include spear points with notched bases for hafting, large blunt-ended knives flaked on both sides, end-scrapers for both hand use and hafting, and skin-dressing tools of schist, similar to those still used today for native hide-working. Microblades are not present. Sophisticated bone and antler tools were probably used but were too delicate to have been well preserved. Large, flat, notched cobbles are also present and may have been hafted onto clubs for dispatching wounded game.

About 700 AD or almost 1300 BP a volcanic eruption from a vent under the Klutlan Glacier in eastern Alaska deposited the 'White River Ash' over a wide area in southwest Yukon. The effects of this eruption on the inhabitants of the time and their lifestyle is unknown. The ash provides an identifiable stratigraphic marker throughout the area and has been arbitrarily chosen to separate the Taye Lake culture from its descendent Aishihik culture phase.

The Aishihik culture (AD 700-1800) has been defined from several sites lying stratigraphically above the White River Ash which exhibit no sign of European trade goods. The technology was basically similar to the Taye Lake phase with some refinement of form and the addition of implements of native copper (manufactured locally from nuggetts from the White River area) and indications that the bow and arrow were in use. Tools of ground stone, including abraders and adzes are also significant. The transient, hunting lifestyle remained essentially unchanged from the Taye Lake culture (Workman 1974).

The climate continued to deteriorate during the time of the Aishihik people. The Little Ice Age (AD 1400-1800) resulted in temperatures colder than any since the end of the Wisconsin glaciation, glaciers expanded, large ice-dammed lakes were formed at least twice on the Alsek River, and the spruce forest expanded to its present area. These conditions presented the Aishihik people with an extremely demanding environment.

Figures 12.2, 12.3 and 12.4 illustrate some of the tools associated with the Little Arm, Taye Lake, and the Aishihik phases, respectively.

The Bennett Lake culture phase (1800-l 900 AD) is the culture of the indigenous Tutchone people as first known by European man, and is characterized by the appearance of European trade goods (such as metal goods, rifles, and trinkets) and increasing involvement with the fur trade. Fundamental changes to aboriginal life resulted from these contacts with the white man and disease and inter-group hostility may have affected population size and distribution. Solid log villages replaced previous less permanent structures. These were usually located at seasonally favoured sites and occupied at various times through the year.

As mentioned, the previous description is based on material collected throughout the Kluane area, not just within the Park. Prehistoric remains located to date in the Park do not contain many diagnostic artifacts. The presence of a few microblades at one of the Airdrop Lake locations suggests an association with the Little Ann phase; therefore, an indication of occupation during the earliest times (Stevenson 1982). The possiblity of different time periods for the same technology between alpine areas and the valleys is also recognized as providing the possiblity of a later date for the Airdrop Lake material (Stevenson 1982). It is further suggested that differential patination of the obsidian flakes indicates re-occupation over an extended period (Stevenson 1982). Climatic conditions in the Airdrop Lake area lead to the conclusion of a summer-use area (Stevenson 1982). For the most part the locations around Airdrop Lake appear to be associated with hunting and tool production, an obsidian source also being available locally.

Investigations at locations other than Airdrop Lake were largely unsuccessful (Stevenson 1982). The survey method may have resulted in a limited number of sites being located but erosion and limited prehistoric use are also partly responsible.

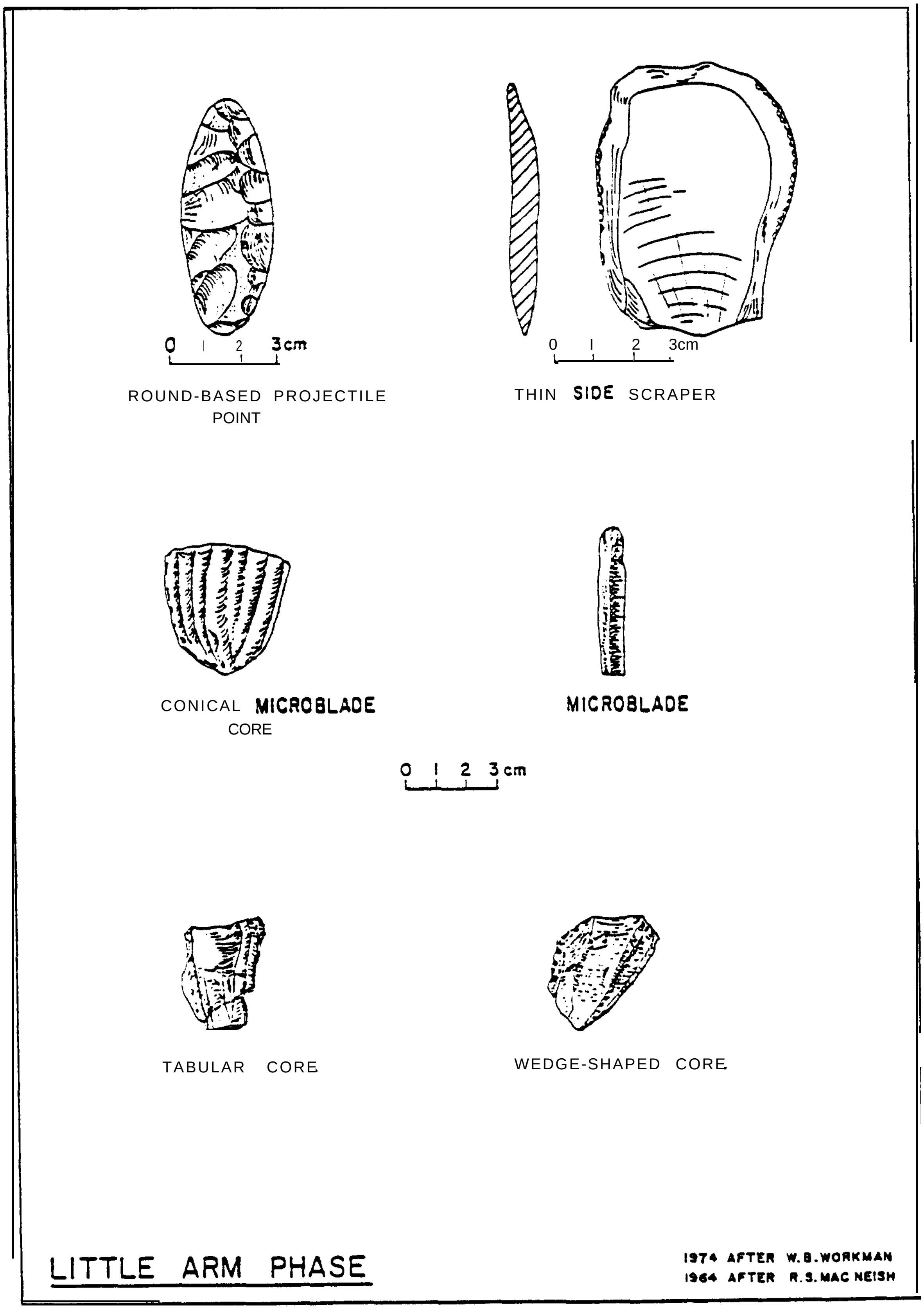


Figure 12.2 Tools associated with the Little Arm culture.

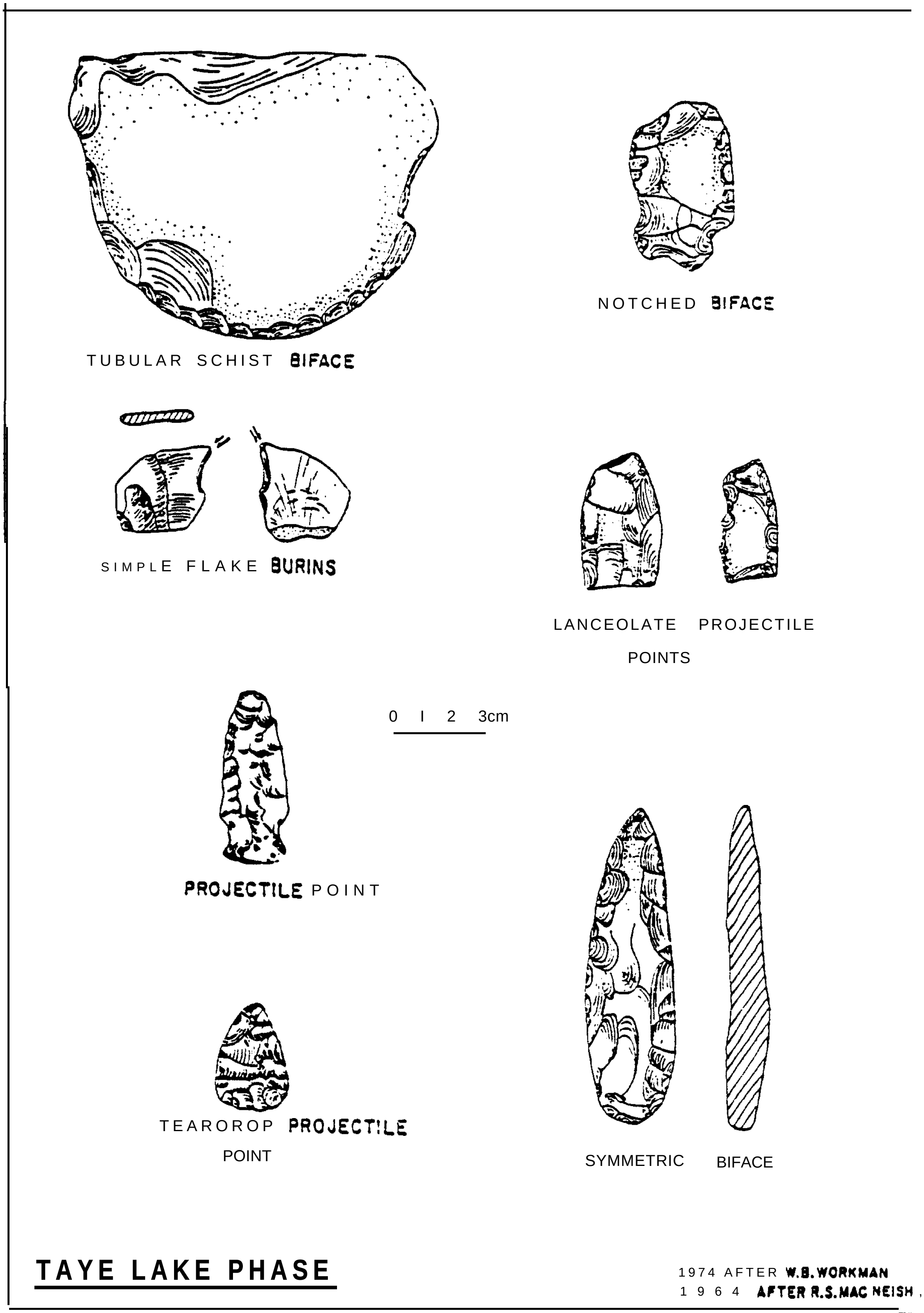


Figure 12.3 Tools associated with the Taye Lake culture.

