University of Alberta

Caribou Hunting at Ice Patches: Seasonal Mobility and Long-term Land-Use in the Southwest Yukon

By

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In memory of Tagish

ABSTRACT

Recently documented ice patch sites in the southwest Yukon are ideal for evaluating precontact hunter-gatherer land-use patterns in the western subarctic. Located in the alpine of the mountainous regions of the boreal forest, ice patches are associated with well preserved hunting equipment, caribou (*Rangifer tarandus*) dung and an abundance of faunal remains dating to over 8000 years ago. However, current models are inadequate for explaining caribou hunting at ice patches as they tend to emphasize large-scale communal hunts associated with latitudinal movements of caribou. Much less is known about the alititudinal movment of caribou and the associated hunting forays to ice patches in the alpine.

Based on literature from caribou biology an altitudinal hunting model is proposed. During summer months caribou are predictable in their use of ice patches for relief from insect harassment. Pollen dated from caribou dung frozen in organic layers from the Granger (JdUt-1) and Friday Creek (JcUu-1) ice patches was analysed and compared to pollen assemblages from modern caribou dung to test whether ancient caribou were using these locations during summer months. The multivariate statistical technique, Nonmetric Mutlidimensional Scaling shows that ancient pollen assemblages are unlike any modern dung. Results indicate that pollen derived from dung is complex and various temporal transformations and taphonomic factors such as: (i) the use of modern analogue samples; (ii) changes in phenology; (iii) mode of pollination and; (iv) caribou feeding strategies must be understood before making interpretations on seasonality from dung pollen. I propose that a qualitative model of seasonal

pollen signatures also be used to evaluate ancient pollen spectra, especially when there is no modern analogue. Regardless of these factors, the identification of a diversity of forbs and the presence of insect-pollinated taxa such as *Polemonium* and *Epilobium* suggest that some of the dung was deposited by caribou in the summer.

Ancient hunters, knowing that caribou aggregate in mixed herds on ice patches in summer months, took advantage of this behaviour. Hunting equipment found on ice patches indicates that atlatls (8360± 60 to 1250± 40 yrs BP) and bow and arrows (1300 ± 70 to 90 ± 40 yrs BP) and hunting blinds were part of the ice hunting strategy. Faunal analysis suggests caribou was the primary game animal hunted at ice patches, although sheep (Ovis *dalli*) may have been important at some locations. Developing an altitudinal migration model provides a fuller picture of caribou hunting at alpine locations in the southwest Yukon and assists in understanding Holocene precontact hunting and land-use patterns in the western subarctic.

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1.0 INTRODUCTION

1.1 Background

In mountain environments, which are highly seasonal and patchy, hunter-gatherers are required to choose from a range of strategies to deal with environmental variability. The objective of this research is to elucidate strategies of caribou hunting as they relate to precontact hunter-gatherer land-use and mobility patterns in the southwest Yukon. Literature on caribou biology is used to develop a seasonality model of caribou hunting at ice patches. Independently collected palynological data sets from caribou dung from the modern Ibex herd and from two ice patches associated with archaeological materials, are used to test the proposed seasonal hunting model.

During the warm summer of 1997, extensive deposits of prehistoric caribou (*Rangifer tarandus*) dung and a small fragment of a 4000 year old hunting dart were collected from a melting ice patch in southern Yukon Territory (Kuzyk et al. 1999). Since then, dozens of Yukon ice patches containing organic remains dating back more than 8000 years have been identified (Bowyer et al. 1999; Farnell et al. 2004: Hare et al. 2004; Helwig et al. 2008). The presence of ice patches and associated archaeological materials is likely part of a phenonmena in North America that extends into Alaska's Wrangell Mountains, the Northwest Territories, and the Colorado Rocky Mountains (Andrews 2009, 2010; Benedict et al. 2008; Dixon et al. 2005, 2010; Galloway 2009; Lee et al. 2006, 2010; VanderHoek 2010; also see Callanan and Farbregd 2010; Farbregd 2009 for Norway). An exceptional collection of perishable hunting artifacts, mummified small mammals and birds, large mammal bones, antler and horn, feces of herbivores, and an abundance of paleoenvironmental proxy evidence have been recovered (Farnell et al. 2004). The ice patch record of extraordinary, well-preserved perishable materials provides a unique window on the biology, climate, and hunting activity in the southern Yukon over much of the Holocene. In recognition of the significance of the ice patch sites the Ice Patch Research Project was formed. The research outlined herein is part of the Ice Patch Research project whose objective it is to advance discoveries and research on ice patch sites and the materials they contain (Bowyer et al. 1999; Kuzyk et al. 1999; Farnell et al. 2004; Hare et al. 2004).

The abundance of caribou dung associated with ice patches was unexpected, as only two small herds of woodland caribou occupy the study area at present and in some parts of the study area caribou are no longer found (Farnell et al. 2004; Hare et al. 2004). The ice patches with caribou dung discussed in this study are located (Figure 1) within the traditional territories of Carcross-Tagish, Champagne and Aishihik First Nations, and Kwanlin-Dun First Nations traditional territory (Yukon Ice Patch First Nations 2010). These First Nations are of Tagish, Tlingit, and southern Tuchone cultural backgrounds of the Northern Athapaskan linguistic grouping. Until very recently, the First Nations people of the area relied heavily on caribou and actively hunted them in the mountains where the ice patches are located (Hare et al. 2004). A large body of First Nation's published oral history and traditional stories indicates that caribou were once far more abundant in the area (Cruikshank et al. 1990). Evidence suggests that bison and moose were also present at various times throughout the Holocene (Legros 2007; McClellan 1975; Stephenson et al. 2001; Workman 1978), yet very little is known about the history of any of these animals. Currently, discrepancies exist between the archaeological and ethnographic records in regards to the history and importance of ungulates in the subsistence economies of precontact hunter-gatherers of the southern Yukon (Workman 1978; Cruikshank 1997; Stuart et al. 1989).

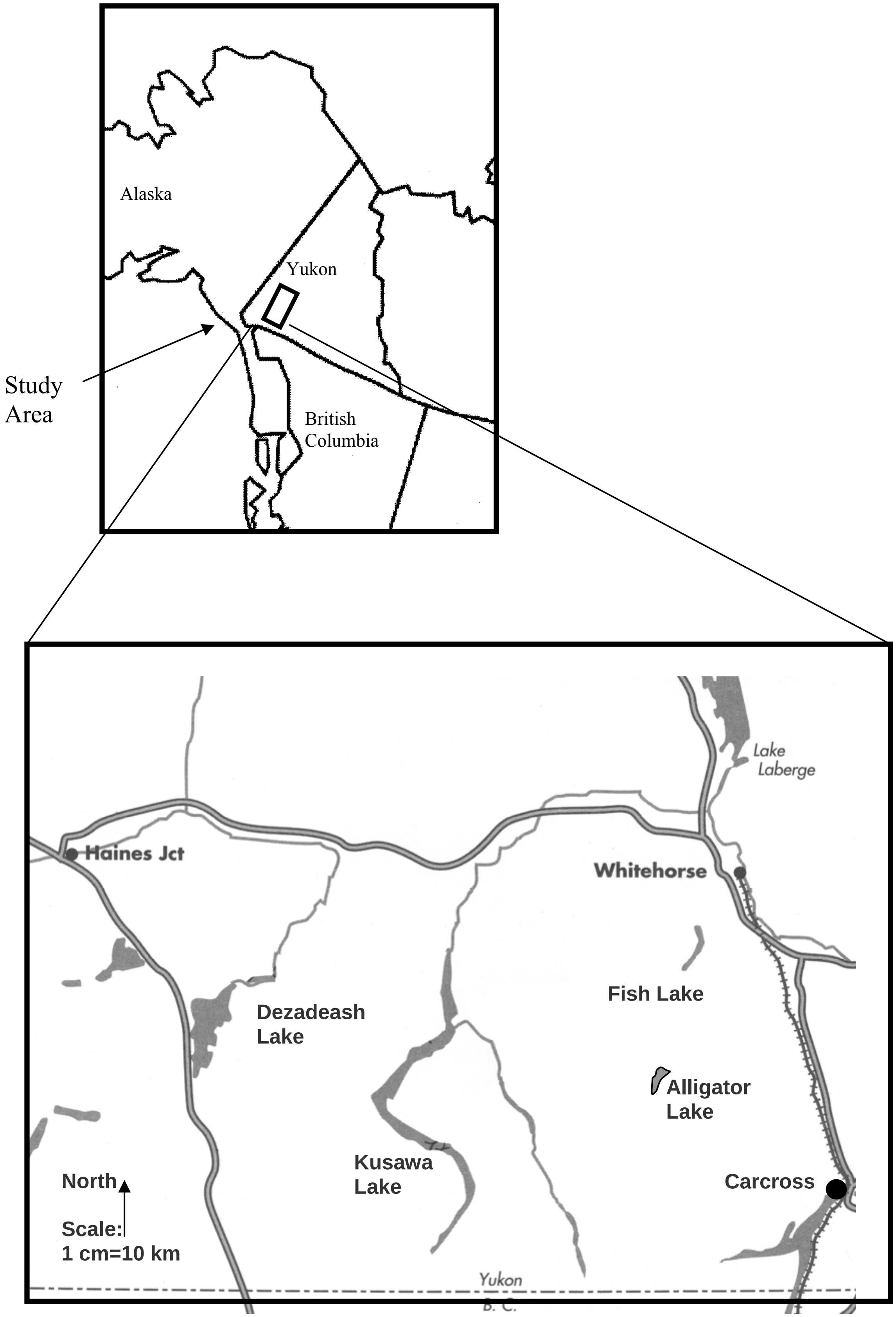


Figure 1. Map of study area.

1.2 Objectives

This research examines the relationship between the nature of the southern Yukon past environment and the ways in which hunters and gatherers positioned and organized themselves in order to make a living. Although very little is known about the regions's ungulate resources throughout the Holocene, they are generally assumed to be widely scattered and even scarce. Given that the environment sets parameters around hunter-gatherer land-use patterns, my objective is to establish how long-term variability in structure and availability of ungulates in the southern Yukon shaped hunter-gatherer land-use. Organizational features, such as scheduling and group formation, involve a network of relationships between people and groups of people within which subsistence activities are carried out (Bamforth 1988:5; Lovis et al. 2005). The basic problem that is addressed here is how the availability of needed resources in time and space affects the ways in which human beings can successfully utilize those resources. To achieve this goal, this research has the following objectives:

1) develop a model of altitudinal caribou migration based on biological literature and use this to develop a model of caribou hunting;
2) test the model of caribou hunting based on independently collected pollen data sets derived from dung of the modern Ibex caribou herd and ancient dung from two southwestern Yukon ice patch sites;
3) discuss the implications this research has for understanding ancient hunter-gatherer land-use patterns in the southwest Yukon.

1.3 Theoretical Approach

Hunter-gatherers gain their livelihood fully or predominantly by some combination of gathering, collecting, hunting, fishing or scavenging the resources available in the plant and animal communities around them (Sheehan 2004; Broughton and Bayham 2003; Byers and Broughton 2004; Hockett 2005; Lovis et al. 2005; Winterhalder 2001:12). In this way, an ecological approach provides a context for understanding ancient hunter-gatherer land-use patterns and provides a useful conceptual framework for examining archaeological questions. However, it is recognized that many factors influence hunter-gatherer decision-making (Byers and Broughton 2004; Byers and Hill 2009; Butzer 1990; Kim 2006; Lovis et al. 2005; Oliver 2007; Sheehan 2004).

The ecological approach does not simply require a description of the environment together with human behaviour. Rather, an ecological approach to cultural behaviour requires that any part of human behaviour be examined within its natural context, keeping in mind that this context may vary in space and time (Hildebrandt and McGuire 2005; Jochim 1981, 1989; Lovis et al. 2005). Implicit in understanding an ecosystem is an appreciation for the dynamic nature of the relations between cultural, biological, and physical processes (Moran 2006, 2008). The emphasis on the importance of human adjustments to the natural environment does not assume that the environment operates in isolation from cultural aspects such as ideology and social organization, or that other factors do not influence or help structure a people’s way of life (Bamforth 1988; Broughton and Bayham 2003; Hildebrandt and McGuire 2002, 2003, 2005; Kim 2006;

Trigger 1989). The present emphasis simply indicates that people everywhere must adjust to a variety of influences, including the natural environment (Bamforth 1988; Lovis et al. 2005).

When dealing with hunter-gatherers it is important to recognize the mechanisms used for dealing with fluctuations in both resources and the physical environment (Kim 2006; Morgan 2009). For many hunting and gathering societies, the structure of the environment required a range of cultural strategies, such as mobility, subsistence diversification, information gathering and the maintenance of social alliances (Kim 2006; Mandryk 1993; Morgan 2009; Wiessner 1982). Recent notions around hunter-gatherer land-use and mobility patterns recognize that hunter-gatherer behaviours are not simply responses or determined by the natural environment. Rather land-use patterns are selected from a variety of feasible options that are embedded within broader ideological perceptions and social organization (Ives 1990, 1998; Kim 2006; Trigger 1989). This thesis is ultimately grounded in Steward's cultural ecology, where the environment and culture are not separate spheres but are instead involved in an interplay of feedbacks (Burch 2007; Moran 2006, 2008, Steward 1955; Hardesty 1977; Kaplan and Manners 1972). There is a reciprocal influence of social, political, ideological, and economic aspects to culture although the extent and influence of these interacting factors may vary widely from one society to the next (Trigger 1989). From this perspective the environment is a cultural landscape historically produced through human-nature interactions.

2.0 STUDY REGION

2.1 Northern Athapaskans

The First Nations people of the southwest Yukon are part of the northern Athapaskans, a linguistic group of societies inhabiting much of the interior of northwestern North America (Figure 2; also see Osgood 1936). In general, the northern Athapaskans live primarily in subarctic or alpine forests and their way of life has encompassed a variety of subsistence strategies including communal hunting of caribou, bison hunting, boreal forest foraging and salmon fishing (Ives 1990). The northern Athapaskans have been subdivided in several ways. Osgood (1936:20-21; Ives 1990:13), for instance, made a distinction between Arctic and Pacific Drainage Athapaskans. The presence of salmon, greater micro-environmental diversity and greater sedentism west of the continental divide are roughly correlated with various forms of social complexity (Graburn and Strong 1973). East of the continental divide many authors have remarked upon the relatively simple social systems and the homogeneous resource base (see Ives 1990).

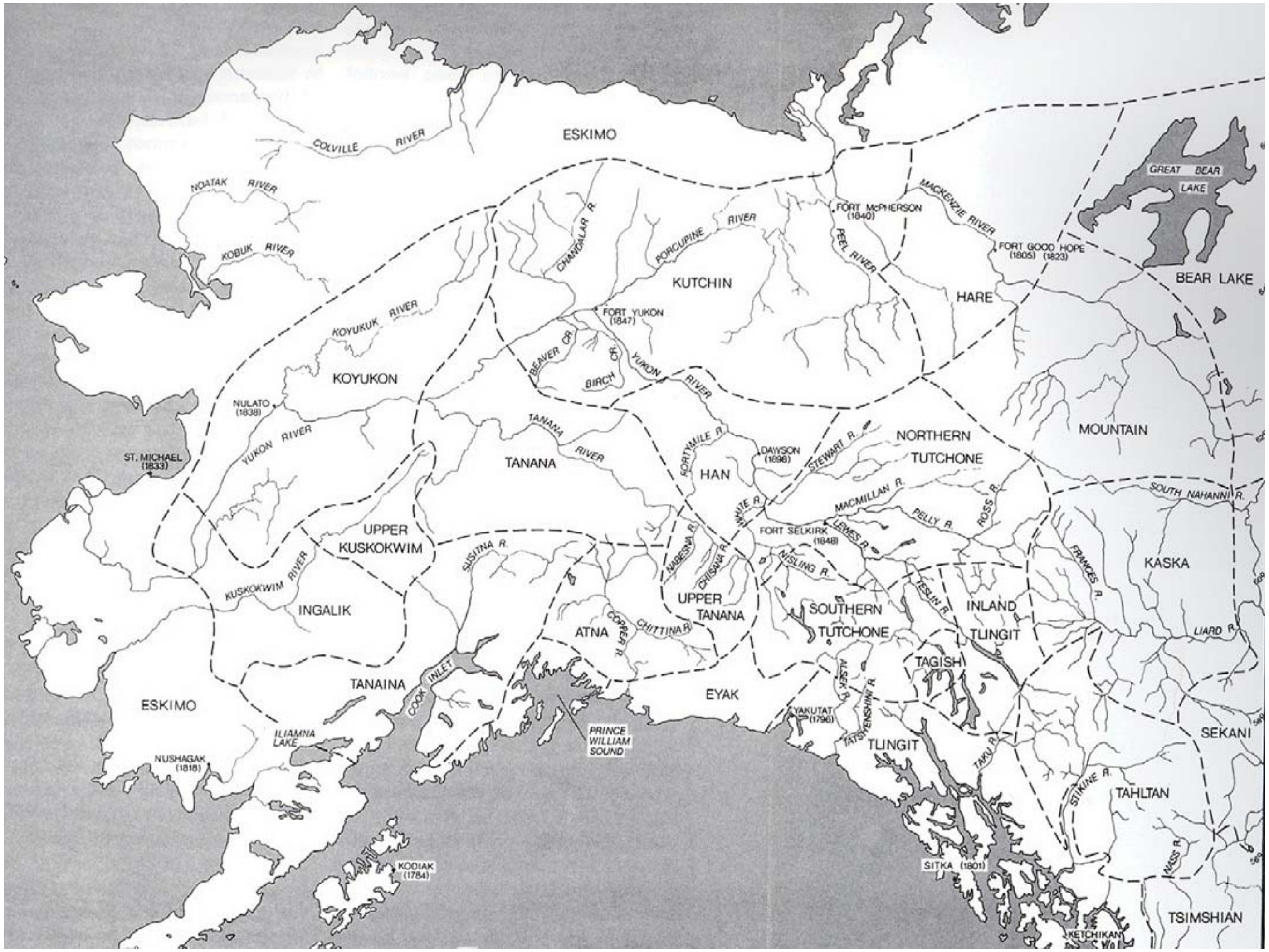


Figure 2. Linguistic Groupings of Northern Athapaskans. From McClellan 1975.

In more recent years, many specialists have questioned the emphasis on the role of salmon and a corresponding lack of attention to the importance of various land animals, particularly caribou, moose, and sheep, and freshwater fish in the lives of the Cordilleran people (McClellan and Denniston 1981a, 1981b, 1981c, 1081d; VanStone 1974). As a result, various attempts have been made to establish a more detailed regional classification of Northern Athapaskans - one that stresses the significance of the mountainous habitat of the region (McClellan and Denniston 1981a:373; VanStone 1974). The use of physiographic units gives maximum recognition to the most significant ecological factors that have influenced the lives of the Athapaskan First Nations. This approach emphasizes the great ecological contrasts within northwestern North America and the flexibility of Athapaskan culture in general (VanStone 1974).

The northern Athapaskans of interest in this dissertation are those that inhabit the physiographic unit of the Cordillera (following McClellan and Denniston 1981a; Van Stone 1974). This physiographic unit is named after the great mountain chain that runs in a generally south to north direction through western British Columbia and the Yukon Territory and into Alaska. The native groups of the subarctic Cordillera are distinguished as Sekani, Kaska, Tsetaut, Tahltan, Tagish, Inland Tlingit, Tutchone Han, and Kutchin. Other groups, who had similar habitats and cultures, include the Mountain Indians, upper Tanana River, and Upper Koyukon River First Nations, and are included in this study (following McClellan and Denniston 1981a:372; VanStone 1974:11). Of the Cordillera groups, the Chilcotin and Carrier are at the extreme southern location of this environmental area (following Helm 1981). In addition, it is recognized that the Sekani may be recent to the area (McClellan and Denniston 1981a).

This grouping of subarctic Cordillerans does not coincide exactly with the distinction made by Osgood (1936) between northern Athapaskan speakers of the Pacific and Arctic drainages. Osgood's dividing line ignored the reality of the Cordilleran physiography and the ecological niches it contains (McClellan and Denniston 1981a). What justifies the use of the subarctic Cordilleran grouping in this study is the unity of the physiographic bloc in which the people have lived and their distinctive subsistence patterns that combined big and small game hunting with fishing and gathering with an emphasis on high mobility and flexibility (following McClellan and Denniston (1981a:373).

2.2 The Cordillera of the western Subarctic

The Canadian Cordillera is a system of valleys and mountain ranges that run generally in a south-north direction from the United States border to the Beaufort Sea (Bostock 1965; Gardner 1981; Wahl et al. 1987). Within the southern Yukon, the MacKenzie and Selwyn mountains mark the eastern edge of the Cordillera and are northern extensions of the Rocky Mountain (Figure 3). With the Ogilvie Mountains to the west, the mountains form a drainage divide between the Yukon and MacKenzie watersheds and present a rugged topographic and climatic barrier (Gardner 1981). The Cordilleran region extends to the north to the Richardson Mountains and to the west through the Brooks Range in Alaska. This complex topography of rugged mountains, plateaux, lowlands, and valleys has been extensively modified by glaciation, erosion, and weathering (McKenna and Smith 2004).

The study area falls within the Coast Mountains, which consist of mountainous topography and several ice-covered peaks above 2400 m a.s.l. (Oswald and Senyk 1977). Altitudinal differences in the Cordilleran region result in its environment not being uniformly subarctic (Gardner 1981). There are variations in aspect, slope and altitude that lead to closed forest, transitional forest, alpine tundra, and bare rock, replicating latitudinal variations between subarctic and arctic environments.

Figure 3. Map showing Cordillera Physiographic Region of North America. Adapted from Hall 1967. Map available online http://atlas.nrcan.gc.ca/site

2.3 Glacial History

The Yukon has a complex glacial history because ice advanced northeastward and westward from the Cordilleran ice sheet and westward in southern Yukon from the continental ice sheets (Clague 1992; Duk-Rodkin 2004; Jackson et al. 1991). During interglacial periods montane glaciers remained at high altitudes (Duk-Rodkin 2004). The study region is dominated by till, glaciofluvial gravels, and glaciolacustrine clay and silt deposited during the

McConnell Glaciation. McConnell age ice is thought to have covered the lowlands sometime after 28,000 years ago, and was likely gone before 15,000 years ago (Duk-Rodkin 2004). Subsequent to the maximum extent of the McConnell ice, deglaciation disrupted drainage systems and produced large glacial lakes as a result of a complex assemblage of ice lobes, which were restricted to valley bottoms and controlled by local topography (Duk-Rodkin 2004). Blockage of drainage, possibly supplemented by isostatic depression, created extensive lakes in the area during deglaciation so that the lowlands are underlain by extensive glaciolacustrine sediments.

2.4 Permafrost

Permafrost is defined as the thermal condition of earth materials, such as soil and rock, that occurs when temperatures remains below 0º C continuously for at least two years (Burn 2004; Wahl et al. 1987:8). Permafrost terrain is a seasonally thawed active layer, underlain by perennially frozen ground. The active layer thaws in the summer and freezes in the winter (Burn 2004). Generally, the active layer is less than one meter in depth but climate, terrain, and ground cover are important factors in determining the thickness of this layer (Wahl et al. 1987).

The study region lies within the sporadic discontinuous permafrost zone (Burn 2004; Wahl et al. 1987). Here, the specific location of frozen ground depends on the thickness of the surface organic horizon (e.g. peats) and the moisture content of the active layer (Burn 2004; Henry 2002; Krebs et al. 2001;

Larsen 1980). North-facing slopes are also more likely to have permafrost (Krebs et al. 2001). Changes in ground surface conditions, such as forest fire, can alter the ground thermal regime and can cause permafrost degradation (Burn 2004:33). Infrequent permafrost, only about two to three metres thick, is encountered in the Whitehorse region.

2.5 Climate

The regional climate of the southwest Yukon is modified and complicated by macrorelief and major topographic features (Oswald and Senyk 1977). Orographic barriers (as mentioned above) oriented in a southeast to northwest direction through the Yukon strongly affect precipitation and temperature patterns. Seasonal temperature variations in the southern Yukon are the most extreme in Canada. Daily temperature variations of 30º C are not uncommon, although summers are relatively cool. As both the Arctic and North Pacific Oceans are subject to frequent storms, the southwest Yukon is also subject to more wind and cloud cover than the rest of the Yukon.

The Pacific Ocean (Gulf of Alaska) has a great effect on the southern Yukon's climate and is the main source of moisture for the area. In a typical storm system, southerly winds force air masses to rise over the massive Saint-Elias Coast Mountains, which reach as high as 3000 to 4000 m a.s.l. (Wahl et al. 1987). Most of the moisture is precipitated out on the southern and western slopes of the mountains. The air then descends and dries resulting in a rainshadow effect on the eastern and northern slopes. Generally, precipitation increases with elevation reaching a maximum near 2000 m a.s.l.

The study region falls within the Upper Yukon-Stikine Basin climatic zone (Wahl et al. 1987:36). This climatic zone is a relatively high elevation plateau lying between the St. Elias Coast Mountains to the west and the Cassiar-Pelly Mountains to the east. Deep river valleys generally about 200 to 1200 m a.s.l. indent the region. The most significant climatological feature of the region is low precipitation, a result of the rain shadow effect of the St. Elias – Coast Mountains barrier. Most of the region receives less than 300 mm of precipitation annually. The most arid areas are in the vicinity of Carcross and Kluane Lake, which receive only slightly more than 200 mm.

The Upper Yukon-Stikine Basin climatic zone has the third highest average wind speed for the Yukon with Whitehorse being the most consistently windy location. Strong winds ranging from 30 to 50 km/hr are not uncommon. Strong wind gusts are known to occur in the Aishihik and Burwash areas and occasionally reach destructive force with gusts over 100 km/hr primarily from a southerly direction (Smith et al. 2004). Valleys with northwest-southeast orientation are the windiest, as exemplified by Whitehorse (Wahl et al. 1987:36).

The temperature regime is continental showing a great deal of variability on a daily and seasonal basis (Table 1). Proximity to the Pacific Ocean, however, often results in more frequent mid-winter mild spells than occur elsewhere in the Yukon. Whitehorse and Teslin weather stations, representative of the Upper-

Yukon Stikine Basin climatic zone reported, in degrees Celsius, the temperatures presented in Table 1 (Wahl et al. 1987:40).

Weather Station	**Mean Daily** **(Year)**	**Extreme (Daily) Maximum**	**Extreme (Daily) Minimum**
Whitehorse	-1.3	34.6	-52.2
Teslin	-1.8	33.3	-52.8

Table 1. Summary of climatic information in degrees celsius for the study region. From Wahl et al. 1987.

Mean January temperatures range from -21º to -25º C but mean temperatures are up to five degrees warmer over higher terrain, due to climate inversion. Short periods with temperatures above zero can be expected during the winter months (Wahl 2004). July mean daily temperatures range from 12º to 14º C and are a few degrees cooler over higher terrain (Wahl 2004). In the immediate vicinity of larger lakes, spring can be delayed due to the persistence of ice cover. Conversely, the onset of cold winter temperatures can be delayed up to a month due to the extensive low cloud associated with the lakes as they freeze over.

2.6 Effects of Topography on Climate

The topography and elevation of the Cordillera has a strong influence on the climate in the southern Yukon (Figure 4) overshadowing changes due to most other controls (Wahl et al. 1987). In general, temperature decreases with elevation, except when inversion conditions are present (see discussion below). Otherwise, most climatic elements, such as the amount and frequency of precipitation (including snow), wind speed, frequency of summer frost, and the frequency of cloud cover increase with elevation (Wahl et al. 1987:25).

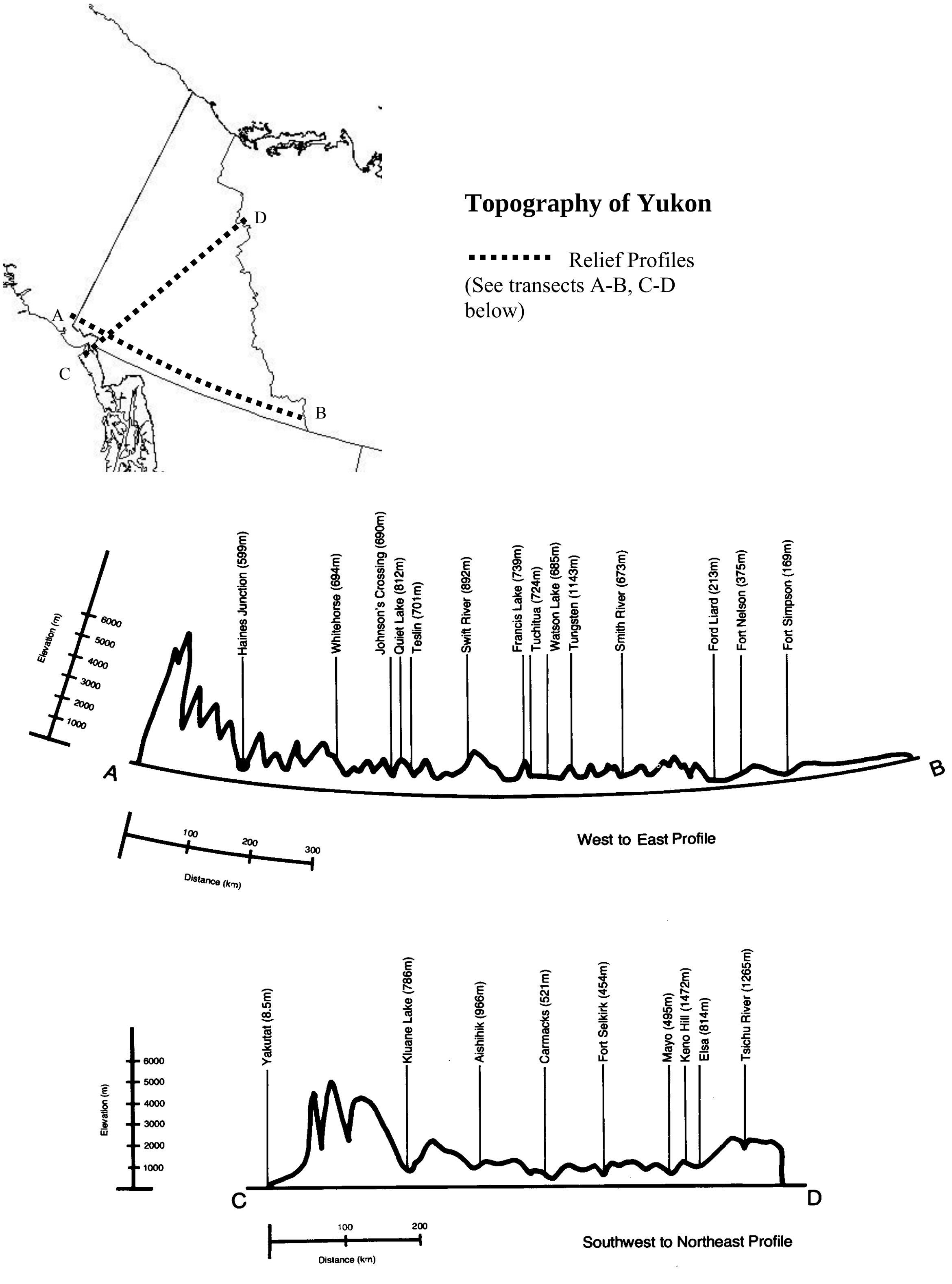


Figure 4. Topography of Yukon Territory, adapted from Wahl et al., 1987.

2.7 The Inversion

The inversion is a reversal of the normal vertical temperature profile. Normally, air temperatures decrease with an increase in elevation. During the winter months, cold air develops over all surfaces and on mountain slopes. This cold air is relatively heavy and slides into the valley bottoms, which results in a reversal, known as an inversion in air temperature. The Arctic inversion can be in effect from late October to March and is at its most extreme in January (Wahl 2004). Most of these inversions are topped by a constant temperature layer but can develop or intensify in deep Yukon valleys under prolonged periods of calm wind and clear skies in winter. Instead of temperatures being cooler with increased elevation, in some cases, temperatures rise with increased elevation (Wahl et al. 1987; Wahl 2004). As a result, the highlands and plateaux of the southern Yukon can experience mild spells more frequently and for longer periods than deep valley locations (Wahl et al. 1987:87). For example, temperatures in the valley floors may range from -20º to -30º C, but will increase at a rate of 3º to 5º C per 1,000 m. to temperatures near -10º to -15º at the 1,500 m level (Wahl 2004). A number of animals take advantage of this climate feature. For instance, mountain sheep and goat reside at elevations of 1000 to 1500 m where winter temperatures are the least harsh (Wahl et al. 1987). Moose are known to migrate to higher elevations during severe cold spells and caribou in Yukon winter in the highlands (Wahl et al. 1987:87).

2.8 Snow Cover

Snowfalls may occur at all elevations by late August. By mid- to late September the snow line has lowered to the 1000 to 1200 m level, but total snow cover on the lower valleys of southern Yukon does not usually occur until the last week in October (Wahl et al. 1987). Generally, snow depths reach their maximum by early to mid-March but closer to early to mid-April at elevations above 1000 m in southern Yukon. Depths of snow in the valley floor in the southwest Yukon range from 30 to 50 cm. By early May the snow melts in the lowlands and it recedes to the 1000 m level by mid-month. Snow only remains permanently above the 1500 m level (Wahl et al. 1987:34).

Snow is considered to be one of the most significant elements influencing the survival of land-based animal species. Although snow has many insulating qualities, changes in snow characteristics are very important. Snow depth, hardness, as well as temperature and wind are important climatic parameters impacting wildlife (Wahl et al. 1987:194). Massive ungulate die-offs in mountainous regions during severe winters have been reported (Stelfox and Taber 1969 in Wahl et al. 1987). Ungulate mobility is impaired when snow depths are too high for the animal (Telfer and Kelsall 1984). In addition, wind, rain, and freeze-thaw cycles can cause a hard crust on the upper portion of the snowpack, which can impede ungulate movement. Some suggest that grazing animals prefer no snow cover and that caribou will not feed in snow depths greater than 50-80 cm (Kelsall 1968).

2.9 Vegetation

Closed canopy forest covers most of the plateaux and valleys in the southern Yukon depending on site conditions (McKenna et al. 2004). The major trees in the Yukon include white spruce (*Picea glauca*), black spruce (*P. mariana*), larch (*Larix laricina*), subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*) and paper birch (*Betula papyrifera*). In the more arid southwest Yukon stands of these species are more open and discontinuous. In some cases taxa such such as *B. papyrifera*, *L. laricina* and *P. mariana* are rare or even absent in the southwest Yukon (Lacourse and Gajewski 2000). Grasslands are restricted to steep, dry, south-facing slopes along the Yukon and Pelly rivers.

Sub-alpine fir is the primary alpine timberline species throughout south Yukon ecoregions (McKenna et al. 2004). Alpine tundra is formed by several communities, ranging from sedge meadows to pioneer colonization of lichens on fell fields. The mesic alpine vegetation is characterized by a combination of prostrate shrubs, grass, sedge, forbs, lichens, and mosses. The soils are well-drained and tend to dry out during summer if the snow free period is sufficiently long.

2.10 Fauna

Moose (*Alces alces*), caribou (*Rangifer tarandus*), and black bear (*Ursus americanus*) are common within the forests and on the uplands of the southwest Yukon (McClellan and Denniston 1981a:375). In the last century about 200 wapiti (*Cervus elaphus*) and 400-500 wood bison (*Bison bison athabascae*) were introduced into the Aishihik area, an area they formerly occupied (Farnell et al. 2004; Stephenson et al. 2001). Grizzly bears (*U. horribilis*) live largely above treeline. The mountains also support Dall sheep (*Ovis dalli*), marmots (*Marmota caligata*), pika (*Ochotona collaris*), and mountain goats (*Oreamnos americanus*). Important furbearers include lynx (*Felis canadensis*), wolf (*Canis lupus*), coyote (*C. latrans*), fox (*Vulpes vulpes*), marten (*Martes americana*), muskrat (*Ondatra zibethicus*), and beaver (*Castor canadensis*). Small game animals include snowshoe hare (*Lepus americanus*), porcupine (*Erithizon dorsatum*), and ground squirrel (*Citellus parryi*) (Smith et al. 2004). Economically important bird species include grouse (Family Tertraonidae) and ptarmigan (*Lagopus spp*.).

Several species of salmon (*Oncorhyncus spp.*) spawn in the river systems that drain into the Pacific Ocean (McClellan and Denniston 1981a; Smith et al. 2004). While salmon ascend the Yukon drainage system, they become progressively poorer in condition as they reach the extreme headwaters where the Inland Tlingit, Tagish and many Tutchone live (McClellan and Denniston 1981a). Various types of freshwater fish are available at various times of the year in the numerous lakes and rivers of the southern Yukon. Whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*), and arctic grayling (*Thymallus arcticus*) are common in the Yukon River system. Other species found in the area include inconnu (*Stenodus leucichthys*), burbot (*Lota lota*), broad whitefish (*Coregonus nasus*), and least cisco (*C. sardinella*).

2.11 Boreal Forest Ecology

Northern Athapaskans of the southern Yukon live within a northern coniferous or boreal forest, which is largely coincident with the subarctic climatic region (Ives 1990). Periodicity, in daily, seasonal, and cyclical forms, dominates all aspects of boreal ecology (Pruitt and Baskin 1978). Most dramatic is the changing of the seasons, which effects snowcover, freezing and thawing of lakes and rivers, and population cycles (Henry 2002; Ives 1990; McClellan and Denniston 1981a; Waisberg 1975 in Helm 1981). The intricate relationships between animal fluctuations and forest fires, snow depths, and climatic factors are just starting to be understood in the boreal forest (Henry 2002). It is generally thought, however, that there is a complex set of variables, which results in oscillations seasonally and over years among populations of large and small game (Waisberg 1975 in Helm 1981). For instance, about every ten years, the number of snowshoe hare reach peaks up to 300 times those at cyclic lows (Henry 2002; O'Donoghue and Staniforth 2004). When hare populations crash, the populations of several predators, such as lynx, coyote, red fox, and great horned owl (*Bubo virginianus*) are known to decline as well (Henry 2002:89). The practical consequences of these oscillations have long been a reality to those who depended on these various fauna for their food supply (McClellan and Denniston 1981a).

The boreal forest ecosystem of the southern Yukon actually consists of a mosaic of plant communities. This heterogeneous vegetation is the product of successional processes reflecting edaphic conditions and historical disturbances (such as fire) (Gillespie 1981 in Helm 1981; Henry 2002; Ives 1990).

Compositionally distinct localities or “patches” on the landscape affect animal behaviour as each successional stage of forest development only provides adequate food for certain species. Consequently, large and small game animals are distributed in a way that makes use of different vegetation patches for food and shelter. This patterned distribution of game presents unique subsistence opportunities and impediments for human hunters of the region (Winterhalder 1994).

3.0 STATEMENT OF THE PROBLEM

3.1 Introduction

In the mountainous region of the boreal forest of the southwest Yukon, alpine ice patches containing well preserved caribou dung are associated with ancient hunting equipment dating back to at least the last 8000 years (Farnell et al. 2004; Hare et al. 2004). The long and close relationship between caribou and people of the region is reflected in faunal material found at archaeological sites, in published ethnohistoric and ethnographic records, and in stories told by First Nations today. Literature on caribou biology and reports on the local resident herds of woodland caribou that inhabit the region today indicate that caribou follow an altitudinal migration pattern from lower to higher elevations throughout the year (Kuhn et al. 2010; Kuzyk and Farnell 1997). As part of their summer migration pattern, caribou make altitudinal movements to the alpine during green-up as they follow high quality forage and use ice patches as relief from summer heat and insects (Ion and Kershaw 1989).

3.2 Early Archaeological Models of Subsistence and Land-Use

Until recently, the interpretation of land-use patterns from archaeological sites in the southwest Yukon have been structured around adaptive strategies based on a grasslands/boreal forest dichotomy (Stuart et al. 1989). These assumptions developed out of the early research of Johnson and Raup (1964), who in their pioneering paleoclimatic/archaeological study, hypothesized that much of the southwest Yukon was an open grassland environment for the past

8000 years. This interpretation was based primarily on the presence in the archaeological record of bison and on the unsubstantiated assumption that the postglacial Hypsithermal (approximately 6000 years BP) of central and eastern North America was a continent-wide event (Keenan and Cwynar 1992). As a result, it was assumed that the early Native inhabitants of the southern Yukon adapted a Plains strategy of hunting bison and other grassland species. The exploitation of predominantly boreal forest species, which is the economic pattern of the ethnographic Athapaskan speaking Tutchone, was a relatively recent post-Neoglacial adaptation to the area (Stuart et al. 1989:34).

The grassland/boreal forest dichotomy became embedded in numerous reconstructions of precontact human/land relationships in the southwest Yukon (MacNeish 1964; Morlan and Workman 1980; Workman 1973, 1974, 1977, 1978; but also see Greer and Le Blanc 1983; Stuart et al. 1989). For instance, MacNeish (1964) suggested that following deglaciation, nomadic microbands of hunter-gatherers were exploiting tundra species such as bison and the occasional caribou and elk as early as 8500 years BP. By 7500 years BP an economic adjustment was made to a mixed grassland/woodland environment of the Holocene. The adjustment is reflected in the expansion of the diet breadth of the indigenous population to include bear, moose, birds, wolf, and other small mammals. The presence of large, rich archaeological sites suggests that big-game hunting was supplemented by hunting, trapping and fishing. According to MacNeish human inhabitants of the southwest Yukon may have become fully adapted to boreal forest conditions by approximately 4000 years BP.

Workman (1978), building on MacNeish's model, also used Johnson and Raup's paleoclimatic reconstruction as a basis for interpreting changing human/land relationships in the area. Workman (1978) proposed that around 8000 to 5000 years BP the original inhabitants of the southwest Yukon were hunting a now extinct species of bison on open grasslands covering former Glacial Lake Champagne. Although caribou and elk may have contributed to the diet, the local inhabitants primarily adapted a Plains-like strategy of hunting bison.