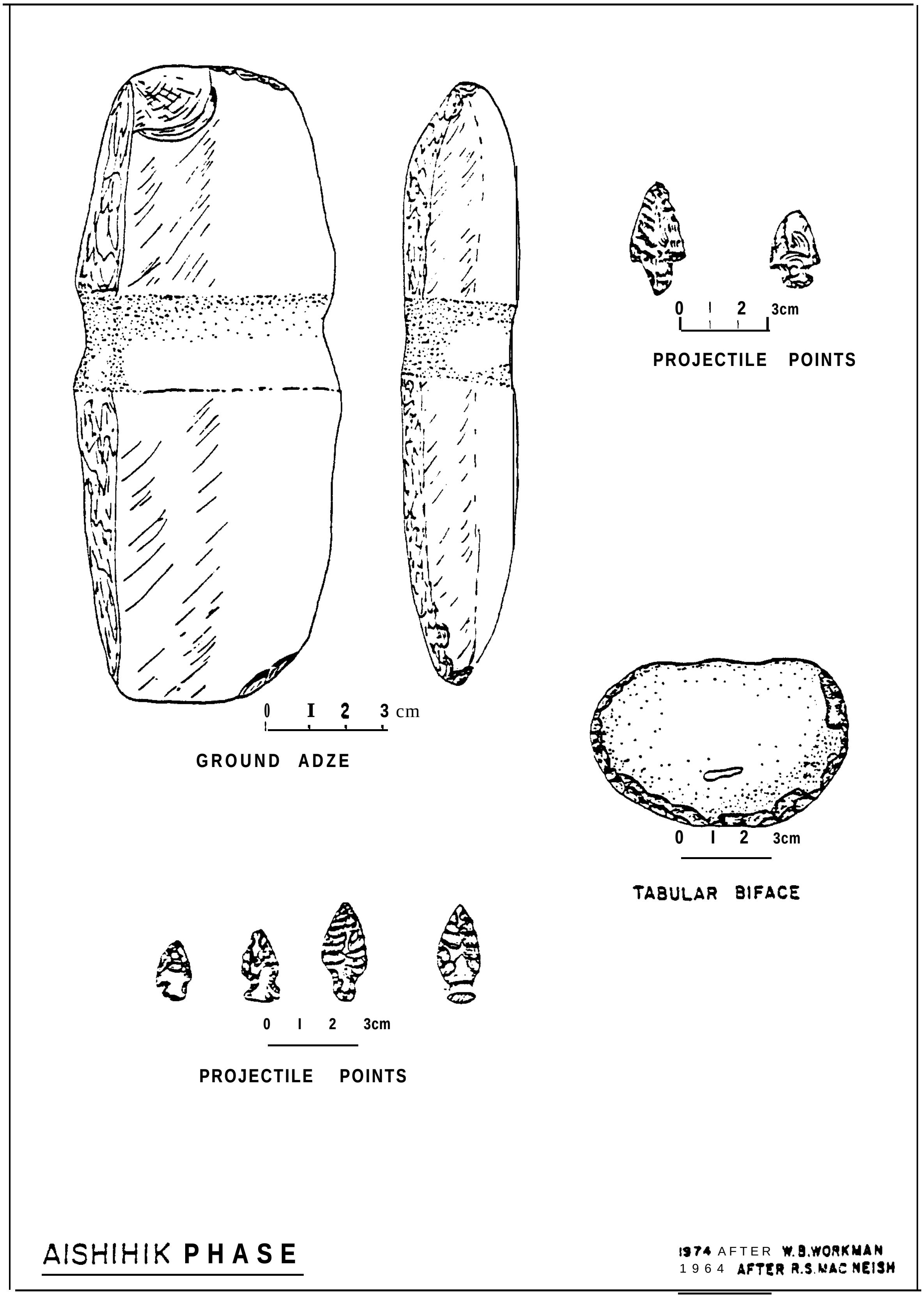


Figure 12.4 Tools associated with the Aishihik culture.

Diagnostic artifacts were not recovered but site locations sugges an association with hunting or fishing activities. In general th present picture is of limited use of the Park area during the pre historic period, the Airdrop Lake area possibly being an exception

12.4 Native Indian History: The Southern Tutchone

The Indian people living in the Kluane area today share a commo Athapaskan dialect. The name Southern Tutchone has been used to distinguish their dialect and culture from those of neighbouring groups. The Indians call themselves "d'An" (persons) and use more subtle distinctions to distinguish their social and cultural groupings. These criteria include food staples, distance and direction from the group to be described, names of places where families of a group traditionally congregated, and the historie: and kin ties of particular persons within a group (McClellan 1975 Workman 1974).

Little is known about the territory occupied by the Southern Tutchone, or their culture, prior to the last half of the 19th century. This lack of knowledge is largely a result of the isolation of the Kluane region and of the 19th century commercial blockade by the coastal Chilkat Tlingits. This blockade barred contact between the interior Indians and the coastal fur traders, while bolstering the profit of the Chilkat middlemen.

The last half of the 19th century was a period of great change. The Chilkat, hungry for furs to trade with Europeans after the depletion of the sea otter trade, extended their trading with interior Athapaskan groups. Trading partners were established and marriages between Tutchone women and the Chilkat traders wera often contracted to cement these relationships. The intensity of this contact and the advent of European goods changed many aspects of the Tutchone culture, most notably in the southern part of their territory. In addition, smallpox epidemics of the 1830's and massacres committed by the Upper Tanana Indians in the 1850's caused a disruption in population numbers and in territorial boundaries (Workman 1974; Gates and Roback 1972). The extent of this disruption is not known.

Oral traditions and the journals of 19th century explorers also provide evidence of some of these changes. McClellan's (1975) Tutchone informants described a 19th century technology which was developed by using a combination of ingenuity and the available natural resources. Percussion and grinding techniques were used to produce stone tools such as adzes, mauls, and skin scrapers. Native copper was cold-hammered and ground to form knives, arrowheads and decorative items. Bone and antler were used to make arrowheads and a variety of tools. These tools were used to catch fish, to process animal skins, and to manufacture clothing anti snowshoes (McClellan 1975). The material culture of the Tutchone had changed so drastically by 1892 that the English explorer and journalist Edward Glave encountered Indians wearing European clothes and using tobacco, guns, blankets, cooking tins, metal fish-hooks and needles. All of these items had been procured in trade with the Chilkats, as the Indians had never before seen a white man.

Metal tools had a great effect on the Southern Tutchone subsistence technology. The introduction of guns curtailed such laborious tasks as the setting and daily checking of moose and caribou snares. Metal axes made the construction of log buildings a much easier task. Mid-19th century examples of these were found by Glave at Klukshu and Neskatahin (also spelled Neskataheen and Nesketahin). Other labour-saving European items such as pots and pans, files, shovels, metal hooks, and knives were also quickly integrated into Tutchone daily life (Workman 1974).

In the latter part of the 19th century dog traction and wooden sleds were also introduced. According to McClellan (1975) and Workman (1974) these devices increasingly altered the economic cycle and cut down the need for the cooperation of larger groups.

Before fur trading become an important part of the economy in the early or mid-19th century, the social patterning of the Southern Tutchone depended on the distribution and abundance of seasonal resources. In the warmer months of the year there was usually plenty of food. Large groups of people would gather at certain localities to hunt game or to trap salmon for a few weeks. Most of this food was air-dried and stored in caches. In the winter the Tutchone dispersed into small family groups. They lived on their summer caches, moving from one kill to the next. If winter hunting was unsuccessful, starvation followed (McClellan 1975).

When fur trading gradually became a more important part of the Southern Tutchone economy, families had to balance their winter route between the availability of fur-bearing animals and the acquisition of game for food (McClellan 1975). The technological advances offered by European tools such as rifles may have compensated for this disruption in traditional subsistence pursuits caused by participation in the fur trade (Workman 1974). Overall, however, the new technology and changing economy of the Tutchone gradually disrupted social patterning where collective effort and joint ownership of resources had previously been necessities of life.

The great influx of miners at the turn of the century, and the accompanying establishment of boundaries between Alaska, British Columbia and the Yukon Territory, brought new laws and regulations which affected the subsistence pattern of the Southern Tutchone. When access was cut off to hunting grounds located in British Columbia, the Neskatahin Indians could not hunt more than 24 km out of their village. As a result of this restriction, many of the people moved to Champagne when Jack Dalton built a post there in 1902 (McClellan 1975).

Some of the Indians participated in the pursuit of gold but although some reported favourable prospects, no one became wealthy. Several years later, Indians from various communities also began to act as guides for parties hunting big game. A few of them acquired their own outfits and competed successfully with white outfitters (McClellan 1975).