According to Workman (1978), the grasslands and hence bison, disappeared with the onset of the Neoglacial and the formation of proglacial lakes at about 3000 to 3500 years BP. Large rich sites were suggestive of seasonal return to favourable locations over a long period of time and big game hunting was likely supplemented by trapping, fishing and bird hunting. Workman argued that the eruption of Mount Bona around 1250 years BP, which resulted in deposition of the White River Ash, had catastrophic effects on the people living in the southwest Yukon (Clague et al. 1995; Ritcher et al. 1995; Robinson 2001; Workman 1979). Workman, agreeing with MacNeish, believed the area was probably abandoned for a number of years.

The pioneering models of subsistence/land-use patterns have relied on the assumption that the early occupants of the southwest Yukon were adapted to a grassland environment and that they adjusted their land-use patterns to accommodate the encroachment of the boreal forest vegetation. The implicit assumption in these early models is that the differences in economic strategies practiced by groups adapted to different biotic zones, such as grasslands and boreal forest, resulted in differences in exploitative strategies, settlement patterns, and material culture inventories. More recently, however, the grasslands/boreal forest dichotomy and its associated economic patterns have been criticized (Stuart et al. 1989; also see Greer and Le Blanc 1983:33). Stuart et al. (1989) have argued that the boreal forest was the dominant vegetative pattern in the Kluane/Aishihik lakes area after 8500 BP and have found no evidence for extensive grasslands in the region, other than those associated with early post-glacial shrub tundra pollen zone (Stuart et al. 1989:34). In addition, it was woodland bison and not plains bison that once roamed the southwest Yukon (Keenan and Cwynar 1992; Stephenson et al. 2001; Stuart et al. 1989). Modern woodland bison live in a varied forest or parkland with xeric uplands and sedge meadows of open grasslands (Keenan and Cwynar 1992).

Biotic units are quite dynamic and there is never a monolithic sameness (Guthrie 1990). Although there is a commonality in character in how we understand “grasslands’, “boreal forests”, or “tundras”, these units are, in fact, composed of mosaics of communities and subcommunities regulated by aspect, slope, drainage, altitude, fire history, herbivory pressure, and a number of other variables (Guthrie 1990:270; Yesner 1989). Plant and animal species combine and mix individualistically across the landscape to meet their specific needs; the result is a complex mix of local and regional variation in species composition (Guthrie 1990).

Rather than labeling environments according to broad categories such as “grasslands” and “boreal forest”, a more productive approach to conceptualizing ancient hunter-gatherer subsistence and land-use patterns, is to evaluate the resource structure of the environment (Kelly 1983). This is a more useful approach for constructing the context of precontact hunter-gatherer land-use without imposing physiognomic units and pre-defined associated economic strategies (i.e. Plains hunter/Boreal Forest forager). By employing this alternative approach various environmental factors, that may have affected land-use, can be investigated.

3.3 History of Ungulates in the Southwest Yukon

Today the southwest Yukon environment supports one of the highest levels of mammal diversity in the western subarctic (Smith et al. 2004). However, the present ungulate associations are very recent to the southern Yukon (also see Legros 2007). For much of the precontact Holocene, the environment of the southwest Yukon has had no modern analogue (Schweger 1997). This is not surprising as paleoecological data indicate that modern mammal communities are in part, the result of individualistic responses of species to climatic fluctuations (Graham 1985). Because species behave individualistically to environmental fluctuations, one can expect to see different diversity patterns throughout the Holocene (Schweger 1997). In fact, it is not certain that the biogeographic changes that came about in response to glacial/climatic cycles in the Yukon are complete.

Unfortunately, very little research has been conducted on the history of large mammals in the study region. The history of elk, goat, sheep, moose, caribou, and, to a lesser extent, bison is poorly understood in the southwest Yukon, although they were likely important resources to precontact inhabitants of the area. Besides the modern fauna that are found in the area today, several lines of evidence suggest a diversity of ungulates were present in the region over the past 10,000 years.

3.4 Elk

Elk are poorly documented in the Yukon. Elk (*Cervus elaphus canadensis*) were in the region during the Holocene and faunal remains have been tentatively identified at the Kusawa Bluff archaeological site (JdVa-5) (Greer 1986; Heffner 1999). Elk remains, perhaps as old as 7500 – 8500 years old, were also found by MacNeish (1964) at the Pelly Farm site (KfVd-2), northeast of the study region. Elk were reintroduced into the southern Yukon in the 1950s but they have not appreciably extended their range or expanded their present numbers of about 200 (Farnell et al. 2004).

3.5 Bison

The presence of bison is relatively well documented for the study region with most evidence coming from archaeological sites (Stephenson et al. 2001). Radiocarbon dates obtained on bison remains from archaeological sites in the southern half of the Yukon suggest that bison have been present for much of the Holocene and up until the European contact period (Heffner 1999:8; Stephenson et al. 2001; Rasic and Matheus 2007). Lotenberg (1996) found that knowledge of bison, bison hunting practices, and the use of bison products still existed among many First Nations elders. In addition, most aboriginal languages in the territory have a word for bison, which suggests their presence in the area until fairly recently. Ethnographic reports from men in Teslin, indicate that the wood bison was last hunted and eaten when their grandparents were small children (McClellan 1975).

Woodland bison (*Bison bison athabascae*) are also a figure in Yukon myth, suggesting some antiquity (Cruikshank 1981). Woodland bison disappeared from the southern Yukon around the 1930s but were re-introduced to the area in the 1980s and 1990s. These woodland bison currently range around the Nisling River watershed north of Haines Junction and have also dispersed into the Aishihik/Selkumun area and the Hutshi Lake drainages (Yukon Bison Management 1998).

3.6 Sheep and Goat

Sheep (*Ovis daali*) remains are documented at several archaeological sites in the southern Yukon (Greer 1981, 1983, 1984, 1986, 1987). Sheep remains are identified from sites along Kusawa Lake (e.g. JdVa 2, JdVa-5, JdVa-10, and JdVa-14) and at several sites in the Southern Lakes district of southern Yukon (Greer 1981, 1984). Sheep are found at Nustsehe (JaUk-23) and dominate Late Prehistoric deposits at the Annie Lake site (JcUr-3) (Greer 1981, 1984). At the Tagish site (JaUn-4), located along the Taku Arm of Tagish Lake, sheep remains are found in the post ash-deposits and Greer (1981) interprets this site as a location where residents were processing this animal. Aside from what is reported for the ice patch research I could not locate any radiocarbon dates on sheep (or goat) material. Regardless, the prevalence of sheep in faunal assemblages from archaeological sites indicates that these animals were important in the lives of precontact inhabitants of the southern Yukon.

Sheep are known as an important resource to the Athapaskans of the Northern Cordilleran (Emmons 1911; McClellan 2001; Nelson 1980). Emmons (1911:71), working with the Tahltan in British Columbia, notes the presence of Dall sheep in the Teslin area. In the southwest Yukon today, sheep are particularly important in the Southern Lakes District around the Watson and Wheaton River Valleys where this area is well known for its sheep hunting (Greer 1981, 1983, 1987:22; McClellan 1975). Given this, more radiocarbon dates and studies devoted specifically to further understanding the Holocene distribution and economic role of sheep (*Ovis sp.*) and potentially goat are required (also see Loerh et al. 2005; Lyman 2009; Esdale 2008; Patterson 2008).

Very little is known about the role of goat (*Oreamnos americanus*) in the precontact history of the southern Yukon. Prior to the radiocarbon date of 2540 +/40 years BP on goat remains at the Sandpiper ice patch, there were no radiocarbon dates for this animal in the southwest Yukon (Farnell et al. 2004). Mountain goats, alpine animals, are found in limited numbers in the Southern Lakes ecoregion today, but are common in the coastal regions, including areas around the Taku River (Emmons 1911; McClellan 2001). A small population of goats was re-established in the White Mountains of the Southern Lakes ecoregion following their extirpation in the 1960s (Smith et al. 2004). According to ethnographic reports, mountain goats are numerous in the alpine of the coastal range to the west of the study region and are also common along parts of the Taku River where the Inland Tlingit once lived (McClellan 1975; also see Shafer et al. 2010). The Tutchone also claim that there are goats found around Kloo Lake (McClellan 1975).

According to the Animal Mother story goat and sheep are high dwelling animals that were able to stay on the swing during the flood (McClellan 1975). Both animals jumped into the rocky bluffs, although goat jumped higher, which explains why this animal is found above sheep country. In the Upper Taku, the mountain goat is a crest animal used for ceremonial purposes, but today none of the Inland Tlingit have mountain goat as a crest (McClellan 1975). Meat and skins are reported as being important in ethnographic reports (McClellan 1975). The prominence of goat in mythology and the desirability of its meat and skins suggest it was an important resource item to precontact inhabitants of the region.

3.7 Moose

Moose have had a sporadic occurrence in the southern Yukon region and have likely recently migrated into the area after being absent for some time (Legros 2007). Moose were extremely rare in the southern Yukon during most of the nineteenth century, however their appearance in the archaeological record and in Tagish myths indicate this was a temporary fluctuation (Cruikshank 1981:82). In MacNeish's (1964) archaeological survey moose were only found in sites younger than 6000 years ago. Local tradition by First Nations in the southwest Yukon suggests that there were no moose in the southern Yukon prior to the end of the 1900s. Residents of the Kathleen and Kluane Lake areas are reported as seeing their first moose around 1910 (Cameron 1952:183 in Workman 1978:17). In addition, during the 1940s and 1950s biologists reported that according to local residents there were no moose in the southern Yukon before the last century (Cruikshank 1981).

As summarized by Cruikshank (1981), early European reports also confirm the disappearance and appearance of moose as indicated by Warburton Pike writing in 1896 (p. 89-90):

> Twenty-five years ago there were very few moose along the Liard and the animal was unknown to Indians westward of Dease Lake….Today…the Upper Liard…is probably the best moose country in the continent of North America.

Similar reports are given for those groups living on the Upper Pelly by Poole Field between 1903 and 1913 (MacNeish 1957). In the southeastern Yukon, older male informants reported that when moose disappeared men forgot how to hunt them. They had to learn how to hunt moose again when the animals returned almost a century later (cited in Cruikshank 1981:82). Cruikshank (1981:82) also reports that in 1911, anthropologist Emmons wrote that the "history of moose in this section can not well be accounted for…for some unexplained reason the animal entirely disappeared early in 1800, to make its appearance again in 1877." Teit (1903:343) reporting on his observations in Tahltan country in 1906 indicates that “twenty-five years ago moose were …very scarce but of late have been increasing in numbers and occupying new localities”.

Radiocarbon dates on archaeological materials place moose in the Yukon from mid to late Holocene. For the study area moose remains have been dated at 5720 +/-50 years BP, and those from Aishihik Lake, at 2900 +/- 130 years BP (Workman 1978). Moose have expanded in western North America since the Little Ice Age (Yesner 1989), coincidentally with apparent decreases in woodland caribou populations as forage composition and habitat areas have changed (Farnell et al. 2004).

3.8 Caribou

According to elders Mrs. Annie Ned of Champagne and Aishihik First Nations and the late Mr. Johnny Johns of Carcross/Tagish First Nation, it was caribou, not moose, that was the major big game animal in the southern Yukon at the turn of the century (Cruikshank 1981, 1990). In addition, archaeological records document the importance of caribou in the subsistence strategies of Holocene hunter-gatherers in the southwest Yukon (Greer 1993, Hare 1995, Wright 1999). Today, the southwest Yukon is occupied by only small herds of woodland caribou (Kuhn et al. 2010; Kuzyk and Farnell 1997). These caribou are available in the area on a year-round basis, although one must go into the high country to hunt them (McClellan 2007; Workman 1978:16). There is evidence that large herds of barren ground caribou once traveled much further south into the southern Yukon than they do today (Kuhn et al. 2010; Legros 2007). Two subspecies of caribou formerly ranged in the southern Yukon – the large herds of Stone caribou (*Rangifer tarandus stonei*) and the Osborn caribou (*Rangifer tarandus osborni*), which travel in smaller groups.

According to wildlife biologists, at the end of the 19th century barren ground caribou (*Rangifer tarandus granti*), which is also known as the Fortymile Herd, crossed the Alaska/Yukon border and ranged as far south as Whitehorse as recently as 1932 (Legros 2007; Urquart and Farnell 1977). These caribou spent the majority of the summer between the Yukon and Tanana Rivers and were known to cross the mountains north of Klukshu in large numbers (Workman 1978). However, towards the end of the last century it was noted that caribou began to move out of some parts of the area. Today, barren ground caribou migrate in two or three major herds, back and forth through the Brooks Range from the north slope of Alaska to the southern Brooks Range and beyond in Alaska and the western Yukon (Gubser 1965:296). Presently, the southern range of these herds extends to the northern edge of the Yukon Flats, and the northern range to the Arctic coast (Gubser 1965).

Native elders tell stories of how caribou were once so numerous they were "black on the ice" and in the "old days even the most southerly Indians could count on some caribou in the summertime" (McClellan 1975). Older Tutchone men remember when huge herds of caribou crossed the mountains above the fish camp at Klukshu (McClellan 1975). According to Mrs. Annie Ned substantial caribou herds were once present at the Takhini River Crossing and were all over the mountains in the area (as cited in Cruikshank 1981, 1990, 1997, 1998). There were so many caribou you could hear their hooves for miles as they clattered across the frozen lakes. On one occasion, large numbers broke through the ice at Kusawa Lake, when their weight was more than the ice could support (as told to Cruikshank 1981, 1990 by Mrs. Ned).

According to late elder Mr. Johnny Johns, caribou were once more abundant in the mountains south of Whitehorse. The name of the present town Carcross is a shortened version of "Caribou Crossing" (Figure 5). This was a place where large numbers of caribou swam across at Nares Lake in groups, although it has been many years since the caribou have crossed there (McClellan 1975). Poole Field, who was a trader on the upper Pelly River, was told by the oldest men that when they were young there were only caribou in the region and no moose (Sheldon 1911 as cited in Cruikshank 1981).

Based on information gathered from published ethnographic and ethnohistoric accounts caribou were, and continue to be an important animal to First Nations of the southwest Yukon (Allen 1994; Cruikshank 1990; Hare et al. 2004; Legros 1999; Legros 2007; McClellan 1975, 2007). The importance of caribou to local First Nations people is exemplified in pivotal stories that “everyone knows”. Many of these stories illustrate the complex shared relationships between humans and non-humans for maintaining the social order (Cruikshank 1981; 1990; 1998; Legros 1999; McClellan 1975). One story in particular, told by Mrs. Annie Ned, tells of how one man spent time with caribou and provides oral testimony to the observation that there have been shifts in their regional population (Cruikshank 1990:277, 336).

Figure 5. Caribou crossing at Carcross. Yukon Archives. Marjorie Manwarning Collection, 84/13 #2.

3.9 Caribou Hunting Models

Although caribou are important animals to inhabitants of the southwest Yukon, our current understanding of precontact caribou hunting strategies throughout the Holocene is not well developed. Ethnographic and ethnohistoric accounts for the western subarctic Cordillera describe a variety of caribou hunting strategies but many of these accounts focus on large-scale communal drive-lane systems (Emmons 1911; Honnigmann 1954; Legros 2007; McKennan 1959; McClellan 2001; Nelson 1980, 1983; Osgood 1936). Ethnohistoric and ethnographic studies indicate that communal caribou hunts were important events in the southwest Yukon and usually occurred in the late summer and fall when herd sizes peaked. Evidence of corrals and other traces of large-scale communal hunting provide highly visible records of caribou procurement in the southewest Yukon (McClellan 2001; Hare et al. 2004).

In contrast, the more mundane day-to-day efforts of small work groups may have been less visible (or interesting) to onlookers. As a result the less dramatic, but still important hunting of single animals, or a few animals, by lone or small groups of hunters, is less well understood. Nonetheless, ethnographic accounts of small scale hunting do exist. Several records document using decoys, wearing disguises, or waving flags to draw curious animals into bow range (Honnigman 1954; McKennan 1959, 1969). In other cases, cooperative hunters constructed blinds so that animals could be ambushed as they were driven past a concealed hunter by other members of a group. Identifying small-scale hunting forays and lone hunting in the archaeological record is more difficult. This is in part due to the lack of archaeological visibility of these events, although hunting blinds or caches may survive (Greer 1983, 1986, 1987; also see Greer and Le Blanc 1983; Hare et al. 2004). While direct evidence for small-scale hunting is rare, indirect evidence for such procurement modes does exist. In the faunal record of southern Yukon, for example, faunal assemblages routinely contain elements of various ungulates and other animal remains (Greer 1986, 1987, 1993; Hare 1995; Heffner 1999).

Although ethnographic records and the archaeological traces of hunting caribou with corrals and fences can assist in identifying ancient hunting methods, these data do not offer a complete picture of how ancient hunters obtained their prey. Productive avenues for understanding caribou hunting patterns of precontact populations in the southwest Yukon can be made through an analysis of general theoretical assumptions based on analogy from directly observed modern caribou populations. The presence of caribou depends on a large number of environmental factors. It is important that appropriate analogies be used for the reconstruction of caribou populations which will assist archaeologists when analyzing the archaeological record (Blehr 1990, Burch 1991; Gordon 1990; Jackson and Thacker 1997; Thacker 1997).

3.10 The Latitudinal Hunting Model

Archaeological explanations of caribou hunting generally focus on a latitudinal hunting model, which emphasizes some degree of human dependence on large migrations of barren ground caribou, and the use of communal hunting

(Burch 1972; MacDonald 1985; Sturdy 1975). Some researchers have gone as far as to propose a "herd following" hypothesis in which human groups are associated with particular herds (Gordon 1975, 1988). These groups of people need to "follow" the caribou and when game runs out they must go elsewhere. In this case the latitudinal model generally involves people who have a large dependence on caribou for a limited season, but are independent of killing caribou the rest of the year (Spiess 1979:131). The most extreme case of people "following" herds is among the Chipewyan around the shores of Hudson Bay (Burch 1991; Sharp 1977; Smith 1976, 1978).

Burch (1972:346) argues that although people cannot "follow" herds they can wait in the path of travelling animals and kill them as they move through a given locality. The main problem for the hunter in these situations is to determine the route by which the seasonal movement of caribou is to take place. Burch (1972) refers to this caribou hunting technique as "head-em-off-at-the-pass" strategy. The main idea behind this hunting strategy is that people wait in the path of travelling animals and kill them as they move through a given locality.

The determination of where to wait is thus a critical problem, and can be fraught with uncertainty (Burch 1972: Spiess 1979). As a consequence, two main seasonal migrations by barren ground caribou are the main factors that give the intercept technique reliability (Burch 1972). These migrations are generally divided into two seasonal movements – to a calving area on the tundra in spring or early summer, and to a winter range in the forest in the fall. Once the decision is made regarding where to hunt, the hunter must move his family and/or other hunters to the right spot and be prepared when the animals arrive (Burch 1972:346). If hunters are at the right spot at the right time they can make a significantly large kill of animals – potentially the largest of any time during the year. It is at this time that the intercept technique is the most effective (Burch 1972).

Embedded in most of the latitudinal models of caribou hunting is the principal feature of uncertainty (Burch 1972). Although caribou movements may be fairly consistent and well patterned for several years, they are known to shift dramatically from one year to the next (Burch 1972; Ferguson et al. 1998). In addition, caribou are subject to radical oscillations in numbers from time to time. At certain times this is the result of a shift of large numbers of animals from one region to another. In other instances this results from variations in the degree of concentration and dispersal of the animals at given seasons from one year to the next (Burch 1972). In other years caribou may shift their calving areas (Kelsall 1968). So, in some instances there are regular seasonal shifts in the food supply that affect where caribou migrate. On the otherhand, there are times when there are totally unanticipated fluctuations (Burch 1972). Burch (1972:356; Ferguson et al. 1998) argues that it is not unreasonable to assume that people largely dependent on caribou will be faced with a major resource crisis at least every two or three generations. Some traditional knowledge studies among the Inuit indicate that barren ground caribou population fluctuations are cyclic, with each full cycle occurring over the lifetime of an elder (Ferguson et al. 1998).

3.11 An Altitudinal Hunting Model

There is a diverse range of caribou behaviour that needs to be considered before developing archaeological hunting models. Recent explanations of caribou hunting have challenged the emphasis on the large-scale latitudinal hunting model as the primary model for human/caribou interactions (Jackson and Thacker 1997). Researchers now recognize the need to acknowledge the difference between large-scale latitudinal and altitudinal caribou migration, and make the additional distinction between latitudinal treeline migrations and altitudinal treeline migrations as important features of herd ranging descriptions (see Blehr 1990: Burch 1991; Gordon 1990; Thacker 1997). In addition, past hunting models have often placed too much emphasis on barren ground behaviour and enough on woodland caribou behaviour (Jackson and Thacker 1997).

Burch (1972) refers to the second main strategy for hunting caribou as the "search and destroy" technique for locating and hunting caribou. This technique is most effective under certain conditions: (i) in areas, or at times of year, in which the animals are likely to be relatively sedentary, or (ii) when caribou prefer a very specific set of environmental conditions (Burch 1972:347). In each case, hunting strategies involve making expeditions of increasing length and in all directions out from camp until animals are found (Burch 1972). Once caribou are located, the best thing to do is kill some animals immediately. Burch (1972) argues that if this is not done, there is a risk that the animals leave before the hunter returns.

Archaeologists developing models for caribou hunting in the southwest Yukon must consider an altitudinal model of caribou movement rather than assuming only latitudinally long-distant, seasonal movements of large barren ground herds. Modern behavioural analogues of caribou in the southwest Yukon indicate that smaller scale altitudinal migration is at least as likely as long distance herd movement (Farnell et al. 1998; Farnell et al. 2004, Kuzyk and Farnell 1997; Kuhn et al. 2010). These smaller scale migrations, altitudinal in nature, were a response to topographic relief, which was significant in terms of vegetational niches and other landscape features (see Thacker 1997:93). Important to the altitudinal model is that human groups were knowledgeable of caribou movement based on the habitat type used. Environmental variables including snow and vegetational distribution affecting seasonal grazing and calving, treelines, topography, water barriers, and landscape features can be correlated with broad patterns of caribou behaviour (Gordon 1990; Spiess in Thacker 1997).

The conditions relevant to effectively hunt caribou during altitudinal migration are: (i) during the height of the fly season in the summer, and (ii) in the depth of winter (Burch 1972). I elaborate on each of these conditions in Chapter 7 and it is the alititudinal hunting model that I test in this research. I propose that precontact hunters in the southwest Yukon took advantage of the altitidunal movements of caribou during the summer when the animals moved to the alpine to seek high quality forage and use snow patches to seek relief from insects and heat.

3.12 Establishing Seasonality

A first step to evaluating whether precontact hunters in the southwest Yukon were using an altitudinal hunting strategy is to determine the seasonal use of ice patches by caribou. Researchers have used various methods to determine seasonality, but among the most common are zooarchaeological analyses, such as dental age and mortality profiles (Byers and Hill 2009; Sturdy 1975). In seasonality studies done at the Hogup Cave archaeological site in Utah, researchers hypothesize that methods for hunting pronghorn antelope changed from one of encounter hunting in the Middle Holocene to large-scale communal hunting during the late Holocene. Researchers propose that tightly grouped seasonality data indicates temporally discrete events, which accompany catastrophic mortality profiles derived from mass kills. In contrast, seasonality spread over multiple seasons is more likely to accompany attritional and prime-age assemblages indicating encounter hunting. Based on the study of dental eruption sequences on pronghorn antelope, age determinations, season of death estimates, and mortality profiles are established. Ancient hunters visiting Hogup Cave were focusing on juvenile and older adults and this pattern varied little across time during the Middle Holocene. It is concluded that large communal pronghorn kills were predominantly a late Holocene phenomena (Byers and Hill 2009).

A very recent and promising type of analysis for studying seasonality and faunal migration is that of strontium isotope analysis of intra-tooth enamel. Recognizing that caribou demonstrate clear cyclical seasonal movements, it is expected that annual movement is reflected in tissue chemistry of the animals themselves (Britton et al. 2009). In a pilot study by Britton et al. (2009), isotopic element profiles were created from incrementally developed dental tissues from a modern herd of migratory Alaskan caribou (*Rangifer tarandus granti*). The isotopic data correlates with the geological setting and the local climate, and environmental conditions, which suggests that isotopic trends correlate with the known movements of the herd as a whole. Results indicate the potential to determine migratory behaviour in extinct and ancestral species, through strontium isotope analysis, which may allow the identification of summer and winter ranges in archaeological and paleoecological faunal samples. For archaeologically important prey species, such as caribou, this can provide insight into the paleoecology of the animal and has implications for understanding human hunting strategies (Britton et al. 2009).

3.13 Using Pollen in Dung to Establish Seasonality

Several studies have demonstrated that the pollen content of dung can help designate the time of year plants were consumed by animals (or humans; Bryant 1974), which can then be used to make other interpretations (Akeret et a. 1999; Bjune 2000; Bjune et al. 2005; Bryant 1974; Gil-Romera 2006; Karg 1998; Kropf et al. 2007; Thompson et al. 1980; van Geel 2008). For instance, Kropf et al. (2007) show that the extinct shrub ox (*Euceratherium collinum*), shifted its dominant spring browse of *Acacia* to *Chrysothamnus* and *Quercus* in the fall. Again, with an extinct animal, Mead et al. (1986) demonstrated that Harrington's

Mountain Goat (*Oreamnos harringtoni*) frequented caves in the early to late spring and possibly during portions of late winter and early summer based on analysis of pollen preserved in dung. Based on the identification of *Fagus, Corylus,* and *Alnus* pollen from sheep/goat dung at a Bronze Age site in Northern Italy, it is concluded that animals were kept inside the settlement during winter and early spring (Karg 1998).

Seasonality was inferred from human paleofecal material from archaeological sites in the United States. The bloom time of several arboreal plants, Liguliflorae (dandelions), and monocots suggests a spring/summer deposition of many of the fecal samples at Mammoth Cave (Bryant 1974). Based on the absence of certain types of pollen, such as that from storable plants like chenopods and grasses, it is suggested that some of the feces were deposited in the winter. Bryant (1974) also suggests that the high percentages of pollen from insect-pollinated plants in some paleofecal samples indicates that flowers were ingested during a spring/summer season when pollen production was at its peak.

Bjune et al. (2005) examined pollen from ancient caribou dung in Edgeoya, Svalbard. The pollen was compared to published pollen data from modern Svalbard caribou dung to assist in determining in which season the dung had been deposited. Ancient dung pollen was dominated by early flowering species such as *Saxifraga* and *Pedicularis* indicating that grazing and deposition of dung took place in spring and early summer months. Modern dung samples were not available for comparison. To be sure which season the ancient dung were deposited, the researchers recommended that their pollen content be compared to the pollen content of modern dung that is collected during different seasons within the same study area (Bjune et al. 2005).

In a similar way, pollen from caribou dung at ice patches in the southwest Yukon can assist in determining the season in which these animals were on ice patches and potentially hunted by humans. A first step in determining seasonal use of ice patches is to examine pollen recovered from dung derived from the modern Ibex caribou herd presently found in the study region. Pollen assemblages from modern dung are then compared to the pollen assemblages from ancient material collected from ice patches. The outcome is interpreted in light of what is currently known about caribou behaviour, their use of ice patches, and how it relates to precontact hunting strategies.

3.14 Objectives of the Research

The objective of this dissertation is to further define the role of caribou hunting as it relates to land-use patterns of precontact peoples of the southwest Yukon. Humans, who are dependent on caribou for their livelihood, have developed different methods for locating and hunting these animals. To be a successful hunter, strategies involved timely scheduling and an intimate knowledge of caribou behaviour and the physical environment (Binford 1978; Bouchard 2004; Burch 1972, 1991, 2007; Kelly 1995; Legros 2007; Milne 2008). Research presented in this dissertation examines the nature and distribution of caribou as a resource, and its potential influences on precontact hunting and land-use patterns that developed in the region.

I propose that the presence of ice patches, which are associated with caribou dung and ancient hunting equipment, indicates an altitudinal hunting strategy that was used by precontact hunters throughout the Holocene. The visible archaeological record seen at ice patches has accrued by the activities of a few hunters leaving transient hunting localities while moving across the region in search of game (following Lovis et al. 2005). Evaluating biological data sets from caribou has the potential to test the altitudinal model and the applicability of ethnographic/ethnohistoric accounts for interpreting the archaeological record. These data can also provide information on:

1) caribou ecology and ethology as it relates to locating caribou temporally and spatially;
2) the effects of seasonality on caribou migration;
3) the impacts of caribou migration on hunter-gatherer hunting strategies and long-term precontact land-use patterns.

The seasonal movement of caribou to ice patches in the summer allowed for the use of an altitudinal hunting strategy. The results reported here may not agree with the latitudinal strategy of barren ground caribou more commonly reported in ethnographic and ethnohistoric reports for northern hunters. The lack of agreement might indicate variations in hunting strategies and land-use patterns not documented previously.

4.0 THEORETICAL BACKGROUND

4.1 Overview of Theoretical Approaches to the Study of Land-use

There are a variety of approaches when it comes to studying land-use in archaeology. Preucel and Hodder (1996) generally divide these into various “landscape approaches”. The first is “landscape and environment” which includes the reconstruction of specific environments and what past people had to live in and adapt to. The second landscape approach is the “landscape as system”, which refers to those studies that place sites within an overall pattern of site and off-site activities. These studies refer to the integration of sites within a settlement-subsistence system. In these studies there is a relationship between the ways in which sites are distributed and the political and economic systems within which they exist. The third approach is “landscape as power” which regards landscapes as ideologically manipulated in relation to domination and resistance. There is an emphasis on contradictions and conflict that emerge in the cognized environment, and that are embedded in power relations (Preucel and Hodder 1996:33). The fourth approach is “landscape as experience” in which the term landscape is taken to refer to how the environment was perceived and imbued with meaning. The emphasis in this approach is on the different cultural meanings (i.e. phenomenological) that are given to the natural environment (Preucel and Hodder 1996).

Preucel and Hodder (1996) suggest that these various ways of approaching the landscape may be viewed as a gradation from landscape as natural to landscape as cultural. To some degree these differences are ones of scale. The settlement approach is regional, whereas the phenomenological approach is grounded in the individual. In other cases however, there are significant ontological differences underlying whether landscape is considered independently of humans or as constructed by human agency (Preucell and Hodder 1996:33). In the following overview the ecosystemic and evolutionary ecological models fall under the "landscapes as environment" and "landscapes as systems" categories. I have summarized "landscapes as power" and "landscapes as meaning" under the heading "Post-Processual or Emic" approaches to land-use.

Cross-cutting all of these approaches to landscape research are those of hunter-gatherer land-use patterns and mobility, and their implications for interpreting the archaeological record. Archaeologists generally have focused on the first two approaches, "landscape as environment" and "landscape as systems" to understand hunter-gatherer land-use (Preucel and Hodder 1996). This is attributed to the fact that constructing precontact technology and economy are less difficult than ascertaining ideological and religious beliefs (Hawkes 1954; Trigger 1989).

4.2 Ecosystemic Approaches to Hunter-Gatherer Subsistence/Land-Use

To fully understand conceptual developments in hunter-gatherer land-use it is first important to review some of the models of hunter-gatherer settlement-subsistence systems. Binford's forager/collector model, which is rooted in the ecological paradigm of behavioural ecology, uses ethnoarchaeology (Middle Range Theory) to develop a framework for interpreting the archaeological record

(Binford 1980, 1983, 2001; Broughton et al. 1999; Kim 2006; Sheehan 2004). Middle Range Theory, as applied in this approach, is characterized by its use of studies of living groups to observe social systems and their interactions with the environment, so as to isolate key principles and processes (Binford 1981, Bettinger 1991a, 1991b; Pickering 2003). The ethnographic record is generally used to generate models in regards to the variation of patterning seen in archaeological residues.

According to the behavioural archaeological approach, the ecological structure, as reflected by the resource conditions of an environment, is critical to the type of land-use pattern employed by hunter-gatherers (Mandryk 1993). In Binford's model, mobility, critical to hunter-gatherer lifeways, is typically seen as a response or a "positioning strategy" to differential availability of resources in the environment in time and space (Binford 1980; Kelly 1983; Mandryk 1993). The strength of Binford's model is that he examines mobility in comparable ethnographic situations and then considers the resulting variability in the structure of the archaeological record (Binford 1980, 2001; Lovis et al. 2005:672).

Based on environmental information and ethnographic data on the G/Wi San of South Africa and Nunamiut of Alaska, Binford (1978, 1980) makes the argument that seasonal or short-term hunter-gatherer land-use should be patterned in predictable ways with respect to spatial and temporal variation in resource availability (Binford 1980, 2001; also see Habu and Fitzhugh 2002 for a review; Lovis et al. 2005). Binford identifies two basic settlement-subsistence systems: forager systems that are characterized by low logistical mobility and high residential mobility and collector systems that have high logistical mobility and low residential mobility (Binford 1980; Chatters and Prentiss 2005; Habu and Fitzhugh 2002:1; Kelly 1992). These strategies are responses to different security problems presented by the environment in which hunter-gatherers live. Archaeologists are able to distinguish between various land-use patterns and patterning in the archaeological record by a detailed examination of the distribution of resources (Binford 1980).

In environments that are highly productive and homogeneous, people adopt a forager type strategy in which they reside at one location until the resources in the immediate area become depleted, at which time they relocate. Foragers undertake residential mobility, which involves moving an entire group from one location to another and is usually tied to the food resources of a region-usually high productivity patches. Foragers also lack storage and use an encounter approach to gathering food (also see Lovis et al. 2005). A residential site is one where several tasks or even stages of processing can occur.

At the other end of the continuum are collectors who tend to have low residential mobility but use logistic mobility to procure spatially or temporally scattered resources (Binford 1980; Mandryk 1993). Binford (1980) introduced the term logistical mobility to express the movement of part of a hunter-gatherer group to secure provisions. Logistic mobility occurs when important foods are separated in space or in time (seasonally) and movements are structured according to the distribution of these resources within the environment, not whether they are particularly abundant (see Lovis et al. 2005). Where there is a high degree of seasonal or spatial variation in resources hunter-gatherer strategies involve a pattern where the residential group stays stationary but certain “task” groups are sent out to retrieve resources and bring them back to camp. Logistical mobility describes the situation in which individuals or small groups move out from, and then back to, a residential camp in order to acquire food resources (Binford 1980; Chatters and Prentiss 2005).

Collectors are distinguished from foragers by the use of specialized task groups, such as hunting parties, that move from more centrally located residential sites to obtain resources from surrounding locations; the products of these activities are brought back for either additional processing or to share with the group (Binford 1980; Lovis et al. 2005). Logistical mobility requires a division of labour whereby different members of the group obtain important resources that are available at the same time but in different locations. Usually only part of the group, defined by gender, age, social status or health embarks on such an expedition. Logisitical mobility can consist of a one-day trek or require multiple nights away from the base camp or settlement, which in itself, may not be permanent. Logistic mobility results in archaeological signatures of short-term and limited-activity sites, such as hunting stations and kill-butchering locations (Binford 1980: Chatters and Prentiss 2005; Lovis et al. 2005).

The significance of Binford’s model is that these categories represent mobility strategies in different resource zones, and/or different segments of the seasonal round. The overall effect of what is viewed as opposing ends of a spectrum is generally seasonal differentiation in the relative roles of residential versus logistical mobility. Binford (1980:19) emphasizes that logistical and residential land-use practices are organizational alternatives, which may be used in varying combinations in different settings. Hunter-gatherers may switch between the two systems as conditions dictate (Mandryk 1993). In some environments, hunter-gatherers may be involved in high residential mobility in the summer, or during the growing season, but have reduced mobility in the winter, with increases in logistical mobility (Binford 1980). These organizational mixes provide the basis for extensive variability which may yield very confusing archaeological patterning. For instance, the more specialized the resource "targets" sought under logistical strategies, the greater the increase in redundancy of archaeological debris in restricted sections of the habitat as a function of increasing logistic dependence.

Actual behaviours, however, rarely meet precise definitions of either form of mobility. It is now acknowledged that no hunter-gatherers are pure "collectors" or "foragers" (Read 2008). Instead, most forms of mobility take on aspects of multiple behavioural options available in the logistical-residential continuum (Kim 2006; Morgan 2009; Read 2008). All groups have some degree of residential mobility and it is likely that all groups engage in some degree of logistically organized procurement (Whallon 2006). The behavioural and semantic distinction between logistical and residential mobility, however, continues to be a useful heuristic device (Kim 2006; Morgan 2009).

Until recently, most definitions of mobility have been behavioural, but it is now acknowledged that descriptions of land-use and mobility encompass social and ideological aspects that are not directly controlled by foraging (i.e. subsistence needs) (Ives 1990, 1998; Kelly 1992; Weissner 1981; Whallon 2006; also see Grove 2009). Mobility can be socially and politically motivated, as people seek allies and spouses, or move in response to sorcery or political forces. Although subsistence incentives are one dimension that needs to be taken into account when seeking to explain mobility patterns, it is now recognized that most often mobility patterns are a result of a combination of factors ranging from climatic to sociocultural to ideological (Wendrich and Barnard 2008). For instance, hunter-gatherers who leave a place physically and conceptually may treat it differently from those who leave a locale physically but still think of it as a place on the landscape, perhaps because of ideological attachment (Kelly 1992:45). In addition, high mobility itself may be culturally valued. Mobile hunter-gatherers often express a desire to move around to visit and see what is happening elsewhere (Kelly 1992).

Central to understanding the archaeology of mobility is to refrain from defining mobility in too fixed a set of categories, thereby denying the dynamic and opportunistic development of mobile peoples (Wendrich and Barnard 2008). Morgan (2009) suggests that we think of mobility as movement. Movement, especially pedestrian hunter-gatherer movement, usually leaves no trace - stopping does, with evidence of stops between moves (Morgan 2009:382). Wendrich and Barnard (2008) define mobility as the capacity and need for movement from place to place. Their definition encompasses several aspects including a combination of the moment in time (length of time, season), the type of movement (mobility pattern chartered over time), the motivation for movement (resources, but also cultural identity, social or economic circumscription), and the segment (parts of the population defined by gender, age, health or social position). There is incredible variability in human mobility, which can also be quite fluid. By understanding the many facets of mobility we are better equipped to conceptualize mobility in new ways (Wendrich and Barnard 2008).

4.3 Evolutionary Ecological Approaches to Hunter-Gatherer Land-Use

Human evolutionary ecology (specifically behavioural ecology) has been central to the study of hunter-gatherer land-use and economy (Bettinger 1991a, 1991b; Bettinger and Baumhoff 1982; Broughton 2002, Broughton et al. 1999; Broughton and Bayham 2003; Byers and Broughton 2004; Chatters and Prentiss 2005; Murray 2002; Myers 1988; Shennan 2002; Winterhalder 1981a, 1981b, 1983, 2001; Winterhalder and Smith 1981; Smith and Winterhalder 1992). Behavioural ecology accounts for variation in ecological contexts by referring to Darwinian evolutionary methods, although this approach is not to be confused with Dunnellian selectionism (see Broughton et al. 1999; Kantner 2008; Winterhalder and Smith 1992). Human behavioural ecology is interested in understanding human decision-making and proponents argue (often implicitly), that processes have shaped cognition and operate as a proxy to selective forces, or that these forces operate directly on human behaviour (Kantner 2008).

Behavioural ecology, most often represented in archaeology and anthropology by optimal foraging models, applies principles developed from the study of animal behaviour and microeconomics (Broughton 2002; Broughton et al. 1999; Broughton and Bayham 2003; Grimstead 2010; Shennan 2002; Ugan 2005). Our understanding of hunting and gathering, particularly in the boreal forest of the subarctic, have relied heavily on the application of optimal foraging theory (Heffly 1981; Kelly 1983, 1995; Winterhalder 1981a, 1981b, 1983; Winterhalder and Smith 1992; Smith and Winterhalder 1992). Models coming out of optimal foraging theory are grounded in biology in that they adopt animal behavioural models and apply them to human cultural activities (Bettinger 1980; Fitzhugh and Habu 2002; Shennan 2002; Sheehan 2004; Winterhalder 2001; Winterhalder and Smith 1992). Winterhalder (1981a, 1983) uses data based on field research among the Cree of the boreal forest of northern Ontario to test models of optimal foraging theory. In these models human foragers develop behaviours that allow them to achieve the highest net rate of energy capture while foraging which is measured per individual. As a consequence these models are reductionist in that human hunting is viewed in similar ways to animal foraging, with energy efficiency and caloric return, all key to a hunter's success (i.e. "optimality").

Critics of this approach claim that these models emphasize economic rationality as the basic principle that determines hunter-gatherer subsistence strategy (Ebert 2004; Fitzhugh and Habu 2002; Bettinger 1980, 1987, Myers 1988; Thomas 1986; Ugan 2005; Yengoyan 2004). However, Broughton et al. (1999:643; also see Hawkes et al. 2002; Hildebrandt and McGuire 2003) argue that optimization does not require that humans be consciously engaged in rational choice nor does it deny the existence of intentionality in decision-making. Proponents of this approach argue that its strength is that it can generate predictions about fitness related behaviour, it can provide linkages between variation in one aspect of behaviour and another, and that these predictions are testable (Broughton et al. 1999).

Studies in behavioural ecology have focused on describing predatory behaviour and the interaction between a population and its resource base (see Broughton and Bayham 2003; Kim 2010; also see Hildebrandt and McGuire 2002, 2003; McGuire and Hildebrandt 2005; Sheehan 2004). To predict decisions made by foragers, numerous models including the Diet-Breadth Model, Prey Choice Model, Patch Choice Model, Marginal Value Theorem, and Central Place Foraging are applied to test whether human foraging is shaped by selective forces to extract calories from environments in the most efficient manner (Bettinger 1980, 1987; Grimstead 2010; Hocket 2005).