The building of the Alaska Highway in the 1940's gradually drew people away from the more remote native communities. The construction of the highway temporarily inundated the land with outsiders, some of whom ransacked gravehouses and behaved in other inconsiderate ways towards the local people. The first Tutchone population statistics were compiled in the 1940's by the Indian Agency. These figures indicated that by 1944 there were only 64 Indians at Champagne and Klukshu, 40 at Aishihik, one family at Hutshi, 49 at Burwash Landing, and 20 in the vicinity of Kloo Lake (McClellan 1975, Workman 1974).

McClellan (1975) described the subsistence activities and hunting territories of six Southern Tutchone bands as they were in 1950. The Tutchone band designations were a reflection of several phenomenon. These included the location of trading posts and the administrative policies of the Department of Indian Affairs. Traditional settlement patterns may also have contributed to the band designations. Although cooperative family settlement groups were no longer necessary for survival in the 20th century, the tradition may have persisted to some degree. Three of the Southern Tutchone bands included in their present or traditional hunting territories part of the area which is now Kluane National Park. These were the Champagne, Aishihik, and Burwash Landing bands.

Most of the inhabitants of the largest Southern Tutchone band at champagne were originally from seasonal settlements at Neskatahin and Klukshu. As a result of the geographical proximity of the champagne band to the Chilkats, in the 19th century their culture had been more influenced by the Chilkats than were those of other Tutchone groups. The Champagne people were sometimes called "Fish People" by other Tutchone in recognition of their heavy use of salmon (Workman 1974).

The hunting territory of the Champagne Indians once spread westward to the flanks of the St. Elias Mountains, to the east as far as the Wheaton River and north to the territory of the Kloo Lake, Aishihik, and Hutshi bands. The southern section of their hunting territory was eliminated in the early 1900's by the creation of the British Columbia border and the western section was cut off in 1943 when it was declared a game sanctuary (McClellan 1975).

In contrast to the Champagne people, the Aishihik band had more marriage ties with the Northern Tutchone of Fort Selkirk and had little understanding of Tlingit culture. The Aishihik Tutchone subsistence was based on sheep and caribou. The former hunting territory of the Aishihik band was reported to extend to the west from Aishihik to the Duke River meadows; northwest to the Donjek and White River drainage; north to the Nisling River and east to the Nordenskiold River. By the 1950's the western boundary of the Aishihik territory had decreased to the eastern shore of Kluane Lake (McClellan 1975).

The Burwash Landing Band were relative newcomers to the Kluane area. Band members appeared to be descendants of Northern and Southern Tutchone, and possibly of Upper Tanana as well. Their base at Burwash Landing was a result of the trading post established there in 1904 by the Jacquot brothers, who encouraged Indian traders of predominantly northern affinities to settle there (Wright 1980a). Workman (1974) has suggested that opportunities to the south of the White River country probably opened up after the mid-19th century massacre of a previous group which was located at Kluane Lake. The hunting territory of the Burwash Band in the 1950's included the drainage of the Upper White River and the Duke, Kluane and Nisling rivers (McClellan 1975).

By the mid-1960's most of the Champagne, Kloo Lake, and Aishihik bands had moved to Haines Junction (Wright 1980a).

2.5 **European Exploration and Resource** Extraction

2.5.1 Fur Trade and the Dalton Trail

The Chilkats, since first trading with the Russians in the late 18th century (De Laguna 1972), denied outsiders access to interior routes and, correspondingly, denied interior Indians access to the coast (Theberge 1980). In this way they secured their position as middlemen between the fur traders and the interior groups.

Although knowledge of the Chilkat route was acquired in 1869 when Chief Kohklux of Klukwan drew a map of the interior for the American surveyor George Davidson, the first outsider known to have crossed the Chilkat Pass was Aurel Krause in 1881. The illness of one of his Chilkat companions forced Krause to stop within sight of Kusawa Lake.

Chilkat control of the distribution of white men's goods from the coast to interior native groups began to be seriously threatened in 1890. At that time Edward Glave and Jack Dalton, two members of the Frank Leslie Exploring Expedition, followed a route leading from the Chilkat River to the Tutchone settlement of Neskatahin.

In the belief that defective transport was "the sole reason for the undeveloped and unexplored state of the land" (Wright 1980a: Chap.4), Glave and Dalton returned the following year with four pack horses. They armed themselves to intimidate the Pyramid Harbour natives, who were fully aware that a successful white venture into the interior with pack horses would jeopardize their trade monopoly. Dalton and Glave were successful in exploring the interior as far as Kluane Lake on this trip.

In 1894 Dalton established a post on the Alsek River close to Neskatahin. Despite Chilkat efforts to intimidate him and one attempt to eliminate him altogether, Dalton managed to maintain direct trade with the interior Indians. As part of his trading operations, Dalton began to improve access to the interior by upgrading the old trading trail which now extended from Pyramid Harbour, past Dalton's trading post and the Klukshu, Dezadeash, and Hutshi lakes, to the valley of the Nordenskiold River. The trail then followed the Nordenskiold River to a point near the Five Finger Rapids on the Yukon River. A western branch of the trail gave access to Fort Selkirk.

In 1898, during the rush to the Klondike, Dalton was permitted by American authorities to exact a toll of $2 a head for cattle and $2.50 for horses on the Alaskan portion of the trail. Although the shorter Chilkoot Pass continued to be the preferred route to the goldfields (Wright 1980a), a North West Mounted Police report for the summer of 1898 estimated that "about 2,000 head of cattle and a like number of horses" went into the interior via the less-steep Dalton Trail (Wright 1980a).

Dalton also capitalized on various other enterprises. He drove cattle to Dawson and packed provisions for the North West Mounted Police. He also ran the Dalton Pony Express Company which carried passengers from Five Finger Rapids on the Yukon River across the Dalton Trail to the coast, until steamers began to navigate the river (Theberge 1980).

Dalton continued to trade with interior Indians. In 1899 the North West Mounted Police reported that the Indians had enjoyed an excellent hunt the winter before and as a result Dalton took "a good stock of furs" to the sales in San Francisco (Wright 1980a: Chap. 4). There are few details in the published literature regarding fluctuations in the fur trade after this date, or about the closure of Dalton's trading post. The trail had apparently fallen into disuse by 1905 when local mining prospects faded (Theberge 1980). Catherine McClellan reported that Dalton built a new post at Champagne in 1902 and that "fur trapping has continued during this century, although it fell off markedly with the collapse of the fur market in the 1920's" (McClellan 1975:25 and 95). Wright mentions that trapping continued during World War I. "There were other traders in the region now: Oscar Burbank and then Frank Stretch at Kloo Lake; Joe Beauchamp at Bear Creek, and shorty Chambers at Champagne" (Wright 1980a: Chap.6).

12.5.2 Mining

Prior to the Klondike strike, prospectors confined their activities to the main rivers of the Yukon basin and the more accessible tributaries (Wright 1980a). Very few ventured into the Kluane area.

The area west of Klukshu Lake, which was officially designated as "The Last Chance Mining District", was the first to generate an increase in mining interest. In 1898 over 80 claims were staked in the vicinity of Alder, Shorty, and Kha-sha creeks. A group of 36 prospectors led by a former U.S. Cavalry lieutenant named Adair staked a number of claims and excavated two tunnels in the summer of 1898. The group, which became known as the "Mysterious 36", spoke optimistically of their finds but left at the end of their first season, never to return. Most of the mining activity in the following year concentrated on Porcupine Creek and Rainy Hollow, in the Dalton Trail Post area. The Last Chance Mining District was more or less deserted.

The Porcupine Creek area continued to produce gold in 1900, with an estimated total production of $75,000. In 1901 a gold discovery on Mush Creek triggered a stampede which drained the population of the Porcupine area. The Mush Creek gold, however, soon proved to be as elusive as that in other districts. It was not until 1903 that miners received new encouragement of rich gold deposits in the area. In that year Frank Altemose, Fred Ater, Morley Bones, and J.W. Smith discovered a rich concentration of placer gold on Bullion Creek in the Slims River Valley. Forty-three ounces of gold were recovered from nine days work on this deposit. Bones and Ater also staked a claim on neighbouring Sheep Creek. These finds precipitated another rush:

> "Bullion and Sheep Creeks were soon staked from top to bottom, and claims were also recorded on Vulcan, Metalline, Multi- metal, Canada and other St. Elias streams. By the time this rush slackened, some 2,000 claims had been recorded in the Kluane area."
>
> (Wright 1980a: Chap. 5).

A local infrastructure to support the new influx of miners began to develop. Cabins, tent frames, and a hotel were established at Bullion Creek and at Sheep Creek. There were reported to be 30 tents on Ruby Creek, with an average of three men in each. Ruby creek, located to the east of Kluane Lake, had been heavily staked in 1903. In addition, a mining community called "Silver City" was springing up at the mouth of Silver Creek:

> "Here, at the northern terminus of the Whitehorse - Kluane trail, goods arriving overland during the summer were transferred to boats for delivery to points along Kluane Lake. It was also the location of the offices of the mining inspector for the district, Lachlin Burwash."
>
> (Wright 1980a: Chap. 5).

Other creeks in the vicinity of Kluane Lake continued to be staked in 1904, including a claim by Altemose, Ater, Bones, and Smith, on Burwash Creek, which triggered yet another stampede. Despite the many intermittent discoveries of gold in the Kluane area, a strike similar in value to that in the Klondike continued to evade prospectors:

> "The rich pocket on Bullion Creek proved to be a flash--in-the-pan occurrence... In these mountain streams, unlike the unglaciated creeks of the Klondike, the overburden of glacial gravel deposits proved to be the greatest stumbling block to the recovery of gold."
>
> (Wright 1980a: Chap.51

The general average yield **was low,** seldom exceeding $3 to $5 a day per shovel. Unpredictable glacier meltwater levels and spring flooding were additional problems affecting mining endeavors on some of the mountain streams.