Based on a general ecological model from animal foraging behaviour (Horn's blackbirds), Heffly (1981) develops a Central Place Foraging model and applies it to ethnographic data for Upper Tanana, Ingalik, and Chipewyan Athapaskan hunters. Heffly (1981:126) proposes that there is an optimal relationship between group size and location (i.e. settlement pattern) and resource distribution. Key variables of the ecological model used by Horn are location, size, and predictability of resources. The size and the location of the hunting groups that are able to use resources efficiently are the dependent variables. There are two key assumptions in this model. First, the resources at stable, evenly distributed points are simultaneously available. Second, resources at mobile, clumped resource points are available at one or a few points. Athapaskan settlement patterns are viewed as behavioural responses to predictable–stable and uncertain-mobile food resources. From this perspective, settlement patterns in the western subarctic require flexible strategies that put groups in optimal spatial and temporal positions for the exploitation of uncertain mobile resources, such as caribou and stable, evenly spaced resources such as fish, small game and moose.

Large settlements were centrally located in relation to resources which were clumped, mobile, and unpredictable. In contrast, small settlements were dispersed in the exploitation of evenly-spaced, stable resources (Heffly 1981:146). However, the ethnographic cases that Heffly uses show that variations in settlement pattern were not accounted for in the model when (i) detailed information about the resource location was being actively shared; and when (ii) clumped but predictable resources (including stored food) were being used.

Although behavioural ecologists acknowledge that hunter-gatherer behaviour is complex, they argue that its various causes must be understood separately. The focus is on economic objectives, target resources, and the efficient exploitation of game (Byers and Broughton 2004; Berkes and Folke 1998; also see Hildebrandt and McGuire 2002, 2003; McGuire and Hildebrandt 2005; Sheehan 2004; Ugan 2005). Optimal foraging models focus on the foraging strategy in which the objective is to acquire key target resources (Winterhalder and Smith 1992). In these models, resources are ranked on an ordinal scale from most efficient to least efficient based on the net caloric return rates of individual food items (Hockett 2005). As a consequence, there is a mechanistic view of the native forager as capable of only “gastronomic calculation and animated by nothing more than a presumed prowess at resource optimization” (McGuire and Hildebrandt 2005:696).

Recently, Kim (2010) has argued that optimal foraging models, such as the Prey Choice Model, are not accurate predictors of hunter-gatherer behaviour because they are ecological and based on analogies with animal behaviour. A more productive approach is to make a clear distinction between ecology and economy (Kim 2010; Mithen 1989). The significance of this distinction is that an economy includes the spatial/locational movements of hunter-gatherers to procure resources in their ecological context, but adds appropriational movements, which are the social relations between the various ecomomic units (Kim 2010; Halperin 1989). In addition, economic behaviours are usually planned and involve decision-making, which can include the calculation and prediction of supply and demand, opportunistic costs, risk avoidance, and trade-offs between short term gain and long-term sustainability. These decisions tend to be based on prior information (Kelly 1995; Kim 2010). A second problem with the ecological orientation of the Prey Choice Model is that it rarely takes into account hierarchical and sequential human-decision making processes. When hunters are planning a trip they must consider: (i) what to search for and (ii) what to take when an encounter occurs (Kim 2010). These considerations must include decisions regarding the type of hunt that will take place and the intended prey characteristics (Kim 2010).

Hunter-gatherer decision-making processes regarding prey choice will first involve deciding on what and how much to acquire on the basis of current needs and an overall economic plan. Needs and the overall economic plan might include macronutrient balance, food for storage, or items for social needs such as trade goods. If energy return and efficiency are not an issue, then specific target resources may be the focus of the hunting trip. In this case, hunters will choose where to forage and how to hunt a particular resource based on prey characteristics, distribution, and seasonality. Task groups will then move to particular patches and search for that targeted resource (Kim 2010:81, 83). Hunting locations may be patches with specific resources, where the task group expects to acquire a particular animal (or animals). Task groups are well aware of the products and locations of the resource patches that they plan to visit. Although some target switching may occur during the hunting trip, it occurs only when a new target can be substituted for the original target (Kim 2010:83).

A target mode of hunting may be less efficient than opportunistic hunting, but it has some important advantages, which mainly involve the predictability of the resource (Kim 2010). In this case, task groups know where they need to go and what they need to acquire and do not need to search for any other animal, other than their target resource(s) (Kim 2010). In addition, if hunter-gatherer groups have reliable information about the geographical distribution and productivity of resource patches and the seasonality (optimal procurement time) of target resources at each patch, the procurement of resources can be better scheduled and organized (Kim 2010). Importantly, however, hunters may choose from a repertoire of hunting modes (i.e. opportunistic, target) as appropriate. For instance hunters may use an opportunistic mode in the winter and a target mode in the summer, or choose an opportunistic mode in acquiring some resources and a target resource in acquiring other resources (Kim 2010).

Kim (2010) suggests that the mode of hunting can be recognized in faunal assemblages from resource acquisition sites within patches. In the case of a target mode of hunting, the taxonomic diversity of each assemblage from resource acquisition locations will be relatively low and will be dominated by the specific target resources. In essence, the assemblage structure at each patch is a product of the intentional choice made by task groups in exploiting that patch (Kim 2010). Prey choice in a human context is an economic decision regarding what resources to supply. It is not simply an ecologically-driven reaction to resource availability (Kim 2010:92).

Another criticism of optimal foraging theory is that it fails to take into account resource fluctuations and is inattentive to the time frame in which foraging occurs (Ebert 2004). Often, foraging is assumed to happen in a timeless and unchanging landscape. While patch choice takes into account resource distribution and depletion, it fails to take into account resource fluctuations, whether caused by seasonal change or natural disaster (Ebert 2004). Ebert (2004), revising and updating the optimal foraging theory, tests various models (e.g. diet breadth, patch choice model) to develop a predictive model for hunter-gatherers of the boreal forest of Manitoba. Ebert (2004) develops an archaeological predictive model (APM) in which environmental variables as well as cultural aspects of the environment are used. It was shown that archaeological sites are predictable when using models that incorporate natural and cultural aspects of the environment (Ebert 2004:55). Ebert (2004) proposes that land-use patterns, even among acculturated groups, have considerable time depth. Working with elders, Ebert demonstrates that information about the local environment is applicable much deeper in time than previously thought.

It is now recognized that there are many factors that influence hunting decisions, which may have nothing to do with foraging. In addition, hunting decisions are shaped by factors such as ideology and social organization (Burch 2007; Yengoyan 2004; Wiesnner 1982; Kim 2006; Nuttall 1992; Oliver 2007). Recently, theoretical models rooted in evolutionary ecology propose that hunting takes place for reasons other than foraging and subsistence (Hawkes et al. 2002; Hildebrandt and McGuire 2002; McGuire and Hildebrandt 2005). McGuire and Hildebrandt (2005:696) argue that many optimal foraging models "cloaked in the mantle of evolutionary ecology" fail to make explicit the relationship between caloric intake, foraging efficiency, individual reproductive fitness and Darwinian evolution. This is evident in studies around the taking of large game and the claim that large meat packages are a source of protein, calories and nutrients that measure efficient foraging. McGuire and Hildebrandt (2005:696) argue that hunting may be carried out for very different reasons than foraging efficiency or group adaptation.

The relationship to reproductive fitness (i.e. Darwinian evolution) is more explicitly stated in these models than in optimal foraging theories. McGuire and

Hildebrandt’s (2005; also see Hildebrandt and McGuire 2002) theoretical approach, which is grounded in evolutionary ecology, outlines the relationship between dietary choices and social factors. In the case of hunting, men hunt large game as a way to gain reproductive fitness through greater prestige and better access to partners (Hildebrandt and McGuire 2002). These non-subsistence hunting activities may be an inefficient strategy in terms of caloric return but the benefits include an increase in decision-making roles, seeking and maintaining alliances and information gathering. Large game may be sought on an encounter basis or in an opportunistic manner as other activities are carried out (McGuire and Hildebrandt 2005). Logistical mobility is one strategy that is motivated by male hunters (generally high status men) who are participating in non-provisioning pursuits.

4.4 Post-Processual Approaches (Emic or Humanist Approaches)

The humanist perspective is a response to what is interpreted as overly economic-based materialist approaches to understanding human behaviour. Within archaeology, humanist perspectives are taken up by post-processualist schools of thought, which emerged as a response to the disillusionment with the positivism and processualism of middle-range theory and its focus on ecological systems and relationships. The humanist perspective encourages greater appreciation of the impact of mental phenomena, beliefs and ideas (Pickering 2003; Trigger 1989, 1991). The focus of study from the post-processualists’ perspective is on human awareness, intention, mental constructs, world views and beliefs of individuals. The theoretical and methodological focus is on the interpretation from the perspective of the "performer" or "other" rather than the observer (Pickering 2003:18).

Theoretical perspectives in humanist approaches to landscape archaeology are generally informed by postmodern currents in anthropology as a whole, and particularly in social theory, and regard landscapes as an ideational construct of the human mind (Kantner 2008:57; Walsh et al. 2006). This approach emphasizes landscape as creations of human cognition, which are always subjective (Kantner 2008). Landscapes only exist in that they are perceived, experienced and contextualized by people, suggesting a phenomenological approach to landscape. From this perspective, landscape is regarded as comprising places that no matter how physical or essential to basic human needs, are only meaningfully constituted through human action in reference to them (Kantner 2008). Mobile foragers, for example, move through a regional space of trails, views, hunting points and water holes. Together, these constitute a cultural landscape, since people have assigned these places meanings mediated by their collective experiences with them over time (Boaz and Uleberg 2000; Kantner 2008). "Place" is a fundamental concept within landscape archaeology that encapsulates the central theoretical perspective of this paradigm, which is that places are temporal human creations within landscapes.

Critics of the evolutionary ecology and forager/collector approaches argue that hunter-gatherer land-use is viewed purely in materialist terms (Nuttall 1992; Oliver 2007; Yengoyan 2004). These approaches take on a functionalist perspective in which hunting is seen as a mechanistic response to subsistence needs in the context of predator-prey relationships and greater caloric efficiency (but also see Hildebrandt and McGuire 2002, 2003). Materialist perspectives ignore the ideological aspects of a world-view that regards the human-animal worlds as interwoven (Boaz and Uleberg 2000; Nuttall 1992; Walsh et al. 2006; Yengoyan 2004). This is because most models of hunter-gatherer land-use are embedded in Western notions that conceptualize nature as subordinate to humanity (Boaz and Uleberg 2000; Burch 2007; Ingold 1999; Moran 2006). Such studies leave out the hunter as a conscious being interacting with elements in the natural world (Nuttall 1992).

According to some ecological anthropologists, the separation of mind and nature (i.e. the nature/culture dichotomy) is not appropriate for understanding hunter-gatherer land-use (Burch 1971, 2007; Cruikshank 2001; Ingold 1999; Moran 2006; Nelson 1983; Nuttal 1992; Oliver 2007; Riches 1982; Tanner 1979; Walsh et al. 2006; Yengoyan 2004). From this perspective, the domain in which humans are involved as social beings with one another cannot be set apart from their involvement with non-human parts of the environment (Berkes and Folke 1998; Cruikshank 2001; Ingold 1999; Walsh et al 2006). Traditional stories from the southwest Yukon show the social nature of all relations between humans and humans and non-humans, that is animals and landscape features (Cruikshank 2001; Kan 1999). Knowledge in hunting societies is encoded in a belief system that conceptualizes animals and humans as sharing a common world and their connections as mutually sustaining (Brink 2008; Cruikshank 1998:70; McClellan

2007). Among First Nations in northern regions, many stories emphasize the inseparability of environment from everyday life (Cruikshank 1998, 2001; McClellan 2007). The practice of hunting involves relations between people, people and places, and between people and animals (Ives 1990, 1998; Nuttall 1992).

Indeed, several studies of circumpolar peoples have emphasized the ideological aspects of hunting (Bass 2004; Berkes and Folke 1998; Burch 2007; Irimoto and Yamada 1994; Nelson 1983; Riches 1982; Tanner 1979). An important component to understanding hunter-gatherer landscapes is that of the hunter's image of the environment, which evolves in relation to his experience. It is the sense of belonging, the sense of locality and continuity, and the attachment to locality that is significant. Places become repositories of local memories where hunters remember the landscape in relation to their hunting activities (Nuttall 1992:9; Oliver 2007). It has been repeatedly demonstrated through stories told by First Nations elders of the southwest Yukon that economic activities, social alliances, and ideology are bound up with the land (Cruikshank 1990, 1997, 1998, 2001; McClellan 1975, 2007).

A hunter's memory of the landscape is important because it is through knowledge and memory that hunters negotiate images and understanding of the land. Without memory or historic continuity the human-land relationship remains overly economic (Holly 2002; Nuttall 1992; Oliver 2007). The landscape is an enduring record of the lives and works of past generations who have dwelt within it; a memoryscape is constructed with people's mental images of the environment with particular emphasis on places as remembered places (Ingold 2000).

In light of the criticisms presented by the humanists, many anthropologists are now in the process of revising and updating the ecological paradigm and there are recent attempts to reconcile these approaches (Pickering 2003; Pruecel and Hodder 1996:33). In a study by Boaz and Uleberg (2000), attempts are made to demonstrate that mythological cultural landscapes constructed by precontact hunter-gatherers are amenable to studies using GIS technologies. Although it is acknowledged that it is not possible to understand how Mesolithic hunter-gatherers perceived their landscapes, they argue that aspects of change and continuity in the construction of cultural landscapes can be understood through GIS methodology.

It is acknowledged in the research undertaken here that hunter-gatherer land-use is multifaceted and requires many approaches to fully appreciate its complexity. A truly materialist perspective must acknowledge that human beings react to the world "not as it is, but as it is perceived to be" (Trigger 1989:404). From this perspective, ideological and mental phenomena are incorporated into a materialist perspective (Trigger 1989). However, a materialist approach should not be ruled out for understanding the human past. External constraints, such as the environment do not determine economic, political or social institutions, but it may strongly limit the type of variation in economic behaviour or technology (Trigger 1989:394, 403). In other words, it is acknowledged that social and ideological factors shape human consciousness but subsistence strategies and technology also have the potential to strongly influence social, political and intellectual processes of life. As a consequence, the economic base limits the possibility of variation in other aspects of human behaviour rather than dictates what the nature of that behaviour will be (Trigger 1989:403). There is no reason to deny the reciprocal relationship between ideological, social and political instutions and economy and technology, although the precise nature and extent of this influence needs to be defined and may vary widely from one society to the next (Trigger 1989:403).

The approach taken here is that archaeologists studying the remains of mobile hunting and gathering people require a close examination of the landscape, the availability of resources, as well as the scale and lay out of the world through which people moved (Wendrich and Barnard 2008). Landscape reconstruction, identification of resources, and the reconstruction of the climate and ecology are all important in understanding mobile groups of the past.

4.5 Spatial and Temporal Variation in the Boreal Forest

Hunter-gatherers in the subarctic boreal forest were faced with the challenges of obtaining food in an environment where the resources were both spatially and temporally scattered (Heffly 1981; Winterhalder 1981a, 1981b, 1983; Lovis et al. 2005). Many studies have emphasized how boreal forest hunter-gatherer land-use patterns reflect adjustments to changes in population and availability of resource species (Jarvenpa and Brumbach 1988; McClellan 2001; Minc 1986; Nelson 1980; Rogers and Black 1976; Winterhalder 1981a, 1981b).

There are three scales of resource fluctuations: (i) seasonal- those are variations that occur within one year; (ii) interannual – these are between-year variations and (iii) long-term variations that extend over a generation or more (Mandryk 1993). For instance, barren ground caribou herds may shift their migration patterns seasonally within one year. In addition, caribou may periodically shift their habitat as a response to factors such as overgrazing every ten to fifteen years. Finally, barren ground caribou may completely shift their herd size and range every sixty to one hundred years (Nelson 1980; Minc 1986). In some cases, some species are at a high in their population cycle while others are at a low (Nelson 1980). These combined temporal and spatial variations suggest that hunter-gatherer populations must be prepared to adjust to these variations (Rogers and Black 1976).

4.6 Patch Ecology

Studies of boreal forest hunter-gatherers have long been concerned with patch environments. The term patch ecology refers to the uneven distribution of resources, expressed as higher or lower densities across a physiographic region (Brunswig 2003; Winterhalder 1981a, 1981b, 1982; Yesner 1989). Variation in climate, substrates and soils, slope, aspect, and altitude are among some of the variables that combine to form heterogeneity within ecological communities. Wiens defines patches as areas distinguished by discontinuities in environmental character from their surroundings (in Bamforth 1988:18). Wu and Loucks (1995:446 in Osborn and Kornfeld 2003) propose a more complex characterization: “The physical meaning of a patch may vary greatly, depending on the system under study and the scale at which the system is viewed. Patches vary widely in size, shape, type, heterogeneity, and boundary characteristics.” Importantly, patches are ecologically distinct locations on the landscape; they are problem- and organism-defined, relative to the behaviour, size, mobility, and habits of the population being studied.

Patchiness describes the degree to which resources are clumped rather than dispersed in space (Bamforth 1988; Winterhalder 1983). Spatial patchiness may be defined and quantified in terms of both patch composition and spatial configuration. In other words, patchiness refers to the local patterns of productivity in an environment and the fluctuations in resource availability within a patch. As a result, patchiness has become a basic unit of analyses in topics of animal habitat selection and hunting and gathering (Brougton and Bayham 2003; Byers and Broughton 2004; see Hockett 2005; Read 2008; Winterhalder 1994). Both patch shape and orientation are critical in the dispersal of animals and plants across a landscape (Forman and Godron 1986:107 in Osborn and Kornfeld 2003:7). Each type of game is probabilistically associated with one or more vegetation type and is somewhat localized in distribution, which can change with the distribution of vegetation (MacDonnell and Wandsnider 2003).

Patches exhibit variable capacities to accommodate (resist) or adjust to longer or shorter-term environmental changes (Bamforth 1988; Brunswig 2003). Ecologically richer or higher density patches exhibit persistence and resilience (Berkes and Folke 1998; Brunswig 2003; Winterhalder 1994). Persistence refers to a patch area’s degree of fluctuation through time and its response to ecological variables, usually those associated with long and short-term climatic cycles. Resilience deals with a patch ecosystem’s ability to maintain its primary ecological structure in the face of external disturbance processes (Brunswig 2003).

Any large-scale physiographic region is composed of a complex mosaic of high- and low-density patch environments (Brunswig 2003). High density patches tend to be geographically circumscribed areas with environmental variables that allow them to persist through adverse environmental impacts over time (e.g., periodic climatic shifts). Low-density patches are physical areas with environmental variables that make them more vulnerable (than high-density patches) to ecosystem change during periods of less favourable climatic conditions (Brunswig 2003:45).

Links between patch characteristics and human behaviour have explanatory power for understanding past societies (Byers and Broughton 2004; Hockett 2005; Osborn and Kornfeld 2003; Read 2008). Each patch is different in regards to the type of game it attracts and the impediments it puts on hunter and prey (Winterhalder 1983). Environmental patchiness should affect the number of different habitats within which a hunter seeks resources, patterns of movement over the environmental landscape, or the hunter’s influence on the resources themselves (Winterhalder 1981a, 1981b).

The ecological concept of patch is not new to anthropological and archaeological theory nor to hunter-gatherer subsistence or land-use studies

(Brougton and Bayham 2003; Byers and Broughton 2004; Hockett 2005; Read 2008; Kelly 1983; Osborn and Kornfeld 2003:6; Osborn 2003; Winterhalder 1981a, 1981b, 1994). Hunter-gatherers are generally thought to be nearly always somewhat mobile, moving across well-defined resource areas (i.e. patches) to acquire needed supplies as they became seasonally available within a regional system of environmental zones (Brunswig 2003:46; Burch 2007; Lieberman 1993; Lovis et al. 2005; Moran 2006; Read 2008). Ethnographic and archaeological sources indicate that most hunter-gatherers practice seasonal scheduling and mobility in order to exploit seasonally available sources found in adjacent environmental zones (Brunswig 2003; Burch 2007; Lovis et al. 2005; Moran 2006; Read 2008). As a result, hunter-gatherers generally rely on seasonally and persistently dense patches for their livelihoods.

4.7 Seasonality

Hunter-gatherers living in more seasonal environments, especially those who must store food for the winter, must be concerned with understanding the location and temporal variability of particular resources (Byers and Hill 2009; Kelly 1983:289; Read 2008). Seasonality affects human groups in several ways. Many resources are only available during particular seasons or for delimited periods of time (Kelly 1983). These periods become shorter and more sharply defined with increasing seasonality. Seasonality is a measurable aspect of the environment and can therefore be used to develop models of hunter-gatherer land-use (MacDonnell and Wandsnider 2003).

Seasonality is a critical variable in understanding the exploitation of caribou. In virtually all areas of animal physiology and behaviour, mammals have a seasonal component; thus in the complex relationship that human hunting entails, the effect of seasonality cannot be neglected (Byers and Hill 2009; Driver 1990:13; Read 2008). In addition, certain characteristics need to be known about the animals to make the pursuit successful. If the behaviour of the animal is known for instance, certain hunting techniques may be used. In addition, many large animals display pronounced seasonal variations in habitat, migration, population density, meat quality, and social behaviour (Brink 2008; Britton et al. 2009; Driver 1990; Read 2008).