Development of mining in the area was also curtailed by the combination of low to moderate mineral yields with high shipping costs. The North West Mounted Police reported in 1904 that the cost of supplies in the district **was** prohibitive. The freight rate alone from **Whitehorse to Kluane** Lake amounted to **30¢** per pound.

The Bullion Hydraulic Company began to use hydraulics to work on Bullion Creek and in 1906 reported **a** yield of $4,500. This account conflicted with D.D. Cairnes' 1914 report for the Geological Survey of Canada. He reported the yield from placer mining to be $1,000. According to Wright:

> "Cairnes estimated that the total yield of the entire creek **was** approximately $5,000, and **that the discovery** claim of Altemose, Ater, Bones and Smith, with its **spectacular pocket of gold,** had actually yielded about one-fifth of this."
>
> (Wright 1980a: Chap.51

By 1908 only two two-man claims were being worked on Bullion Creek.

According to Cairnes' 1914 report Sheep Creek, yielding about $10,000 total in gold, turned out to be more prosperous than Bullion Creek. Seven thousand dollars of this amount was from 40 days work on claims no. 74 and 75, worked by the Fisher brothers. Cairnes estimated that Burwash Creek had been, and still was in 1914, the most productive gold-bearing stream in the Kluane district, with an estimated total production of thirty to forty thousand dollars.

Dollis (Squaw) Creek was the last area to yield gold before World war II. In 1927, Big Jim and Paddy Duncan, the two native Indian discoverers, were reported to **have** obtained 53 ounces of gold from their claim. Dollis Creek, like other creeks in the Kluane area, never became a second Klondike, but it did continue to produce a modest yield for many years.

Appendix II summarizes mining activity in the Rluane Park area.

12.5.3 The North West Mounted Police

In 1897 the North West Mounted Police Commissioner of the Yukon Territory, Major J.M. Walsh, sent 18 men under the command of Inspector A.M. Jarvis to enforce the law along the Chilkat Pass route to the goldfields. One detachment was stationed at Five Finger Rapids, at the Yukon River terminus of the Dalton Trail, and a second detachment was to be stationed on the Dalton Trail at the International Boundary.

The post established in May, 1898 near the Alaskan boundary was called the Dalton Trail Post. By August of the same year, the increase in mining activity along the trail led to the construction of a second post, Dalton House Post, near Dalton's trading post on the Tatshenshini River (Wright 1980a).

As the first representatives in the region of the government of Canada, the police force faced a variety of duties (Guest 1983). In the absence of a customs official, the police officers examined all goods coming into the country along the trail. The officers collected duty if it had not already been paid. They were also required to inspect permits for liquor and to ensure that all travellers coming into the country brought the mandatory ton of supplies with them to ensure their self-sufficiency.

The inspector was required to act as mining recorder for the Yukon district on the Dalton Trail. To fulfill this duty, the officers recorded and collected all fees charged for mining activities.

A correct register was kept of the traffic flowing both ways on the trail, and included an account of all horses, cattle, mules, and their brands (Wright 1980a). In addition, detailed annual reports were written each year by the commanding officer. These reports usually chronicled all noteworthy local events and activities which occurred during the year, including mining, trading, and police activities, and as such the reports provide valuable documentation for the history of the area.

The North West Mounted Police also patrolled the Dalton Trail between Dalton House Post and the Yukon River although crime was reported to be minimal. They maintained harmony between the miners and the Indians. Where conflict occurred, they stepped up their patrols and succeeded in preventing any violence (Theberge 1980a). In 1899 three small winter patrol cabins were built between Dalton House and Dalton Trail Post at Bear Camp, Glacier Camp, and at Rainy Hollow.

The Dalton Trail, Dalton House, and some of the temporary posts became obsolete after 1903, when an agreement was reached regarding the location of the Canada-Alaska coastal boundary. At the same time, the pattern of regional activities changed and began to centre upon events further inland (Wright 1980a).

In 1905 a separate Kluane Mining District was proclaimed, and a mining recorder's office was established at Silver City. The North west Mounted Police also established a permanent post at Silver City, which was to replace temporary detachments there and at Bullion. A permanent post was also established at Champagne Landing, but temporary detachments which had been stationed at Pine Creek and Ruby Creek were withdrawn.

As dreams of a major gold strike ended, the population of the Kluane area began to decrease, and a substantial police force was no longer needed.

> "The police were facing retrenchment. Ordered to reduce their strength in the Yukon, they had gone from 300 all ranks on December 1, 1904, to 150 all ranks by the spring of 1906, and to 118 all ranks by October 31."
> (Wright 1980a: Chap. 5).

12.5.4 Surveying, Geological Studies, and Mountaineering

Surveyors, geologists, and mountaineers played a major role in the exploration, mapping, and scientific study of the mountainous regions of Kluane.

The first expeditions entered the Kluane area from Alaska in the late 19th century. These expeditions attempted to ascend Mount St. Elias, the most prominent mountain visible from the coastline. This mountain was the first peak in Alaska glimpsed by the explorer Vitus Bering on July 6, 1741, St. Elias day. The name was eventually applied to the entire range of mountains and icefields that straddle the Yukon-Alaska boundary along the 141st meridian (Wright 1980a).

The American Frederick Schwatka, funded by the New York Times, attempted an ascent of Mount St. Elias in 1886 (Wright 1980b). He was followed in 1888 by a British-American party led by Harold Topham, and by the geologist Israel Russell, sponsored by the U.S. Geological Survey and the National Geographic Society, in 1890. Other groups also attempted to climb Mount St. Elias, but it was not until 1897 that the Duke of the Abruzzi, an Italian high-mountain explorer and his party reached the summit. Abruzzi added two names of his own for two major peaks, Bona and Lucania (Wood 1980).

The second major series of mountaineering parties were composed of surveyors for the International Boundary Commission. Their task was the physical demarcation of the international boundary line, as set out by a 1903 agreement between the United States and the United Kingdom regarding the boundary separating the Alaska panhandle from Canada. A further agreement, which provided for the demarcation of the 141st meridian from Mount St. Elias to the Arctic Ocean, was signed in 1906. The surveyors were required to identify in the field the various boundary points selected by the Boundary Tribunal. The geographical position of these points was accurately determined and monuments were placed at suitable locations along the straight line courses between the points (Wright 1980a).

From 1904 to 1912 the boundary was marked from the Arctic Sea coast to the White River, and from the southern perimeter of the coastal boundary to Mount St. Elias. In 1912 and 1913 the surveyors established more than 100 survey stations between Mount St. Elias and the White River, across the most rugged and extensively glacierized terrain in North America. This feat of traversing hundreds of kilometres of high-mountain terrain required considerable mountaineering skill as well as highly professional field organization, logistics, technical skill, and endurance (wood 1980).

The photo panoramas and elevation determinations made by the survey teams also furthered the efforts of subsequent Kluane mountaineering parties after World War I. Mount Logan, which the boundary survey parties had determined to be the highest mountain in Canada, became the first target of this renewed mountaineering interest. In 1925 the Alpine Club of Canada organised a joint Canadian-United States expedition which was successful in scaling Mount Logan. The group set out from McCarthy, Alaska, and travelled 128 kilometres (80 miles) to their goal (Wood 1980; Lambart 1926). Mount Bona was the third major summit to be climbed. Terris Moore, Allen Carpé, and Andrew Taylor followed a route similar to that of the 1925 Alpine Club expedition and were successful in reaching the summit of the mountain in 1930 (Wood 1980).

The American Geographical Society's 1935 expedition was led by Walter Wood. This was the last major climb to be attempted without using aircraft. Instead, Wood used the services of the Burwash Landing Jacquot brothers and their pack horses. Wood completed some survey work and successfully climbed Mount Steele.

In 1935 Bradford Washburn led a National Geographic expedition which explored the core of the Icefield Ranges. The introduction of the use of aircraft on the expedition removed the labour of travelling to the preliminary base camp and left more energy for the final climb. It also enabled Washburn to produce comprehensive aerial photographic coverage of the region. The freighting was done by Everett Wasson in a single-engined Fokker "Super-Universal" from Northern Airways in Carcross. The aerial photography flying was done by Bob Randall in a Fairchild CF-2W2.

In 1937, the well-known pioneer bush pilot, Bob Reeve, flew Bradford Washburn to the Walsh Glacier, at the base of Mount Lucania. When sudden thawing occurred on the glacier, plans to use the aircraft to return were abandoned. Washburn and his companion, Robert Bates, climbed Mount Lucania and Mount Steele before returning by foot to the Donjek River. Here they fortunately met up with a pack train which transported them to Burwash Landing (Wood 1980).

The last mountaineering exploit before World War II was an attempt in 1939 by Walter Wood to climb Mount Wood. Unfortunately he was forced to turn back due to bad weather.

After World War II mountaineering gained widespread acceptance. Between 1950 and 1975 more than 300 individual ascents or journeys were undertaken in the St. Elias Mountains (Wood 1980). The record of mountaineering rapidly became a matter of statistics rather than a story of individual achievement (Wright 1980). Whereas prior to world War II parties had been comprised of two to six persons, most of the later expeditions were teams of four to twelve climbers.

Three institutions also sent scientists to the St. Elias Mountains in the 1950's and 1960's. The first of these was the Geological Survey of Canada. In 1954 and 1956 a team led by John Wheeler carried out reconnaissance surveys of the geology of certain areas of the Kaskawulsh watershed and the Kluane Ranges. In the course of their work they recorded the geographical coordinates for 40 summits which they were the first to reach (Wood 1980).

The Arctic Institute of North America sponsored the second group of scientists to arrive in the Kluane area. This group, called Project Snow Cornice, was based in the Seward Glacier area from 1948 to 1951. Their studies included glaciology, geophysics, meteorology, climatology, topographic mapping, and botany. The team of mountaineers responsible for the safety of the scientific personnel were also successful in climbing Mount Vancouver in 1949.