One of the most significant seasonal aspects of many large game animals is migration. Migration is generally undertaken in response to food or water availability. In a migratory species such as caribou, the availability and predictability influences the seasonal acquisition of the animal being hunted (Britton et al. 2009; Burch 1972; Enloe and David 1997; Gordon 1988; Ingold 1980; Spiess 1979). The location of forage and a number of other environmental factors affect the location of caribou and the chances for hunters to predict their location. It might be expected that seasonal variation in caribou behaviour and physiology would affect the time at which a species was hunted and how it was hunted. Some have suggested that this will be more pronounced in northerly latitudes where seasons are better defined and where winter is a period of critical food shortage (Driver 1990:15).

4.8 Predictability

Resource predictability relates to the hunters' ability to locate ungulates that are necessary for various resources (Bamforth 1988; Burch 2007). If knowledge of some environmental condition enhances this ability, the particular resource is said to be predictable. Such knowledge might include information about a regular seasonal pattern of ungulate migrations or the spatial distribution of a landscape feature regularly used by animals. Another basis for predicting animal locations is a detailed knowledge of environmental conditions and of ungulate responses to them (Bamforth 1988:20; Brink 2008; Burch 2007).

Two factors, constancy and contingency, must be considered in an analysis of the predictability of a resource (Bamforth 1988; MacDonnell and Wandsnider 2003). Constancy measures the continuous availability of a resource, and contingency measures the predictability of a resource based on seasonality. Overall, temporal predictability of a resource is a combination of its constancy and contingency (MacDonnell and Wandsnider 2003). Constancy and contingency are dependent on the environment and the group's knowledge of the environment. If a resource is always in the same area, then its constancy level is high. If a resource is regular in its occurrence under certain circumstances, then its contingency is high.

The degree of patchiness and predictability can be assessed by considering the numbers of animals in a region, the size of herds they form, the degree to which herd size changes over the year, and from year to year, the frequency, speed, and distances of herd movements, and the regularity of those movements within a season and from year to year. Although correct prediction is rarely guaranteed on every hunt, environmental variables including vegetational distribution, treelines, topography, water barriers, and landscape features can be correlated with broad patterns of ungulate behaviour (Gordon 1990, Thacker 1997). In addition, several local environmental features are significant in determining ungulate predictability (Jochim 1976:103). These include the amount of snow and vegetation affecting the size of areas suitable for seasonal grazing and calving, the relative proximity of different seasonally suitable habitats, summer grazing, migration routes, winter habitats, fire frequency, and abundance of predators.

4.9 Mountain Environments of the Boreal Forest and Variability

The contrasted environments of the mountainous regions of the northern boreal forest were subject to change, and required different tactical solutions by inhabitants in the region depending on the situation (see Gamble 1986:115). Changes in spatial and temporal patterns of resource structure have important implications for how people situate themselves over the landscape (see Grove 2009; Lovis et al. 2005). Consequently, the archaeological record should exhibit variation in the different types of archaeological sites on the landscape (Gamble 1986:115; Lovis et al. 2005).

The organization of the environment (i.e. patches and seasonality) to which precontact hunter-gatherers in the southern Yukon had to adjust, no doubt imposed constraints and opportunities on human land-use patterns. Mountain environments, such as those of the southwest Yukon, are viewed as highly seasonal in terms of resource productivity and in some instances can be up to 3.5 times more diverse (i.e. patchy) than valley settings (see Morgan 2009). This is due to the effects that orographic precipitation has on biotic zone distribution and composition with growing seasons constrained by temperature and snowpack (Aldenderfer 1998; Morgan 2009). The results are mountains with compositionally and elevationally discrete biotic zones, each compressed into small horizontal spaces (Morgan 2009). Each discrete biotic zone contains smaller resource patches such as ice patches, berry picking locations, salt licks, and lithic sources. As a whole, each zone can be seen as large patches that are fundamentally distinct from each other. The effect is a zonal patchwork of very different resources (Aldenderfer 1998; Morgan 2009). In addition, no mountainous environment is constant from one year to the next; winters may be mild one year and severe the next and summers may be wet one year and dry the next (Kelly 1995). As a consequence, hunter-gatherer lifeways are not static, not even over a short period of time (Kelly 1995).

Humans have developed an impressive array of cultural mechanisms for dealing with environmental variability (Adams and Bowyer 2002; Aldenderfer 1998; Cashdan 1990; Halstead and O'Shea 1989; Kelly 1995; Kim 2006; Gamble 1986; Mandryk 1993; Morgan 2009; Read 2008; Rowley-Conwy and Zvelebil 1989; Weissner 1982; Whallon 2006). Cultural mechanisms used to mitigate environmental variability may include using various means of storage, diversification in resource use, employing multiple mobility patterns and establishing social alliances. Hunting and land-use patterns in the mountainous southwest Yukon must be defined in the context of these decision-making processes. Once an overall strategy has been established, however, it can persist for hundreds or even thousands of years (Chatters and Prentiss 2005).

Ethnographic and archaeological studies illustrate that boreal forest hunter-gatherers employed a wide range of mechanisms in the face of environmental variability (Hamilton 1988; Ives 1990; Minc 1986; Rogers and Black 1976). For instance, people regularly constructed social relationships to mediate spatial and temporal resource variation (Kelly 1995; Kim 2006; Moran 2006; Read 2008; Rushforth 1984; Whallon 2008; Wiessner 1982). In sparse environments, with high levels of temporal and/or spatial variability, which includes exploited seasonal rounds that cover large areas, cooperation between groups and the exchange of information about local and regional environments is important (Burch 2007; Cashdan 1990; Gamble 1986; Moran 2006). Alliance systems keep groups informed on the availability and location of resources and help distribute people advantageously over the landscape (Gamble 1986; Ives 1998; Moran 2006).

Exchange of information among hunter-gatherers is facilitated by the development of shared sodalities and kin structures (Albers 1993; Ives 1990, 1998; Moran 2006; Stone 2003:246). By extending social links over sufficient social and spatial areas any imbalances in resources can be addressed and decisions can be based on an interplay of resource predictability and productivity (Gamble 1986; Ives 1990, 1998). Alliances are used to gather information upon which to base strategic hunting decisions, but they also provide a further safety net if resources fail (Gamble 1986:55). The decisions on where to hunt or which resources to use are made by individuals, families, and groups that might cooperate beyond the local level.

Since resources inevitably vary and sometimes fail in northern forests, survival may be assured by not only the establishment, but also the maintenance of social bonds with groups using adjacent or overlapping resource-use areas (Hamilton 1988). Working in the boreal forest of northern Ontario, Hamilton (1988) suggests that one way of protecting the group is by establishing and maintaining alliances with a range of neighbouring groups (also see Whallon 2006). Humans using such regions may be very mobile and utilize a seasonal round that is flexible enough to contend with various physical, supernatural and political contingencies (Hamilton 1988:52). In order to be effective as a safety net, however, the rights and obligations created by these regional, social networks must be maintained so as to be fresh and active for everyone involved. This may entail the establishment of new social ties as well as the reaffirmation of existing ones often enough to keep both social relations and information solid and reliable (Whallon 2006:261).

Ives (1990; 1998), focusing on the principles underlying social group formation, found two broad patterns among Athapaskans that relate to alliance networks and information sharing. In the first, kinship structures promoting exogamy regulate the size of local groups, which results in the formation of extensive alliance networks. The higher levels of social organization function at the level of the regional group. In the alternative case, endogamy is promoted, leading to growth of the local group, and the emergence of social complexity within the group. The endogamous tendency, which results in the growth of local groups, also promotes the formation of inward-looking, socially isolated groups unlikely to share their knowledge. Ives (1998) suggests that these two types of local group formation may leave different patterns such as different approaches to communal hunting, variations in long-term land-use patterns, and stylisitic variations in artifacts.

4.10 Environmental Variability and Mobility

"There are no gardens of Eden on earth, no single locales that can provide for all human needs. Mobility – residential, logistical, long-term…..was the first means humans used to overcome this problem." (Kelly 1992:60).

Mobility is one way in which hunter-gatherers organize themselves in order to cope with problems of spatial and temporal fluctuations in resource acquisition (Kim 2010; Halstead and O'Shea 1989; Kelly 1983; Lovis et al. 2005; Mandryk 1993). However, variations in environmental productivity can result in uncertainty when deciding whether or not to move. A group or individual leaving one place risks that the costs of moving will not be offset by the benefits of accessing a new resource area or patch (Morgan 2009). Therefore, flexible strategies that employ both residential and logistical mobility patterns are one of the best ways to deal with environmental variability. Alternatively, search strategies in larger catchments may be more advantageous when seeking for diffuse or randomly distributed resources, especially when information on resources is poor or absent (Grove 2009). In fact, there is likely overlap between the potential for information gathering and the mobility strategy employed by a hunter-gatherer group (Grove 2009).

Accumulated knowledge about specific localities and general information about the environment play a particularly important role in mountain boreal environments (Burch 2007; Gamble 1986; Kelly 1983). Knowledge of an area is essential for collecting societies relying on resources that may vary in concentration, abundance, reliabilty, and preditictability both spatially and temporally (Lovis et al. 2005). In addition, hunter-gatherers living in more seasonal environments, especially those who store food for the winter, must put more effort into collecting information on the location and temporal availability of particular resources (Kelly 1983).

Hunter-gatherers know (with varying degrees of probability) when and where particular resources are available and rarely do they move at random (Kim 2010; Kelly 1995; Mithen 1989, 1990). A model where hunters are intimately familiar with animals and an area (or areas) is much more realistic than a model based on unrestricted wandering and fortuitous exploitation of resources by isolated groups of people (Hamilton 1988; Milne 2008). The degree to which a hunter may encounter resources requires that more or less effort be put into information-gathering which means that the patch structure of an environment is to be measured not only in terms of the physical distribution of resources but also the hunters' knowledge of those resources (Kelly 1995).

There are many ways to know and gain information about the environment. For instance, among the Nunamiut, during late childhood and into his premarital years, a young person learns local terrain in great detail. This is accomplished and conceptually mapped in terms of stories and experiences of earlier generations in that particular environmental setting and by the accumulation of personal experiences (Binford 1983:31; Burch 2007). During this "walkabout" young men are instructed on various aspects of the land, such as the denning areas of wolves, the trails frequented by caribou, the location of salt licks where sheep can be taken, and in general, monitoring the dynamics of the habitat (Binford 1983:40). The factors influencing the use of a particular location includes an understanding of the distribution of resources in particular habitats (Smith and McNees 1999; Wandsnider 1992).

Hunter-gatherers must also be familiar with an area and assess the usefulness and reliability of various resources and combine information on multiple resources (Kim 2010; Milne 2008:181). Advantageous to this situation is a sophisticated understanding of the variable resource potential of the area, and knowledge of the schedule of availability for each microhabitat. Such an understanding favours the hunter who maintains knowledge over a wide region or range. It would be necessary to be familiar with a repertoire of habitats (i.e. patches) in a relatively large region. This potentially would require considerable seasonal mobility within the area of familiarity. However, the familiarity of an area, alone, may be too limiting, whereas intimate knowledge about animals' habits in relation to a particular area and terrain applies widely and affords large numbers of alternative choices for hunting. In the process of gaining information about an area, hunters acquire knowledge relating to animal distributions and animal ethology. This allows for greater flexibility in the hunter's response to changes in animal location (Lovis et al. 2005).

Hunter-gatherers must continuously monitor the potential resources or locations where resources might be located and when they are available. Binford (1982) suggests that there is a quantifiable 'extended range' with which persons are generally familiar and about which they attempt to keep informed with respect to resource distributions and changes in production, although they may not be using that area at the time of observation. The extended range can be thought of in terms of future plans, ties with distant kin, and insurance in times of resource stress (Binford 1982: Grove 2009).

Logisitical mobility is advantageous when there is a great deal of terrain to be covered to acquire information on resources and gather information on current and potential future states of resources (Kelly 1983). Under conditions in which a group of hunter-gatherers know when a resource will be available, but they have less of an idea about where it will be available, the group must attempt to collect information on that resource – usually through logistical mobility (Kelly 1983:300). In this case, information gathered when monitoring resources can be used immediately or in the future. A hunter may decide to take a caribou on an ice patch immediately, or use the information gathered during the summer to locate and plan caribou hunting strategies during a fall migration. Due to the effects of commuting time, extensive logistical mobility becomes viable only when large faunal resources are to be acquired. Logistical mobility becomes even more important when there is a decreased capacity to depend on stored resources because when winter stores need to be supplemented, terrestrial fauna is one type of resource a group can use in the winter (Kelly 1983).

While hunter-gatherers who are dependent on fauna may use large tracts of land annually, they do not necessarily cover it thoroughly. For instance, among the Cree, hunters seek particular prey species in a few patch types that the species are known to inhabit at a given time, but avoid some patches altogether (Winterhalder 1981b). In addition, hunter-gatherers rarely leave residential locations on logistical forays to accomplish a single task (Binford 1980; Kelly 1983; Kim 2010; Whallon 2006). Large fauna are also exploited through extensive logistical mobility when there is a need for non-food items, such as hides, antler, bone and raw materials (Kelly 1983).

Hunter-gatherers in mountain environments tend to focus on logistical hunting, a pattern seen in the Rocky Mountains, Sierra Nevada, Great Basin, and the Andes (see Morgan 2009). However, the importance of logistical mobility is underrepresented in summaries of northern hemisphere precontact hunter-gatherers. Mountain environments, such as those of the boreal forest in the southwest Yukon are seasonal and patchy. People in these situations may choose to employ very little residential mobility and support themselves with logistical forays in small catchments (Morgan 2009).

5.0 ETHNOGRAPHIC AND ETHNOHISTORIC MODELS

5.1 Introduction

This ethnographic overview focuses on Athapaskan groups of the Cordillera and the inland big-game hunters Tanana and Koyukon of the Alaska Plateau (following Helm 1981; Nelson 1980; Townsend 1970). The people who occupied the region shared distinctive subsistence patterns that combined big game and small game hunting with fishing and gathering, with an emphasis on high mobility. In addition, subsistence patterns emphasize big-game hunting and the importance of caribou in the economy (McClellan and Denniston 1981a:372).

5.2 Overview of Traditional Northern Athapaskan Subsistence Economy in the Cordillera

According to ethnographic accounts, Athapaskan cultures of the Cordillera subsisted on a combination of big and small game hunting, fishing, and gathering of supplementary plant foods (Albright 1984; Gillespie 1981; McClellan 1975; McClellan and Denniston 1981, 1981a, 1981b, 1981c; MacLachlan 1981; Slobodin 1975; Nelson 1980). There was an emphasis on high mobility and nowhere did the inhabitants live year round in one place (Helm 1981; McClellan 1975; McClellan and Denniston 1981:375). According to McClellan and Denniston (1981), people of the Cordillera moved around in small groups annually, exploiting hundreds of square kilometres of their varied habitat. Periodically they adjusted their movements to large-scale changes in their traditional subsistence resources – such as changes in the core foraging or calving locations of caribou, increases or decreases in moose or salmon populations, or shifts in animal migration patterns (McClellan 1981c:493).

The focus of this research is to determine how caribou hunting at ice patches fits into the broader context of land-use in the southwest Yukon. Based on a synthesis of published ethnographic and ethnohistoric sources, I have summarized and presented an economic model of land-use for the Athapaskans of the northwestern Cordillera (Figure 6). The model presented here outlines general subsistence activities according to the spring, summer, fall and winter annual round (McClellan 1975; McClellan 1981b, 1981c, 1981d; Osgood 1971; Honigmann 1954, 1981). As presented in the model, variations in mobility patterns of human populations depended on the availability of resources in the immediate region. Seasonal availability of resources influenced decisions about specific pursuits, the movement of people from lowlands to uplands, and dispersion and aggregation patterns of social groups.

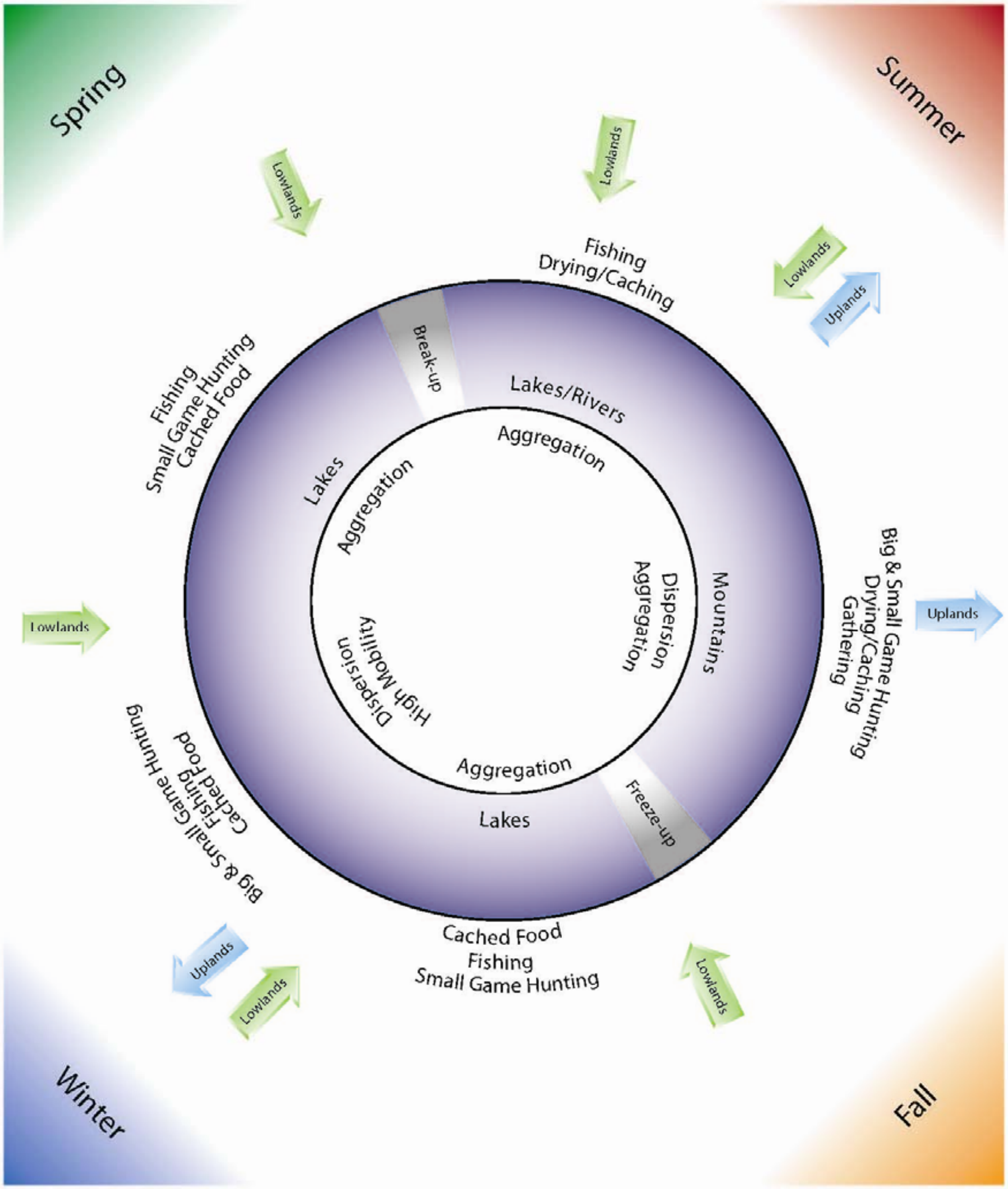


Figure 6. Annual Economic Cycle of the Northern Athapaskans. Based on McClellan 1975 and others.

In summer, those who had access to salmon, such as the Tutchone and Han, were catching and drying them for winter use (McClellan and Denniston 1981:376). The Tagish and Inland Tlingit had access only to poor quality salmon, while the Kaska had to rely on char and whitefish (McClellan 1981a, 1981b, 1981c; Honigmann 1954, 1981). When the dried fish was stored in caches, people moved high into the mountains for the late summer meat hunts critical for the survival of all groups. As people moved upland they made use of ground squirrels, marmots, and berries (McClellan and Denniston 1981a, McClellan 1981a, 1981b, 1981c). People hunted moose, caribou, sheep, and goat depending on what was available in the area. The main goal was to get prime meat and skins. Where great caribou herds were expected as in Tutchone and Han country many families comprising regional groups (terminology following Helm 1965, 1968) gathered together to drive animals into caribou fences or circular corrals (McClellan and Denniston 1981). Some groups also intercepted caribou at water-crossings. As with fish, much of the meat was dried and stored.