In 1961 the Arctic Institute of North America and the American Geographical Society sponsored another group of scientists to work in the mountains of the Park. This group, called the Icefield Ranges Research Project, was directed by Walter Wood. Like Project Snow Cornice, the goal of the new project was to promote field studies leading to the increased understanding of a high-mountain environment. Numerous high-mountain ascents were also made. Light aircraft modified to land on either ground or ice were used to land and take off on glaciers and other unprepared surfaces (Wood 1980).

The last large mountain expedition was organised to celebrate Canada's centennial, in 1967. The Yukon Alpine Centennial Expedition climbed 14 previously unexplored summits. Twelve peaks were named for the provinces and territories of Canada, and one was named Centennial Peak. The fourteenth peak on the international boundary was climbed by a joint Canadian-United States team, and was named Good Neighbour Peak.

12.5.5 Big Game Hunting

A few of the outsiders who arrived in the Kluane area in the early 1900's as miners, trappers, surveyors or policemen settled in the country. For some of these settlers, big game outfitting became a way of supplementing an income which was usually based on trapping. From 1912 until 1943, local residents made a considerable amount of money by guiding and outfitting wealthy American hunters eager for a frontier experience (Wright 1980a; Theberge 1980).

The Jacquot brothers were two outfitters who had left their Klondike claim to join the rush to Burwash Creek in 1904. They built a trading post at a location which they called Burwash Landing which became the centre of a small community made up mostly of independent outdoorsmen and their native wives (Theberge 1980). These outfitters included Thomas Dickson, Jack Haydon, and Morley Bones (Wright 1980a; Theberge 1980).

Big game hunting excursions usually began with a horse and wagon trip from Whitehorse to the south end of Kluane Lake. The hunting party then continued by boat up the western shore of the lake to Burwash. From Burwash the party would travel by pack-train up the Duke River to the Burwash Uplands and on to the White River (Theberge 1980:118).

In the 1920's and 1930's there were usually two to four hunting parties per year, each registered for 30 to 40 days. The fees charged by outfitters were between $2,000 and $3,000 for each hunter (Wright 1980a). According to Theberge (1980) Dall's sheep, grizzly bear, moose, and caribou were the main targets, but small game species such as hare and ground squirrel were also taken. Trips were also often made up the Slims River to take mountain goats.

The hunting era ended when the area was proclaimed a game sanctuary in 1943 (Theberge 1980).

12.5.6 Developments Resulting from World War II

The Alaska Highway was built as a joint venture by the United States and Canada in the early 1940's. The decision to build the road was precipitated by the Japanese bombing of Pearl Harbour in 1941, the later attacks on the Aleutians, and the possibility of a Japanese attack on the west coast.

The role of the United States in the project was to complete the survey, construction and maintenance of the highway. Canada's role was to provide the rights-of-way and to make the required supplies of timber, gravel, and rock available from adjoining provincial or dominion lands. Canada also waived import duties, sales taxes, licence fees, and made other concessions. Six months after the end of the war, the portion of the road in Canada became part of the Canadian highway system (Wright 1980a).

The United States Army Corps of Engineers began construction in the spring of 1942. The highway was built in sections, with the 18th Regiment rushing north toward the Alaska boundary to meet the 97th rushing south (Theberge 1980).

In the Kluane area construction proceded rapidly on the part of the route which followed the old wagon road. The drilling and blasting required to cut a route along the shore of Kluane Lake soon slowed progress considerably. North of Burwash Landing, the engineers were further impeded by the logistical problems of building on permafrost (Wright 1980a).

Initial construction of the road was completed in only nine months (Theberge 1980). In the winter of 1942-43 the engineers were transferred back to regular wartime duties and civilian contractors moved in to upgrade the road. This upgrading operation involved five management contractors, more than 70 road and bridge contractors, and a peak work force of over 16,000 men (Wright 1980a).

During the upgrading phase of the Alaska Highway, a road was constructed which roughly followed the Dalton Trail route between Haines, Alaska, and the Alaska Highway. This road, which came to be known as the Haines Road, was to serve as an alternate to the railway. It also relieved some of the pressure on the port facilities at Skagway, and alleviated the necessity of re-handling freight bound for places north of Whitehorse (Wright 1980a).

Road upgrading ended in the winter of 1943, when the Americans assumed an offensive position in the war in the Pacific. The Alaska Highway was no longer needed as a strategic transportation route. For the remainder of the war years, the army limited its role in the highway project to essential maintenance only.

Two incidental developments to the Alaska Highway construction were the installation of a telephone land line and a crude oil pipeline. Both projects roughly followed the highway right-of-way.

The Canol pipeline was built to distribute oil from Norman Wells, NWT, to army forces along the Alaska Highway, in the event that regular sources were cut off by enemy action. The pipeline was never used for its intended purpose and was removed when a new pipeline was built from Haines, Alaska to Fairbanks in the 1950's.

The highway brought considerable change to the Kluane area. The new transportation route attracted many new visitors to the region. These included archaeologists, geologists, and other governmental officials interested in examining the resources of this previously remote terrain. In 1944 the Federal Department of Agriculture established an agricultural research farm at Pine Creek. Some of the local residents began to invest in the new tourist trade by opening such businesses as a service station, restaurant, lodge, and later, a general store.

After the Canadian Department of National Defense assumed responsibility for the highway system in 1946, they built permanent highway maintenance camps which became the nucleus of several small highway communities (Wright 1980a). One of these settlements, located at Mile 1016 on the highway and known as Haines Junction, attracted the most commercial development.

The growth of Haines Junction was due primarily to its strategic location at the junction of the Alaska Highway and the Haines Road. Haines Junction experienced an economic boom as field headquarters for the construction of the Haines-Fairbanks pipeline in 1954-56. Year-round jobs became available at the Haines Junction pump station. When the operational phase of the line began, the Junction became an important petroleum distribution center (Wright 1980a).

In the mid-1960's, however, the population of Haines Junction began to decrease when the experimental farm at Pine Creek closed. In 1971 a further exodus was caused by the closing of the Haines-Fairbanks pipeline system. Economic stability of the area grew to depend on the Alaska Highway maintenance and Kluane National Park, which was established in 1972.

12.6 Evaluation

Cultural resources identified in the Park consist primarily of the evidence of non-native activities during the present century. Most of these are the remains of gold mining activities and are located along the numerous creeks where gold was found with varying degrees of success. Mining was attempted several times during the century at some of the locations so that early facilities may have been reused, renovated, or substantially rebuilt. In some instances more casual use also continued to recent times. Such sites generally consist of the remains of a structure, some indication of equipment associated with mining, and other debris accumulated during the occupation. The latter consists of the variety of domestic or household material from day to day living but in some instances also includes much of the furnishings used on a site.

None of these sites has been used recently and many have not been used for several decades or more. They are all actively deteriorating. Few of the cabins could be occupied in their present condition or with minimal repairs. Once a building becomes open to the elements, even in a small way, it begins to deteriorate. eventually the roof falls in and the walls begin to disassemble. The process is also hurried along by the growth of adjacent vegetation. Any organic items, such as cloth, decompose relatively rapidly if exposed to the elements and all ferrous items begin **to** rust.

The question of significance must identify the frame of reference within which the resources are to be evaluated. Significance for research or anthropological purposes is not necessarily comparable to significance for interpretive purposes. Stevenson (1978) has put forth one assessment of significance of the historic period resources, based on the situation current at that time. His comments and suggestions remain valid, to the extent that development plans have remained unchanged.

The historic period resources collectively provide a reflection of the existence and nature of **a** specific type of activity, primarily gold mining in this instance. The type of accommodations created, the type of equipment used, the type of furnishings and supplies, and the manner in which facilities are arranged and maintained all provide some indication of a lifestyle. A visitor observing the remains would be able to develop some feeling or understanding of what had happened in the past. The question of which sites could contribute most to an interpretive program would depend on the quantity and variety of resources remaining at a site and the aspect or period of human history selected for interpretive emphasis.

It is likely that the earlier gold rush activities will be emphasized and thus the more complete or better preserved sites of this period would be considered **more** significant. Within these, greater significance would be attributed to sites located in areas proposed for development and consequently interpretation.

The role in interpretation to be assumed by some of the sites remains to be established. Some of the sites have not yet been examined extensively or inventoried and some of the areas in which gold mining is known to have occurred have not been examined for existence of cultural remains. Future research should be directed to examination of sites in areas identified for development or examination of areas in which sites have not yet been noted.

Two problems exist in association with these resources: 1) they will continue to deteriorate; and 2) **they** are not always particularly attractive. The latter has resulted in some interest in cleaning up sites. Such activity should be avoided except under special circumstances. If a site includes materials potentially dangerous to Park staff or the public, such materials should be removed. An example here would be the presence of dynamite reported at some of the mining camps. If cultural resources are threatened by natural processes, such as flooding or erosion, some salvage effort could also be considered, given that the site is recorded before materials are removed or relocated. The urge to remove fuel drums, possibly considered unsightly, should be avoided since their presence and distribution are also an indication of past activities. They may, for example, illustrate how site appearance was considered secondary to the recovery of gold. Extreme sentiments such as the "junk must be flown out and buildings repaired, or the whole thing burned down and removed" (Theberge 1972:24) are inappropriate for cultural resources.

Continued deterioration of resources is a major problem without an obvious solution. Although stabilization theoretically provides an answer, the number of structures and other remains and the advanced state of deterioration of some precludes its consideration as a serious option. Partial stabilization, restricted to structures which have deteriorated less and structures which may play some role in an interpretation program, may be feasible. This, however, does not consider the extensive clutter of artifacts/equipment which may also be present and which should also be a major component of site interpretation.