Toward the coldest part of the year all groups returned to their settlements of two or more households of kin-based groups, to live on stored food, supplemented by winter fishing and small game snaring. For instance, among the Southern Tutchone several households gathered around sheltered camps usually at good fishing lakes (McClellan 1981c). People attempted to stay together at least through the coldest and darkest times, but no group could remain sedentary for the entire winter. By late winter family groups were constantly moving again from one fresh caribou or moose kill to another or from one fish-lake to the next

(McClellan and Denniston 1981:472). During the coldest part of the season, the large winter camps usually broke into small units of one or two households that travelled independently in order to find big game, better fish lakes, and more abundant small game. This period of high mobility was halted by the difficult conditions of the spring thaw and this is when starvation was most likely, so people usually stayed where whitefish might be present (McClellan and Denniston 1981, McClellan 1981a, 1981b, 1981c). Hare and grouse often supplemented the spring diet. Hare, however, are subject to great population fluctuations and during years when hare and salmon populations were lower, hardship was inevitable. Starvation is reported for all subarctic Cordillerans although it is unclear how often this occurred in precontact times.

5.3 Caribou as a Human Resource

To those people inhabiting subarctic regions of North America, caribou have long been an important resource (Blehr 1990; Brink 2005; Cruikshank 1990; Gordon 1990; Irimoto 1982; Jackson and Thacker 1997; Legros 1999; Spiess 1979; Wright 1995). According to Burch (1972:339; Brink 2005) caribou may have been the species of single greatest importance in the literature of hunting societies. Not only were the animals a source of meat, especially as a cached resource in the winter, but they also supplied the materials for clothing, shelters, boats, netting, tool production and were a source of spiritual belief (Bishop and Krech 1980; Honigmann 1954; McKennan 1959; Nagy 1990; Osgood 1971; Smith 1975; LeBlanc 1984).

5.4 Caribou Hunting

Northern peoples have developed a wide range of sophisticated methods to hunt caribou (Burch 1972; Gordon 1990; Jackson and Thacker 1997; Jordhoy 2008; Spiess 1979). The most obvious factor leading to successful hunting of caribou is a thorough knowledge of the animal (Brink 2005; Burch 1972, 1991; Helm 1972). The reaction of caribou to the presence of humans greatly affects the way the animals are hunted. Factors that determine the reactions of caribou to humans include the season, the terrain, and the number of caribou in a herd. The means by which caribou detect humans are by scent, sound, and sight, all in varying degrees of sensitivity depending on the season and climate (Brink 2005; Gubser 1965:321; McClennan 1975:111). The hunter must consider these various responses of caribou to be successful in selecting the appropriate hunting strategies and tactics.

Caribou were hunted by means of tracking or stalking, which was carried out by individual hunters or small hunting parties. Single snares were often used along with arrows with detachable stone, bone and antler points. Spear points made with stone, were also used to dispatch the animals (Honigmann 1954). Occasionally, single snares, attached to drags, were set along caribou trails (McKennan 1959). Stalking sometimes involved the use of decoys. Among the Kaska, decoys consisted of the head and cape of a caribou and a caribou-hoof rattle, which imitated hoof clicks characteristic of the animal (also see McClennan 1975:111). The decoy was kept in front of the hunter while he crawled within bow-and-arrow range of an animal (McKennan 1969).

Open-water has a profound influence on caribou movement and distribution. Caribou are very strong swimmers, likely due to their buoyant pelage and broad hoofs and dewclaws, which provide an excellent propulsion mechanism (Kelsall 1968). As a result, caribou do not hesitate to enter lakes and swim many hundreds of meters (Kelsall 1968). Many caribou crossing places are used with such regularity that they become locations where hunters can anticipate the presence of caribou (Kelsall 1968; LeBlanc 1984).

The most commonly reported form of caribou hunting among northern Athapaskans involved communal hunting. This form of caribou hunting involves the organized channeling, concentrating and culling of caribou using natural or human-made devices. These methods varied with herd size (following Gordon 1990:280). In regions where there were large annual migrations of caribou the constructed surround was a commonly used hunting technique (Brink 2005; Emmons 1911; Gordon 1990; Honigmann 1954; McKennan 1959; McClellan 1975; Osgood 1936; Slobodin 1962). For instance, among the Peel River and Chandalar Kutchin in Yukon and Alaska, use of the surround was the main method of hunting. The surround was often a permanent structure of considerable size (Osgood 1936). Surrounds built by the Kaska were up to 20 meters in diameter, whereas surrounds among the Kutchin were estimated to be just over two kilometers in diameter (Honigmann 1954; Osgood 1936).

Hunting fences used in conjunction with snares are reported to have been used by almost all northern Athapaskan groups (McKennan 1959). Where large caribou herds existed, surrounds consisted of two long converging fences that opened into a corral that was up to several hundred metres in diameter (Osgood 1971; Spiess 1979). One side of the surround was left open and from this entrance stretched two lines of posts that widened like the mouth of a funnel (Osgood 1936:25). Posts, about one meter high were set into the ground to form the circular enclosure. Poles and brush were placed between the posts to prevent the caribou from escaping, except for the narrow openings in which snares were set. Hunters would line up at the entrance of the corral and shoot the animals that tried to escape. Otherwise, some caribou were caught in fence snares, although most were caught in the surround (Osgood 1936; McKennan 1959).

There were variations in the way in which the caribou surround technique was employed, depending on local geographic features. Among the Kaska, hunters drove caribou into a ravine or against a cliff where they could be easily speared. A similar form of game barrier consisted of fences of stakes and boughs built across low divides or well- traveled trails. These fences had frequent narrow openings in which snares were set, and which caught the antlers of caribou as they attempted to pass (Emmons 1911).

Sometimes humans formed caribou surrounds (Balicki 1963 as cited in Le Blanc 1984; Honigmann 1954). Balicki (1963) documented large communal hunts of caribou using boats at traditional migration crossings on the Porcupine River in the northern Yukon (Le Blanc 1984:21). The Han in Alaska surrounded caribou with several people and then dispatched them (Osgood 1971). According to Osgood (1971:109) “men, women, children, and old people” would join together while young men drove the caribou into the circle. Children waved sticks and hit the legs of caribou, while hunters shot the caribou with spears and bows and arrows.

5.5 Caribou Hunting Season

Caribou were hunted throughout the year, although there is a great deal of variability in the timing of caribou hunting. Depending on the region, seasonally changing caribou herd behaviour and size resulted in modified hunting methods (Gordon 1990). According to ethnographic accounts of northern Athapaskans, the most intensive harvesting of barren ground caribou took place during fall migrations when all ages of caribou moved to winter ranges. Among the Upper Tanana of Alaska, great numbers of caribou were hunted during two migratory seasons when large herds passed through the region. The late autumn drive took place around October/November, while the spring drive was in the middle of May (Gordon 1990:287; Guedon 1974; McKennan 1959). During his stay at the Nabesna River, Alaska during late November and December, McKennan (1959) observed up to 60,000 to 70,000 caribou crossing the river. Very few days went by without several caribou being in sight. In the fall and spring, the Koyukon used drive lane systems to block several mountain ravines where large herds of caribou traveled (Gordon 1990). Among the Great Bear Lake people (Hare, Slavey, Dogrib), a northeastern Athapaskan group, barren ground caribou were hunted during late spring/early summer, when great numbers of these animals migrated to the territory surrounding Great Bear Lake (Rushforth 1984). At this time, people gathered into large groups and focused their subsistence activities around caribou.

Winter was an important time to hunt caribou as it supplemented and prolonged winter stores for the northern Athapaskans. Among the Upper Tanana, caribou were most frequently trailed on snowshoe and shot with arrows (McKennan 1959). Among the Han in the interior of Alaska, hunters waited until the surface of the snow melted and then froze over so that they could move with ease as they stalked caribou. The caribou, on the otherhand, were almost immobilized when breaking through the ice-capped, crusted snow (Osgood 1971). Decoy hunting is also seen in connection with hunting caribou in winter. Among the Kaska a hunter watching a caribou on a lake would fashion a decoy by spreading a caribou skin across a willow framework. The caribou decoy, which was easily visible against the ice and snow background of the lake, was left on the ice, with the hunter a short distance away. Upon investigating the decoy, the animal was dispatched when in shooting range (Honigmann 1954). Among the Tahltan, woodland caribou were systematically hunted once the snow reached a depth of 60 cm or more (Emmons 1911). Finding a herd of animals, the hunters would drive them to a valley or a pocket where the snow was of sufficient depth to impede their movement at which point they were easily dispatched (Emmons 1911). Frozen lakes, especially long and narrow ones such as Dease Lake, were obstructed at favourite caribou crossing locations. At these locations, the Tahltan erected single brush fences leading to pole corrals on the shore, where frightened animals, with no place to run, were easily speared (Emmons 1911).

According to Osgood (1971), when there were several hunters and their families available in the winter, the Han travelled to the mountains looking for signs of caribou. Once caribou sign such as tracks were located, a camp was set up at the nearest open spot, such as on some clear ice or near a glacier. Most of the people camped at this location while five or six men looked for caribou, sometimes following them for two or three days and up to a week. When the hunters caught up with the caribou they herded them towards the camp. When the caribou were close enough to the camp everyone made a circle around the clear ice. When the circle was closed and the caribou were packed tight, people frightened the caribou into the surround, while the hunters shot them with spears and bow and arrows (Osgood 1971:108).

The following reports provide some insights into caribou hunting at ice patches during summer months. The Slavey hunted caribou primarily along the shores of Great Bear Lake, or near snowfields where caribou were known to escape swarms of flies and mosquitoes (Rushforth 1984:22). During fieldwork in the Richardson Mountains, Gwich'in elder from Arctic Red River, Mr. Walter Alexie, reported that in the past the Gwich'in used ice patches as harvest areas principally in summer for "stay-behind-caribou" as opposed the migrating caribou that move through the area in late fall (Hare 2007). Further north of the ethnographic area considered herein, Binford (1978:313:1980) reports that during the summer three Nunamiut men on the front ranges of the Brooks Range sought caribou on high mountain glaciers, where the animals are known to seek relief from insects. The climb from the men's hunting camp was almost 1000 meters over very rugged terrain where they located several large, fat bulls "near the ice".

The men camped near the kills for two days "enjoying the view" and then packed the choice meat portions down from the mountains to the hunting camp.

5.6 Caribou Hunting in the Southwest Yukon

Caribou in the southern Yukon were communally hunted towards the end of summer and into late fall when small work groups of two or three families (local bands; following Helm 1968) dispersed into seasonal hunting camps in the mountains (Allen 1994; Gotthardt and Hare 1994; Hare et al. 2004; McClellan 1975; Osgood 1971). The southern Tutchone went on "Shakats" to hunt game (Allen 1994). Shakats literally translated means summer, but also describes a harvesting period that lasted from the beginning of June to the end of September (Allen 1994). During this time, people moved from their fish camps to camps further in the mountains and along the valleys. The harvesting of larger animals such caribou, sheep and moose began from mid-July to the end of September when the animals were in prime condition. (Allen 1994). The Aishihik people are known to have used many Shakat trails, which followed along valleys and creek beds (Allen 1994:5).

Caribou were caught most often in snares set in fences (McClellan 1975:108). Usually a fence was constructed in the vicinity of known caribou browse in such a way that a limited number of individuals could drive them into the fence. Some of the fences consisted of a single long structure, often over a kilometer in length, and set with snares (15 - 150) a few metres apart. Brush was piled up like windfalls running straight or in a zig-zag fashion along the flank of a mountain. Some of the fences on mountainsides were simply made of solid brush so that hunters could drive caribou into a ravine or against a cliff where they could be speared or killed with bows and arrows rather than at snares (McClellan 1975).

In the southwest Yukon, caribou formed an important food item over the winter months, when cached supplies of dried fish and meat dwindled (Allen 1994; Gotthardt and Hare 1994; McClellan 1975). During times when people recall large numbers of migrating caribou, the mountainsides were so "black with caribou" that people could spot them from a distance and travelled to the mountains to harvest a few in the winter months. In other instances, some individuals recall that once cached supplies dwindled, people moved from one caribou kill to the next during winter months (McClellan 1975). Generally, caribou were hunted until weather moderated in March (Allen 1994) (Figure 7). Figure 8 shows caribou hunting in the alpine by non-Native hunters.

Figure 7. Caribou on ice patch. Yukon Archives. Emile Forrest Collection, 80/60 #248.

Figure 8. Caribou hunting in the alpine by non-Native hunters. Yukon Archives. Emile Forrest Collection, 80/60 #378.

6.0 UNGULATE ECOLOGY - OVERVIEW

6.1 Introduction

The essential relationship important in this study is that between human hunter and ungulate populations of the southwest Yukon. A hunter can, in many instances, anticipate animal distributions and densities based on factors such as forage conditions, migration and aggregation patterns. This does not mean that ungulates are totally predictable, but it suggests that there are some patterns in animal behaviour on which hunters can rely in deciding when and where to look for game. Patterns in animal behaviour define the structure of ungulate resources within a region to which a hunting society must adapt (following Bamforth 1988:43).

6.2 Forage Conditions and Ungulate Digestion

The process of food selection is fundamental to understanding many aspects of ungulate ecology (Hobbs et al. 1983). Food selection is an important determinant of the relative suitability of habitats for ungulates and is closely related to their patterns of dispersal, social structure, and tactics of predator avoidance (Hobbs et al. 1983). Limited food supply makes animals more vulnerable to predators, weakens calves, and leaves them more susceptible to disease. Therefore, ungulates move around in order to obtain adequate forage, and the area which these animals utilize during a given season reflects closely the kinds of food they require and can digest.

Different species of ungulates have developed specializations for various plant species or plant forms (Guthrie 1982; Sinclair 1975). For instance, studies among East African grazers indicate that there is considerable specialization for different plants of different protein/fiber content (Guthrie 1982). Smaller animals have a higher metabolic rate, and thus require higher protein and soluble carbohydrate requirements. In contrast, larger animals can tolerate more fiber (Guthrie 1982:313). Various grazers can live sympatrically where there is adequate diversity along this protein/fiber spectrum (Guthrie 1982:313). There are, however, other ungulate specializations in plant species or form, independent of the protein/fiber spectrum (Guthrie 1982:313).

The chances of any one herbivore being adapted to eating any one random plant species as a dietary staple are low. Energy and nutrients are available to herbivores but the main problem is how to avoid the plant chemical defenses, dilute their effectiveness, or detoxify them (Guthrie 1984:274). For instance, many plants in northern regions of the boreal forest and tundra are unpalatable or even toxic to large mammalian herbivores (Guthrie 1990:202, 204). Most of these plants are adapted to slow growth and slow rates of nutrient removal from the soil, and cannot tolerate heavy browsing by herbivores (Guthrie 1990:202). Plants use nutrients conservatively, allocating some resources to growth, and others to toxic chemical defense. These toxic chemical defenses make the plants unpalatable to many herbivores. Thus the plant species or plant parts an herbivore may utilize depends on how well that herbivore is adapted to each plant's defenses. For instance, ruminants are adapted to antiherbivory defenses such as alkaloids, which are associated with young successional and weedy species (Guthrie 1984:281, Figure 13.3).

Different herbivores not only rely on specializations for different species of plants but also for different plant parts (such as leaves or stems) (Bamforth 1988; Guthrie 1982:311). Ungulates have evolved the ability to select plants and plant parts with higher nutritional content than that of the available vegetation as a whole. This has led to various species of ungulates living in the same area to develop largely complementary feeding strategies (see Bamforth and citations 1988:44). The diverse food preferences of different species results in mixed populations of ungulates consuming a greater proportion of the total available plant food in a region than any single species could consume on its own (Talbot and Talbot 1963 in Bamforth 1988:45).

Complementary feeding strategies of different ungulates tend to create “grazing succession”. A grazing succession is created when a species with one food preference, such as leaves, exposes the stems and improves grazing conditions for a species that prefers them (Bell 1971 in Bamfoth 1988; Guthrie 1982; Martin 1982). Ungulates do this by selecting for the plant parts that are most nutritious and by selecting plants in earlier stages of growth (Guthrie 1982:311; Hobbs et al. 1983 in Bamforth 1988:44). Plant cells are surrounded by a relatively inflexible wall, which is largely composed of the carbohydrate cellulose along with hemicellulose and lignin (Hudson and White 1985; Johnston et al. 1968). The cell wall provides a support structure for the plant. In young tissues, which have to expand and do not support weight, the cell wall is thin and flexible. This condition is characteristic of the leaves and fruits of grasses and other flowering plants. In older tissues, the cell wall becomes thickened and hardened. This is the situation in the culms of tall grasses and stems of woody plants. For herbivores the division of feed between cell contents and cell walls is important because it effects the availability of protein and energy (Hudson and White 1985). For instance, caribou do not manufacture the digestive enzyme necessary to break down the cell wall of plants. Therefore, cellulose digestion is a slow process for caribou, particularly when the cell wall is lignified (Hudson and White 1985; Johnston et al. 1968).

Herbivores not only depend on plant communities for their existence but they also cause changes in plant community composition and structure. Studies suggest both inhibition and promotion of different palatable plant species (Augustine and McNaughton 1998; Beeskow et al. 1995; Crete et al. 2001; Helle and Aspi 1983; Kay 1995; Kay and Chadde 1992; Olofsson 2006; Ouellet et al. 1993; Risenhoover and Maas 1987). In some cases, intensive long-term herbivory can increase the dominance of highly palatable species (Augustine and McNaughton 1998; Helle and Aspi 1983). In a review by Augustine and McNaughton (1998), it was found that high levels of nutrient input or recycling and an intermittent temporal pattern of herbivory (often due to migration) are key factors increasing the re-growth capacity of palatable species, and hence maintaining their dominance in plant communities supporting abundant herbivores. In the Serengeti, the combination of seasonal migration, ungulates foraging in large, dense herds, high input rates of nitrogen to the soil system on growing season ranges, and plant disturbance such as trampling likely play a role in limiting unpalatable species (Augustine and McNaughton 1998).

6.3 Ungulate Migration

Individual animals live within a relatively circumscribed area, although the size and location of this region may change over time. The areal restriction is partly due to the animal’s ability to learn where, within a range, they can find suitable food, water, and shelter. The area an animal lives in includes the habitats that an animal regularly exploits or periodically revisits in the course of daily or seasonal movements. The size of this area depends on the density and distribution of the resources and is set by the seasonal locations of the animal’s preferred foods. When preferred foods are scattered over large areas, the exploited area is large and when they are concentrated in smaller areas, the exploited area is small. The areas within which ungulate species move during a given season, therefore, reflect the distribution of the kinds of foods they require, and by understanding the seasonal distribution of these foods, the animals’ seasonal home ranges can be predicted (Bamforth 1988:48). For instance, in summer and winter, meadows are primary locations for bison, where sedges, a preferred food, are found (Fortin et al. 2003; Hudson and Frank 1987).

The patterns of ungulate migration and aggregation can be determined by evaluating the density and distribution of forage and water in the animals’ area, in conjunction with the social and reproductive needs of the animals being studied (Bamforth 1988). As mentioned above, ungulates have evolved the ability to select a diet with a significantly higher nutritional content than that of the available forage as a whole. Therefore, some degree of mobility is an inevitable part of ungulate adaptations because animals deplete the food in a region by feeding and because water does not occur in all feeding areas (Bamforth 1988:48).

Many migrations occur when the forage in a local area is depleted. Under poor forage conditions, animals move more often, farther, and faster than under good forage conditions. When forage is widely available over large areas, the distance a herd will have to move between feeding areas will be less than when it occurs in widely separated patches. Under the typical pattern of seasonal forage use, herds tend to be largest during the plant growing season and smallest during the winter. The distribution of water has similar effects. Animals tend to form large aggregations around water where it is scarce, and disperse when water sources are more widely distributed (Bamforth 1988).

Many studies have shown that it is often possible to locate animals based on habitat preference (Burch 1972; Ion and Kershaw 1989). This is true not only for large-scale seasonal movements between widely separated habitats, but also for smaller movements between feeding areas within a single season. Evidence indicates that many ungulates perform “calculated migrations” (Baker 1978 in Bamforth 1988) based on assessments of suitability of a given habitat. When forage is depleted, animals often move to patches where they expect feeding conditions to be better (Bamforth 1988). Humans knowledgeable about the habits of game and their preferred forage were able to monitor habitats and make decisions about where and when to travel to pursue game. Although hunters may not have necessarily predicted exactly the location of game, they may visit certain types of habitats knowing there is the possibility that certain game may be located and potentially hunted when encountered.

7.0 CARIBOU ETHOLOGY

7.1 Introduction

Rangifer tarandus includes caribou and reindeer, and is a member of the family Cervidae, which belongs to the order Artiodactalyla (even-toed ungulates). Specific nomenclature for *Rangifer tarandus* has varied (see Spiess 1979:32-35), although Banfield (1961) has made a determined effort to revise and simplify caribou taxonomy. The caribou of northern North America are considered to belong to a single widespread species (*R. tarandus* (Linnaeus)), although there are some geographical subspecies (Banfield 1974). Caribou possess a number of features that indicate it is one of the more primitive members of the deer family. These features include the presence of antlers in both sexes, the relative prominence of "dew claws", the low placement of dew claws on the foot so that they bear some of the body weight, and the relatively simple crests on the cheek teeth (see Banfield 1974:383 for a complete listing). The common North American vernacular name is caribou, while early European explorers referred to these animals as reindeer. Indigenous names for caribou are varied. The Tagish refer to caribou as wAdjI (madzi); the Tutchone refer to caribou as mAdzi (udzi), and among the Tlingit, these animals are known as wAtsix (McClellan 1975). Gubser (1965:296) also outlines caribou designations among Indigenous populations who use attributes such as age, sex, size, and condition of the coat to distinguish between categories of animals.