Survival of resources could also be prolonged if sites were marked with signs identifying them as being of historic importance and specifically discouraging removal of material (for firewood) or collecting of objects. This could be supplemented by a monitoring program on an ad hoc basis so that changes in site condition could be noted early and remedial action taken if possible. This activity would be more critical for sites in areas of more regular use by the public: sites which are likely to be disturbed by human activity. Such monitoring could be assisted by the development of a source book of photographs, using some photographs from the archaeological surveys of 1978 and 1979. In some instances photographs would have to be taken of a site since it is not well represented in a photograph file. Such a source book should also allow space for notations as sites are visited and changes are noticed.

Prehistoric resources share some of these problems but their main characteristic is that they appear to be primarily surface features. Deterioration is no longer an issue but disturbance by indiscriminate collecting or extensive traffic can have a major effect on their significance for research purposes. Study of prehistoric sites does not only consider the type and quantity of items or materials present but also their location and inter-relationships. These are easily disturbed by collecting or rearranging. Avoidance of sites by visitor traffic is possibly the simplest approach.

The list of sites contained in Appendix I also indicates management activity necessary or appropriate at each site.

It should be emphasized that the importance of cultural resources lies in their association with events of the past and their potential for contribution to **an** interpretation and understanding of that past. Not only their existence but their form is important. Deterioration should be delayed if possible and collecting or rearranging of materials curtailed. The latter reflects on activities, lifestyle, and attitudes. These attitudes should be communicated to the public.

There are two areas in the history of Kluane National Park which are not well documented. The first of these is native history. In particular, little is known about the native use of those areas now included in the Park. There is also insufficient information available about the early history of the establishment of the national park. To fill these gaps in the historical record, native oral histories should be documented where possible, and the history of the Park from its establishment as a game reserve to the present, should be undertaken.

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APPENDIX

12.1 Historic and Prehistoric Resource Sites in Kluane National Park.

12.2 Mining and Related Activity in Kluane National Park.

Area : **Bullion Creek (10Y)**

;ite	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
0Y1	2.5 km upstream from junction with Slims River; at mouth of Bullion Creek Canyon.	historic; log cabin, root cellar, possible cache, lean-to, 3-room foundation, bench seat, pit saw stand, scattered artifacts.	cabin roof collapsed	early 20th century and 1930s; possible RNWMP post.	monitoring of site condition.
0Y2	1.5 km east of 10Y1.	historic: tent frames, root cellars, platform caches, log cabins, log foundations, privy, scattered artifacts.	deteriorating, roof collapsed, collected by pot hunters.	early 20th century; Bullion City.	stabilization of structures, monitoring of site condition.
0Y3	east side of creek, 6.0 km upstream from 10Y1.	historic; 2-story log cabin, privy, scattered art ifacts.	good (roof intact).	1930s; good example for th period.	stabilization of structure, monitoring of site condition.
0Y4	east side of creek, 1.5 km downstream from 10Y3.	historic: log cabin, furnishings, scat.1 ered artifacts, possible mining pit, tailing piles.	good/stable.	post- 1922	monitoring of site condition.
0Y5	1.0 km west of 10Y2, 0.3 km east of 10Y1.	historic; log cabin, root cel lar, corral, picket fence.	poor/deteriorating, subject to flooding/ sitting.	early 20th century; Bullion City Hotel.	possibly beyond stabilization.
l0Y6	west side of creek, 1 .O km upstream from 10Y1.	historic; two log structures (possibly tent frames).	partially collapsed.	early 20th century, prospectors camp.	monitoring of site condition.
l0Y7	west side of creek, 0.5 km upstream from 10Y6.	historic; log structure (possible tent frame), log bundle, possible structural features, tailing piles.	deterioration.	not dated.	monitoring of site condition.
l0Y8	west side of creek, 0.15 km upstream from 10Y7.	hist.oric; two possible tent frames, garbage dump, privy, tripod, scattered artifacts, tailing piles.	deteriorating	after early 1920s, evidenc for presence of children.	monitoring of site condition.

Area: Bullion Creek (10Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
10Y9	east side of creek, opposite 10Y10 and 10Y11.	historic] wooden flume.	deteriorating.	early 20th century; main evidence of attempt (unsuccessful) at large scale mining.	
10Y10	west side of creek, opposite southern section of 10Y9.	historic) log cabin/tent frame with annex, tailing piles.	collapsed.	early 20th century, W.L. Breeze and the Bullion Hydraulic Company cabins	monitoring of site condition.
10Y11	west side of creek, 0.6 km upstream from 10Y10.	historic; plank cabin, privy, truck, fuel drums, scattered artifacts, tailing piles.	good/intact.	1950s and more recent.	monitoring of site condition.
10Y12	west side of creek, 1.0 km upstream from 10Y11 and 4.0 km upstream from 10Y1.	historic; cellar, privy, scattered artifacts.	deteriorating.	after 1930; evidence for presence of children.	monitoring of site condition.
10Y13	west side of creek, 1.5 km upstream from 10Y12.	historic; tool shed, privy, plywood cabin, garbage dump, sluice box with tools and equipment	good/intact.	early 1970s; good example of recent mining activities; mining never really started.	monitoring of site condition.
10Y14	east of creek, 0.4 km east of 10Y5.	historic; three tent frames, platform.	good?	early 20th century.	monitoring of site condition.

Area: Sheep Creek (11Y)

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
11Y1	near mouth of creek, 1.0 km west of old Alaska Highway bridge on Slims River.	historic; three log cabins, privy, garbage dump, log feature, scattered artifacts.	good/intact.	early 20th century to relatively recent; "Sheep Camp".	monitoring of site condition.
IIY2	west side of creek, 4.0 km upstream from 11Y2.	historic; log cabin, two sluicing operations, scattered artifacts.	good/intact.	1920s to recent; good representative sample of gold mining associated equipment and supplies.	monitoring of site condition.

Area : Sheep Creek (11Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
1Y3	both sides of creek, 0.5 km downstream from 11Y2.	historic; abutment/retaining wall, two sluice boxes.	good?	neither early nor late gold mining.	
1Y4	east side creek, 1.5 km downstream from 11Y3.	historic; log feature, furniture, scattered equipment.	feature burnt.	1920s or later, extensive artifact collection in burnt feature	salvage of artifacts from creekbed; monitoring of site condition.
1Y5	west side of creek, 0.5 km downstream from 11Y4.	historic; plank cabin, scattered equipment.	good/intact.	recent.	protection of artifacts from flooding; monitoring of site condition.
1Y6	on Sheep-Bullion Plateau road, 1.0 km northwest of 11Y1.	historic; plywood platforms, scattered artifacts.	good ?, may already have been destroyed as a safety measure.	1950s and more recent.	removal of dynamite, if still present; monitoring of site condition.
1Y100	east side of creek, 1.4 km upstream from junction with Slims River and 0.2 km west of access road.	prehistoric; three pockets of flakes.	apparently undisturbed by any recent activity.	undated; good location for a lookout or hunting station.	avoidance by development or traffic.

Area: Coin Creek (12Y)

12YT1	east side of creek, 2.5 km north of 10Y2.	historic; two log cabins, mine shaft, pitsaw platform, corral, animal enclosure, depression, scattered artifacts.	danger of a roof collapsing.	early 20th century and 1930s, cabins may not date to initial occupation.	monitoring of site condition.

Area: Shorty Creek (13Y)

13Y1	north side of creek, 30 m upstream from junction with Alder Creek.	historic; two hoisting structures, tent cabin, fuel drum pump, scattered artifacts.	cabin collapsed.	1930s to 1950s.	monitoring of site condition.

Area: Shorty Creek (13Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management Requirement
13Y2	north aide of creek, 30 m upstream from 13Y1.	historic; two tent cabins, log cabin, privy, scattered artifacts.	variable, sometimes good.	recent (1940s and more recent?).	monitoring of site condition.
13Y3	north side of creek, 0.5 km upstream from 13Y2.	historic; two tent cabins, log cabin, privy, scattered artifacts.	variable; sometimes good.	recent (1940s and more recent?).	monitoring of site condition.
13Y4	south side of creek, 0.3 km upstream from 13Y3.	historic] tent frame, mining equipment, scattered artifacts.	frame partially dismantled.	early 20th century.	monitoring of site condition.
13Y5	at confluence of creek's two branches.	historic; tent frame.	unknown.	unknown.	monitoring of site condition.
13Y6	south side of south branch of creek, 0.5 km upstream from 13Y5.	historic; four plywood and plank cabins, wood pile, mining equipment, scattered artifacts.	cabins collapsed or pushed down.	after 1920s; good example of later gold mining; largest mining operation recorded in park.	monitoring of site condition.

Area: Goat Creek (14Y)

Site	Location	Type/Resources	Condition	Date/Significance	Management Requirement
14Y1	east side of creek, at Kathleen Lake.	historic; log cabin, platform cache, pitsaw platform, scattered artifacts.	cabin roof collapsed.	after early 1920s; no definite association with gold mining; possibly a landing and storage facility.	monitoring of site condition.
14Y2	west side of creek, 4.5 km upstream from 14Y1.	historic; cabin/tent frame, platform cache, two sluice boxes, mining equipment, scattered artifacts.	cabin burnt, some equipment may be new.	1930s/1940s, artifact scatter may be more extensive (more complete?) than other sites.	monitoring of site condition.
14Y3	west side of creek/ south side of creek canyon, 1.5 km upstream from 14Y2.	historic; 10 sections of flume/sluice box, scattered mining equip,-ment, platform cache, tailing piles.	cache collapsed.	1930s/1940s, good representation of mining equipment and supplies.	monitoring of site condition.

Area: Goat Creek (14Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
14Y4	west side of creek, 0.4 km downstream from 14Y3.	historic; two tent frames, platform cache, scattered artifacts.	cache collapsed.	1920s/1930s/1940s, possibly associated with 14Y3.	monitoring of site condition.

Area: Mush Creek (15Y)

15Y1	west side of creek, 8.0 km upstream from mouth.	historic; two mining trenches, log cabin, lean-to, cache pit, tent frame, scattered artifacts.	cabin roof collapsed, some structural features burnt.	turn of the century to 1940s, possibly one of earliest non-native sites in park.	monitoring of site condition.
15Y2	west side of creek, 1.0 km upstream from 15Y1.	historic; platform cache, two claim stakes.		unknown.	
15Y3	east side of creek, 7.0 km upstream from its mouth.	historic; log cabin, log foundation, pit saw platform, platform cache, scattered mining equipment and other artifacts.	cabin roof collapsed, cache collapsed,	turn of century and after 1923; may also be one of earliest non-native sites in park.	monitoring of site condition.
15Y4	west side of creek, 0.5 km upstream from 15Y3.	historic; log foundation/tent frame, mining trench, scattered artifacts.	deteriorating.	turn of the century; associated with early gold mining.	monitoring of site condition.
15Y5	east side of creek, 0.2 km upstream from 15Y4.	historic; log cabin, depression, scattered artifacts.	roof collapsed, walis deteriorating.	turn of the century, associated with early gold mining.	monitoring of site condition.
15Y6	east side of creek, Cl.15 km upstream from 15Y5.	historic; tent frame, two claim posts.	frame incomplete.	turn of the century.	monitoring of site condition.

Area : **Mush Creek (15Y) (Continued).**

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
15Y7	east side of creek, 1.5 km upstream from 15Y1.	historic; log cabin.	almost completely collapsed.	turn of the century.	possibly beyond consideration
15Y8	west side of creek, 1.5 km upstream from 15Y1; downstream from 15Y7.	historic; log cabin, tent frame, scattered artifacts.	roof collapsed.	turn of the century.	monitoring of site condition.
15Y9	west side of creek, 0.5 km upstream from 15Y6.	historic; depression, mining trench.	presumably relately stable.	possibly turn of the century.	possibly none.

Area: Kaskawulsh, Deradaaeh and Alsek Rivers (16Y)

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
16Y1	north side of Sugden Creek at its mouth.	historic; log cabin, privy, scattered artifacts.	good/intact.	1950s.	monitoring of site condition.
16Y2	on highest beach terrace on south side of Alsek River, 0.1 km north of Beachview Creek.	historic; log cabin, scattered artifacts.	roof collapsed, walls partly collapsed.	post 1939? possibly a trappers cabin.	monitoring of site condition.
16Y3	on Dezadeash River beach ridge, 16.0 km f rom Haines Junction	historic; flat bottomed boat.	deteriorating.	unknown.	removal from threat by high water.
16Y4	on Alsek River near Marble Creek.	historic; oar.	already removed to Parks office.	unknown.	none.
16Y5	on Alsek River north of Lava Creek.	historic; two log cabins, dog house, still with wood pile, scattered artifacts.		turn of the century and after early 1920s; no definite association with mining or trapping.	monitoring of site condition.
	on gravel fan east of Beachview Creek.	historic; cache.	unknown.	not determined.	investigation on for association and date. monitoring of site condition.

Area: **Mush** Lake (17Y)

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
17Y1	west end of lake, west end of Mush Bates lakes portage.	historic; plank cabin, floor, privy, qarbage dump.	cahin intact.	recent; possibly no association with mining.	monitoring of site condition.
17Y2	north shore of lake, 0.5 km northeast of 17Y1.	historic; log cabin, scattered artifacts.	roof and part of walls collapsed.	19308, 1940s no apparent association with mining; possible association with U.S. Army; possibility of being a stopping point for miners.	monitoring of site condition.
17Y3	north shore of lake, 0.25 km from 17Y2.	historic; platform cache.	collapsed.	not considered to be early	

Area: **Iron** Creek **(18Y)**

8Y1	east side of creek, 2.0 km upstream from mouth (at Bates River) .	historic; log cabin, possible platform cache, depressions.	roof and part of walls collapsed.	early and post-1922.	monitoring of site condition,
BY2	east side of creek, 0.15 km upstream from 18Y1.	historic; tent frame, scattered artifacts.	overgrown.	1920s/1930s?	monitoring of site condition.
8Y3	east side of creek, 0.1 km upstream from 18Y2.	historic; platform cache, scattered artifacts.	collapsed.	early and 1920s?	monitor ing of site condition.
BY4	east side of creek, 0.25 km upstream fron 18Y3.	historic: log cabin, tool shed, tent frame, platform cache, garbage dump, mining equip-ment.	cabin roof collapsed, cache collapsed.	1920s to 1960s.	monitoring of site condition.

Area : Iron Creek **(18Y)** (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management [1] Requirement
18Y5	east side of creek, 0.15 km upstream from 18Y4.	historic; seven plywood structures (cabins?), scattered artifacts.	structures all collapsed or knocked down.	Late 1940s, early 1950s no apparent association with mining, possible association with U.S. Army; probably associated with 18Y4 and 18Y6.	monitoring of site condition.
18Y6	east side of creek, 0.2 km upstream from 18Y5.	historic; sluice box, flume sections	possibly relatively stable.	middle or late mining periods.	possibly none.
18Y7	east side of creek, 0.15 km upstream from 18Y6.	historic; two tent frame, platform cache, flowgate, scattered artifacts.	cache collapsed, frames and gate partly collapsed.	1910s to 1930s.	monitoring of site condition.

Area: Bates River **(19Y)**

Site	Location	Type/Resources	Condition	Date/Significance	Management Requirement
19Y1	south side of river, 2.5 km southwest of Iron Creek.	historic; plank cabin, tent cabin, platform cache, flowgate, flume sections, other mining equipment, scattered artifacts, tailing piles.	cabins intact - with furniture, housewares and clothing; cache collapsed.	post - U.S. Army to recent.	monitoring of site condition.
19Y2	south side of river, 0.25 km from south end of Bates lake.	historic; 2 platform caches.	one collapsed, one leaning.	undeterminate.	monitoring of site condition,

Area: Alder Creek **(20Y)**

Site	Location	Type/Resources	Condition	Date/Significance	Management Requirement
20Y1	south side of creek, near junction with Mush Lake Road.	historic; foot bridge, log pile.	deteriorating.	unknown.	possibly none.

Area: Alder **Creek (20Y)** (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management[1] Requirement
20Y2	**south** side of creek, at **junction** of Alder and **Dalton creeks;** 8.0 km downstream from **20Y1.**	historic; **log** cabin, platform cache, **log** pile, garbage pit, scattered artifacts.	good/intact.	recent **(1960s/1970s).**	**monitoring** of site condition.

Area: Congdon **Creek (21Y)**

21Y1	**north side of creek, 8.0 km upstream from** its **mouth** at Kluane **Lake.**	**historic; log** cabin, rack, logs, **scattered** artifacts.	**good/intact;** cabin probably renovated.	**1920s to 19608,** possibly built by **Eric Ericson (1920s to 1940s).**	monitoring of site condition..

Area: Bighorn Creek (22Y)

22Y1	west side of creek, 11.0 km upstream **from** junction with **Donjek River.**	historic; **log** cabin, two log tent frames, mining equipment, scattered artifacts.	cabin **and tent Frames** collapsing.	early 20th **century (to 1915) short-term occupation,** possibly **by Ed Benson.**	monitoring of site condition.
2212	east side of creek, **8.0 km downstream** from **22Y1.**	historic; log **cabin.**	roof partly collapsed.	**1914/15?** unusual **form/construction.**	**monitoring** of site condition.

Area : Donjek River (23Y)

23Y1	**10.0 km south of junction with Bighorn Creek.**	historic: posts **(inground)** (corral?).	**not** determined, possibly relatively stable.	not determined, recorded only from air.	on ground investigation.

Area: Hoge Creek (24Y)

Site	Location	Type/Resources	Condition	Date/Significance	Management[1] Requirement
24Y1	8.0 km upstream from junction with Donjek River.	historic; plywood tent frame, mining equipment, scattered artifacts.	tent frame incomplete.	recent.	monitoring of site condition.

Area: Grizzly Creek (25Y)

25Y1	1.5 km upstream from junction with Duke River.	historic; posts (corral), fuel drums.	possibly relatively stable.	1950s.	possibly none.

Area : Silver Creek (26Y)

26Y1	8.0 km upstream from junction with Tatshenshini River.	historic; loq cabin, qarbaqe dump, platform cache, animal enclosure.	cabin intact, cache collapsed.	1950x/1960s.	monitoring of site condition.

Area: Airdrop Lake (27Y)

JeVn-1	1.5 km north of Airdrop Lake; south-west side of Hoodoo Mt., adjacent to a small stream draining Airdrop Lake.	prehistoric; obsidian flakes and tools, area of about 75 sq. m.	possibly undisturbed; readily subject to disturbance by human presence; major portion of material collected.	not determined, possibility of lengthy occupation, most extensive prehistoric site recorded; good vantaqe for lookout - lookout/workshop/ hunting location, possible association with earliest prehistoric occupations in area.	protection from disturbance.
(PH-2)	about 1 mile NE of PH-1.	prehistoric; four obsidian flakes.		not determined.	probably none.

Area: Airdrop Creek (27Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
PH-3)	NW of PH-2.	historic; macro blades, core fragments, retouched flakes, utilized flakes, micro blades, broken bifaces.	possibly undisturbed; readily subject to disturbance by human presence.	not determined, size approaches that of PH-1.	protection from disturbance.
PH-4)	north of PH-7; west side of creek, just before start of canyon.	prehistorici thinning flakes, bifacial thinning flakes, core flakes, utilized flakes, retouched flakes.	surface.	not determined.	
PH-5)	southwest of PH-1.	prehistoric; three bifacial thinning flakes.		not determined.	possibly none.
PH-6)	northeast of PH-3, east of a dry lake.	prehistoric; resources not listed.			
(PH-7)	along game trail from PH-4, south of PH-4.	prehistoric; three obsidian flakes.	surface.	not determined.	possibly none.
(PH-8)	250° to PH-6.	prehistoric; signle flake with indication of slight utilization.	surface.	not determined.	none.
(PH-9)	on a knoll 0.25 mile! SW of PH-8.	prehistoric; small number of flakes from two areas.	surface.	not determined.	none.
(PH-10	3.5 miles SE of PH-6	prehistoric; small area of lithic scatter, possible burin spall.	material collected.	not determined.	none.
[PH-11	310° from PH-6, 20° from PH-10.	prehistoric; 3 chert flakes.		not determined.	none.
(PH-12	210° from Airdrop Lake, 300° from PH-6	prehistoric; several hundred cores and retouched flakes.	surface.	not determined.	protection from disturbance.

Area: Airdrop Creek (27Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
(PH-13)	10° from W-12.	prehistoric; two utilized flakes.	surface.	not determined.	none.
(AI-141	170° from PH-12, 250° from PH-6.	prehistoric; two obsidian flakes.	surface.	not determined.	none.
(PH-15,	17° from PH-12, 240° from PH-6.	prehistoric; two flakes.	surface.	not determined.	none.
(PH-16)	0.25 mile north of PH-15, 170° from PH-12, 60° from creek canyon.	prehistoric; several. hundred flakes and cores, area of approximately 100 sq. yds.	surface.	not determined.	protect ion from disturbance.

Area: Victoria Creek (28Y)

28Y1	both sides of creek, 12.0 km upstream from mouth of Kathleen Lake.	historic; plank tent frame, log shed, sluice box, mining equipment, fuel drums, tailing piles, log sled.	ten frame intact.	1950s/1960s good example of recent mining.	monitoring of site condition.
28Y2	0.5 km downstream from 28Y1.	historic; sawmill equipment, sawdust.		not determined.	monitoring of site condition.

Area: Vulcan Creek (31Y)

31Y100	north side of creek, 2.7 km upstream from junction with Slims River; along a game trail.	prehistoric; six green-chert flakes, calcined bone.	surface.	not determined.	possibly none.
31Y101	north side of creek, below and east of 31Y100.	historic; bifacially flaked chert knife, flake.	collected; area eroded and disturbed.	not determined.	none.

Area: Vulcan Creek (31Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management[1] Requirement
-	above 31Y100.	historic; three groups of tent frames, scattered artifacts.		1930s to recent.	investigation for identification, monitoring of site condition.
-	east side of creek.	historic; tent frames, cookshack, garbage dump, cache pit.		1930s to present.	investigation for identification, monitoring of site condition.

Area: **Kathleen Lake (32Y)**

Site	Location	Type/Resources	Condition	Date/Significance	Management[1] Requirement
32Y100	vicinity of day-use and boat launch area; east side of small bay.	prehistoric; lithic scatter - including bifacial knife, unifacial flake, primary and secondary flakes - in two concentrations, obsidian and chert.	materials collected; site disturbed by development and present activities.	not determined.	monitoring for further appearance of material.
32Y101	vicinty of day-use area; on road, 1.7 km from park gate.	prehistoric; broken obsedian biface.	collected.	not determined apparently an isolated find.	none.
32Y102	vicinity of &y-use area; on mining road, 2.5 km from park gate.	prehistoric; lithic scatter and calcined bone.	almost totally disturbed.	not determined.	monitoring for further appearance of material.
32Y103	on mining road, 0.54 km south of 321102.	prehistoric; lithic scatter of obsidian, one chert flake.	badly disturbed.	not determined.	monitoring for further appearance of material.
32Y104	west end of lake, 0.3 km upstream on an unnamed creek.	prehistoric; two green chert flakes.	possibly eroded.	not determined, possibly an isolated find.	none.
	4.0 km east of Goat Creek.	historic; mineshaft.	unknown.	not determined.	possibly none.

Area : Kathleen Lake (32Y) (Continued).

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
JdVh-2	west side of small bay in day-use area; south of several summer cottages.	prehistoric; resources - unknown.	located in area of uprooted trees.	not determined.	possibly on private cottage property.

Areas Slims River

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
	north side of river, at junction with Kaskawulsh River (rivers do not meet?]	historic; cache.	unknown.	not determined.	investigation of contents and date; identify location.
	near river in vicinity of Old Alaska Highway bridge, 0.4 km from cache.	historic; structure, lumber supply, scattered artifacts.	structure incomplete..	1940s?	monitoring of site condition.
	north side of river, in vicinity of Old Alaska Highway bridge.	historic; tent frames, cache, cattle pond(?), possible well.		1940s? possible roadhouse associated with highway.	monitoring of site condition.

Area: Sockeye Lake

Site	Location	Type/Resources	Condition	Date/Significance	Management' Requirement
-	specific location not listed.	historic; cabins, scattered artifacts.	unknown.	unknown, Johobba Mine.	examination/recording of site.

APPENDIX

12.2 Mining and Related Activity in the Kluane National Park area

• **Mining** and **related** activity **in Kluane** National **Park.**

AREA	DATE	LOCATION**	PROSPECTS OR GROUP	ACTIVITY	RESULTS	REFERENCE
Dalton range	April 1898	Shorty Creek	"Mysterious 36" (Adair)	Bunk house and dining hall built.	Unknown, although they found some copper and gold. The 36 men left after one season and did not return.	Wright 1980a: Chap. 4 (Wright's information was compiled from the NWMP report for each year).
	Summer 1898	Kha-Sha Creek (not on current maps)	"Mysterious 36" (Adair)	Two tunnels excavated; a number of claims staked.		
	Late summer 1898	Alder, Shorty, Kha-sha Creeks and Union Gulch	Various	80 claims staked.	-	"
	September 1898	Roberts and Victoria creeks. (Roberts not on currant maps).		Some gold discovered late in season. As timber was scarce, no sluice boxes were made.	Very little done, as it was late in the season.	"
	1899	Shorty Creek District	"Iowa Boys"	Worked one claim.	Recovered $500. per person.	"
	1901	Alder Creek, Shorty Creek	Five or six prospects.	Worked all summer and stayed during winter.	-	"
	1945-47	Shorty Creek	Parker & Ray Ltd.		736 ounces of gold in 1945; 1,125 ounces in 1946; 1,015 in 1947.	Kindle 1953:49.
	1949-50	Shorty Creek	A. Vass, Whitehorse			Kindle 1953:49.

* This chart tabulates mining activity references which have been compiled from the available literature. It does not necessarily represent all mining activity which may have occur-red in the Park.

** There are a few additional mining localities mentioned in the text which are of regional importance. They are not included in this table because they are not in the Park.

• **Mining** and related activity **in Kluane** National **Park** [illegible]

AREA	DATE	LOCATION**	PROSPECTS OR GROUP	ACTIVITY	RESULTS	REFERENCE
lims river drainage	'all 1903	Bullion Creek	rank Altemose, red Atcr, Morley ones and J.W. Smith.	Rich concentration of placer gold diecovered.	ecovered 43 ounces f gold in nine days.	right 1980a; Chap. 5
	ate fall 1903	Bullion Creek, Sheep Creek, Vulcan, Metalline, Multimetal, Canada and other St. Elias stream.	tampeders.	Creeks staked from top to bottom.	,000 claims recorded n Kluane area.	"
	1905	Bullion Creek	ullion Hydraulic Co.	Hydraulic equipment installed.	-	"
	pril 1906	Bullion Creek	"		-	"
	pril 1906	Bullion Creek	"		eported yield of 4,500. Cairns later • timate of $1,000. isagreed with this.	"
	1908	Bullion Creek	-	Two claims worked, with two men on each.	"	"
	1914	Bullion Creek	ewer than 10 men orking.	Little activity.	-	'right 1980a: Chap. 5 from GSC memoir 284)
	ctober 1903	Sheep Creek	ones and Ater.	Staked discovery claim.	-	'right 1980a; Chap. 5
	1904	Sheep Creek	-	A few claims worked.	nly me claim eported pay values	"
	1906	Sheep Creek, 71 above		Sluiced.	ood results reported.	"
	1908	Sheep Creek, seventies above...	isher Brothers	Small hydraulic plant installed.	leaned up about 5,000.	"
	1908	Sheep Creek, forties above..	"	Worked with pick and shovel.	1,000.	"

• Mining and related activities [illegible] Kluane National Park (Concluded).

AREA	DATE	LOCATION**	PROSPECTS OR GROUP	ACTIVITY	RESULTS	REFERENCE
Slims River drainage (continued).	1908	Sheep Creek, sixties above.	Mr. Amstrong & partners.	Installed plant similar to Fisher Brothers'.	Didn't get any sluicing done.	Wright 1980a: Chap. 5
Mush Creek	1901	-	Charles Trowl & partner.	Discovered gold. Started a minor stampede to area.	-	Wright 1980a: Chap. 4
Congdon Creek	1904	-	-	Gold discovered.	-	Wright 1980a: Chap. 5
	1905	-	Bullion Hydraulic Co.	Sawmill arrived.	-	"
Silver Creek	1904	-	-	"Silver City" mining community.		Wright 1980a: Chap. 5
Donjek River	1905		Bones and Ater.	Staked land.		
Kathleen - Sockeye Lakes	1958-59	Between the lakes, near mile 142.5 on Haines Road.	Harry Johannes, H. Boyd and Herman Honing.	Worked a copper-[illegible] deposit associated with bornite.	[illegible] tons of copper ore.	Wright 1980a: Chap. 8
	1959	"	Johoba Mines Ltd.	Ore shipped to Japan through Haines.	-	"
	1961	"	Dominion Explorers Ltd.	Preliminary underground development.	-	"
	1969	"	Kathex Mines Ltd.	-	-	"
	1972	"	-	Propery extinguished by the Crown.	-	"