7.2 Pelage

Caribou pelage varies seasonally, and with age and sex, due to differential moulting characteristics (Kelsall 1968; Skoog 1956). Adult males shed their heavy winter pelage in the spring and early summer but this annual molt begins later for younger animals and females (Kelsall 1968; Spiess 1979). By June or July caribou usually have new coats but pelage is short. Also in the summer parasitic larvae (warble flies) lay their eggs in the skin of caribou (Gubser 1965; Kelsall 1968; Nilssen and Haugerud 1994; Hagemoen and Reimers 2002; Stefansson 1944; Banfield 1954). Larval development continues over the fall and winter and by spring the larvae leave the caribou through their breathing holes cut into the skin and pupate on the ground (Hagemoen and Reimers 2002; Kelsall 1968:271). By the end of summer caribou have a new coat which is made up of long guard hairs (Kelsall 1968).

7.3 Antlers

The growth and shedding of antlers throughout the year varies with age and sex of animals. Among barren ground caribou, adult males begin to shed in early November, just at the termination of the rut. Among adult females most antlers are not shed until calving period in June. The velvet is shed later in females than in males, although according to some reports most caribou shed their velvet by the end of September (Kelsall 1968:40). Both male and female caribou carry antlers, with male antlers frequently achieving impressive proportions.

Cows and young animals usually carry antlers which are smaller and simple in development (Kelsall 1968).

7.4 Caribou Meat and Fat

Barren ground caribou weigh much less than woodland caribou, but generally variations in individual body weights are due to age and to physiological and seasonal factors. The average weight of a male and female barren ground caribou is 150 kilograms and 90 kilograms, respectively. In contrast, woodland caribou weights average 180 kilograms for males and 132 kilograms for females (Allen 1994; Banfield 1961; Gubser 1965; Kelsall 1968). Woodland bull caribou in British Columbia have been reported to weigh as much as 273 kilograms (Gubser 1965:297).

The caribou fat cycle differs in timing with sex and age (Stefansson 1956). Barren ground caribou bulls are heaviest prior to the rut (August, September, or October) when they are known to be in prime physical condition (Kelsall 1968; Stefannson 1956). Bulls are leanest in late fall (November) after the rut. In contrast, adult cows and young, non-breeding animals do not achieve the impressive fat deposits of the big bulls and the timing of their fat cycle is different (Kelsall 1968). Cows carry significant amounts of fat during the rutting season and are thinnest in the spring (May).

7.5 Diet and Forage

A large volume of research is dedicated to assessing caribou diet (Bergerud 1972; Bergerud and Nolan 1970; Boertje 1984; Holleman et al. 1979; Bjorkwoll et al. 2009; Holleman and Luick 1977; Oosenbrug and Theberge 1980; Scotter 1967; Skogland 1980; Thomas and Edmonds 1983; Thomas et al. 1996; White and Trudell 1980). Methods used to reconstruct caribou diet are based on several techniques including field observations, examination of stomach contents, esophageal fistula sampling, and fecal analyses (Bergerud 1972; Bergerud and Nolan 1970; Boertje 1984; Rominger and Oldemeyer 1990; Scotter 1967; Thomas and Edmonds 1983; Thomas et al. 1996). Relying on only one method may, however, provide an incomplete picture of caribou diet. For instance, there are different rates of digestion among some plant groups and not all plants are equally represented in large and small screenings from stomach contents. In some instances, results from two different methods provide different impressions of caribou diet selection (Bergerud 1972; Bergerud and Nolan 1970; Boertje 1984; Rominger and Oldemeyer 1990; Scotter 1967; Thomas and Edmonds 1983; Thomas et al. 1996). This is also the case when examining pollen from dung. Some parts of caribou diet, such as lichen, do not produce pollen and are therefore completely absent from pollen analyses of dung. Keeping these methodological issues in mind, some general comments can be made regarding caribou diet.

Caribou are generalists in food habits and are adapted to eat many different types of foods, incorporating a large number of plant species which many other ungulates avoid (Bergerud 1972). Studies indicate that caribou diets vary greatly among herds depending on the availability of palatable species. The selection of vegetation types by caribou is related to nutrient content, availability of biomass, toxicity, and avoidance of secondary compounds which may cause inhibition of rumen function (White and Trudell 1980).

In general, the dentition of caribou is typical of cervids, but it is particularly adapted to grazing (Kelsall 1968:25). Guthrie (1996:128) suggests caribou are intermediate between browsers and grazers, as they eat substantial amounts of grass and sedges, although the incisors of caribou are relatively weak and not suited to browsing woody vegetation (Bergerud 1972; Skoog 1968). Behaviourally, caribou are browsers and delicate feeders that prefer picking their food with their mouths rather than tearing it as do true grazers (Banfield 1974; Spiess 1979:63). The nature of the foraging process lends itself to the accidental ingestion of a wide variety of small items (Kelsall 1968).

Caribou diet can be divided into seasonal shifts from spring, summer, fall, and winter habitat (Table 2). The dominant food groups presented in Table 2 illustrate the types of variations in diet according to season based on a study done on the Denali caribou herd in Alaska (Boertje 1984). Although caribou diet contains large numbers of plant species and can vary greatly among herds, the emphasis here is on the major seasonal variations and broad categories of dominant food groups.

SPRING	**SUMMER**	**FALL**	**WINTER**
Deciduous shrubs	Deciduous shrubs	Lichens	Lichens
Lichens	Lichens	Deciduous shrubs	Sedges
Forbs	Sedges	Sedges	Mosses
Sedges	Forbs	Mushrooms/Fungi	Forbs
	Mushrooms	Mosses	

Table 2. Dominant food groups of caribou listed in descending order of importance. Based on information summarized in Boertje 1984.

In general, caribou follow fresh, green vegetation as it becomes available in the spring and seek areas where it is most abundant. In the summer caribou are less particular in their feeding behaviour and a number of forbs and the leaves of many woody perennials are eaten as new growth develops. With the onset of autumn the consumption of many plants diminishes as they become mature and tough when there is an increase in cellulose and lignin. Once annual vegetation is frosted and dry, and the snow falls, caribou diet becomes much more limited as lichens become the most important source of winter food.

7.6 Caribou Migration

There are some key differences between barren ground and woodland caribou migration. The barren ground caribou are considered truly migratory as they make directionally oriented, purposeful, and uninterrupted movements twice annually between distant winter and summer ranges (Kelsall 1968). These migrations consist of large aggregations of animals, in the thousands, occupy three to four months per year, and span distances from 160 to 1100 kilometers

(Kelsall 1968). In the spring, barren ground caribou move from their winter ranges to the calving grounds (Kelsall 1968; Skoog 1956; Symington 1965). The spring movement is particularly rapid and direct and is from forest to tundra by direct routes. The second migration occurs from late summer to early winter and may be less rapid and direct than the spring migration. This migration involves a widespread drift from the tundra toward treeline. At treeline caribou move along the forest-tundra or move into the forest briefly before moving back to the tundra. By late fall, after the rut, the migration becomes more rapid and directional into the forest (Kelsall 1968).

Woodland caribou generally fall into the categories of forest or mountain type. The forest-type woodland caribou inhabit mature forest areas and the edges of fens and heaths where there is available lichen (Banfield 1974; Darby and Pruitt Jr. 1984). Caribou of the forest-type tend to be more sedentary and remain year-round in forested areas, often due to deep snow conditions and food availability (Boonstra and Sinclair 1984; Darby and Pruitt Jr. 1984; Edmonds 1988; Freddy 1979; Rominger and Oldemeyer 1990; Stuart-Smith et al. 1997).

Mountain woodland caribou inhabit mountainous regions, where they inhabit alpine tundra and subalpine forests. Mountain woodland caribou also occupy a common winter range that is geographically distinct from neighbouring herds (Farnell and McDonald 1989; Farnell et al. 1998; Kuzyk and Farnell 1997). Mountain woodland caribou occur at lower densities, form smaller aggregations, make less extensive seasonal movements, disperse rather than concentrate when calving, and spend some portion of their lifetime above treeline (Farnell et al. 1998).

In contrast to barren ground caribou, woodland caribou are basically solitary animals. They congregate into bands in winter and early spring when mean group size is around five to six, then later separate so that the fawns are born to isolated females (Pruitt and Baskin 2004; Sheldon 1925:324). In the fall, woodland caribou congregate again, in rutting bands where the mean group size is around six individuals. By late autumn or early winter caribou separate once more into small bands and scatter. The size of the wintering groups is a reaction to snow cover. In winters with thin snow cover the groups are smaller and scattered, but in winters with thick snow cover the caribou congregate into larger bands (Darby and Pruitt 1984).

7.7 Winter Snow Conditions and Summer Insect Harassment

At certain times of the year caribou are relatively sedentary or prefer very specific sets of environmental conditions (Gordon 1990:279; Kelsall 1968; Skogland 1985). These conditions occur regularly twice a year: during winter and again at the height of the fly season in July and early August (Burch 1972; Gordon 1990; Ion and Kershaw 1989). In winter, the critical factor is the influence that snow conditions have on caribou movement. Snow conditions may keep caribou within a fairly restricted region. Snow depth is often an important factor because of the energy costs of removing snow and hard icy snow by caribou when cratering in search of food. Snow and hard icy snow can also impede locomotion, thus decreasing forage intake (Boertje et al. 1996; Brown and Theberge 1990; Holleman et al. 1979; Larter and Nagy 2001; Thomas and Edmonds 1983). Furthermore, more days with snow can increase energy expenditure and also decrease forage intake, selection, and quality (Boertje et al. 1996).

The second time of the year when caribou prefer specific environmental conditions is during the fly season (Edwards and Ritcey 1959; Fuller and Keith 1981; Kelsall 1968; Oosenbrug and Theberge 1980; Skoog 1956; also see Formozov 1946 in Ion and Kershaw 1989 for Eurasia). During the warm season, caribou are plagued by insects and/or heat and are often concentrated in areas which provide relief. During the fly season caribou have a strong preference for hilltops that have either stiff prevailing winds or patches of unmelted snow, which may include areas with snow from the previous winter, cool shady forests, and ice patches. Caribou are known to prefer the cold air on patches of unmelted snow in sheltered hollows along steep northern hillsides (Calef 1981:86). In these types of situations harassment by flies is substantially reduced.

In many regions, winter conditions and summer insect harassment conditions are present at specific localities with some regularity from one year to the next. Hunters who know about these localities can travel to the appropriate places with some assurance that their chances of finding game will be much greater than elsewhere. However, predictability of caribou at ice patches partly depends on climatic variability, which may be measured in terms of fluctuations within seasons, differences from year to year in the timing of freeze and thaw, or yearly variations in the severity of winter.

7.8 Caribou in Southern Yukon Today

There are several caribou herds residing in eastern Alaska and the Yukon. Out of the twenty-six herds, twenty-three herds of woodland caribou *(Rangifer tarandus caribou*) are presently found in the southern Yukon (Figure 9). Recent DNA studies found little or no gene flow between the Fortymile herd (Figure 9, #25) and the herds of the Southern Lakes region, that fall in the study area of this research (Kuhn et al. 2010). The Fortymile herd, a barren ground caribou (*Rangifer tarandus granti*), historically occupied a large area from Fairbanks, Alaska to Whitehorse. Local knowledge of the Fortymile herd suggests that when the herd was large, caribou would be in the central Yukon during the summer and reach the boreal forests of southern Yukon during the winter only. In the past the herd would have occupied its southern range limits during the winter months, when individuals are most dispersed, and the ice patches are covered in deep winter snow (Kuhn et al. 2010). Today this herd is much smaller and largely confined to Alaska (see Kuzyk et al. 1999).

Woodland caribou in the southern Yukon are classified as the mountain/terrestrial ecotype based on their winter foraging behaviour and DNA analysis (Edmonds 1988; Kuhn et al. 2010). Southern Yukon's woodland caribou herds occupy a traditional "core winter range" during late winter. Woodland caribou herds in the region demonstrate strong fidelity to their winter range,

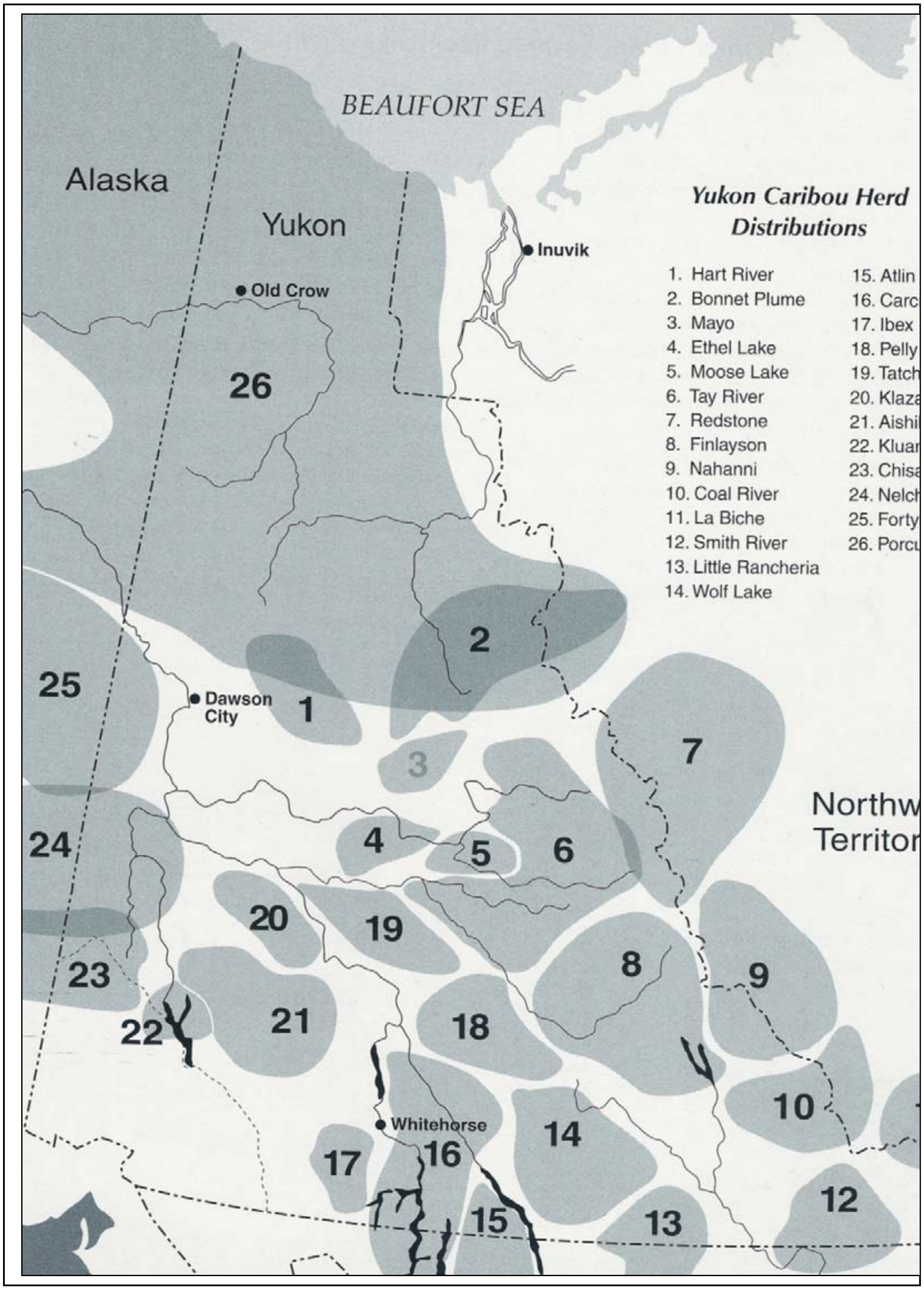


Figure 9. Caribou herds of Yukon Territory and adjacent areas. Adapted from report on Woodland Caribou Management Guidelines, 1996.

which is likely the obligatory response to environmental/climatic parameters such as habitat preference and snow depth (Farnell and McDonald 1989). A number of studies emphasize the importance of winter diet and habitat for the resident woodland caribou herds in the region. This range is influenced by snow cover patterns in relation to lichen abundance (Farnell and MacDonald 1989, 1990; Farnell et al. 1991; Kuzyk and Farnell 1997; O'Donoghue 1996; Woodland Caribou Management 1996).

In the spring, woodland caribou of the southwest Yukon move out of the trees into sub-alpine regions in response to new plant growth in snow free areas (Oosenbrug and Theberge 1980). In late May to early June caribou calve (Table 3) in alpine habitats associated with high, rugged terrain features and cows are often dispersed one to two per mountain-top over a wide area (Farnell and MacDonald 1989, 1990; Farnell et al. 1991; Kuzyk and Farnell 1997; Oosenbrug and Theberge 1980). It is at these locations that cows give birth to a single calf in isolation, which is thought to reduce predation risk (Bergerud and Elliott 1998; Bergerud et al. 1984; Edmonds 1988; Heard and Williams 1992; Oosenbrug and Theberge 1980; Stuart-Smith et al. 1997). As the snow melts caribou move up to the alpine zone following the greening up of forbs, grasses, and sedges. These nutrient-rich plants are also necessary for milk production.

SEASON	**SPRING** (Late May to early June)	**SUMMER** (June to August)	**FALL** (Mid - September to mid-October	**EARLY WINTER** (Mid-December)	**LATE WINTER** (January to early April)
Activity	Calving	Post-Calving	Rut	Move out of alpine	Move to winter range
Location	Isolated mountains	Wind-swept ridges and snow patches in the alpine	Alpine	Timbered valleys in heavy snow years Alpine in light snow years	Snow shadow region between mountain ranges with ample food and nearby lakes
Group Composition	Cows and calves isolated from bulls and non-calving females	Cows and calf groups Mature bull bands These groups do not associate	Bulls, cows, and calves mix together Larger aggregates of caribou	Mature bulls form bachelor groups (often at periphery of herd's range) Cows and calves in core winter range Cows without calves and immature bulls are with any group	Groups continue to be segregated

Table 3. Summary of five important stages of the annual life cycle of woodland caribou in central Yukon. Summarized from Kuzyk and Farnell 1997:5, 6 and Allen 1994.

The subalpine and alpine provide the summer range for caribou in the mountainous regions of the southwest Yukon. Mature bulls are largely separated from the bands of calves and cows during this time (Farnell and McDonald 1990; Farnell et al. 1991; Kuzyk and Farnell 1997). Caribou of the Yukon are known to use permanent snowpatches that occur at high elevations in mountains. For instance, during July and August woodland caribou of the Kluane Ranges dispersed from large aggregations to small groups and individuals as they sought wind-blown terrain and remnant snow patches. Caribou were observed at elevations primarily between 1500 to 1800 m during mid-summer and above 1800 m from mid-August through the rutting period (Oosenbrug and Theberge 1980).

During the rut from about mid-September to mid-October caribou are found in confined, large aggregations of mixed groups in alpine areas. As winter progresses caribou disperse from alpine areas into timbered locations. In light snow years caribou are known to remain on alpine locations but when there is heavy snow they move into the valleys.

7.9 Proposed Altitudinal Hunting Model

To develop a comprehensive picture of caribou hunting in the southern Yukon, it is essential to examine altitudinal caribou migration. Although evidence suggests that long distance migrations were made, for instance, by the Fortymile caribou herd from interior of Alaska to the Yukon, smaller scale, altitudinal migrations also existed in the southwest Yukon. The topography of the northwestern subarctic Cordillera is crucial to understanding caribou migration and hunting strategies in the southwestern Yukon during the Holocene. Smaller scale migrations, altitudinal in nature, are a response to topographic relief, which is significant in terms of vegetational patches and other landscape features (Thacker 1997:93; Lovis et al. 2005). If hunters know that caribou are most likely to be at ice patches at a particular time, then it is expected that hunters will take advantage of them being there.

The seasonality model proposed for ice patch hunting in this research can be tested using pollen recovered from caribou dung. Caribou diet varies across seasons with each season being defined by a different ranking of plants (Table 4). In Table 4, taxa are listed according to season in the order of highest ranking for each season. It should be noted that this table is based on a general assessment of several caribou diet studies from various regions (Bergerud 1972; Bjorkvoll et al. 2009; Boertje 1984; Scotter 1967; Thomas et al. 1996; Thomas and Edmonds 1983). Some variability in major plant categories according to season is expected depending on the herd and geographical location. Regardless, this table provides a set of general patterns that might be expected.

If ice patches were used by caribou in the summer, then it is expected that pollen signatures from dung will reflect that season. The composition of taxa in summer dung might include high percentages of *Salix*, sedges, and forbs. In contrast, winter diet is characterized by high percentages of lichens which leave no trace in the pollen record so this season may be expected to yield dung with consistently few taxa. For spring dung, taxa in early stages of development may have no pollen and this may leave little in the way of pollen traces in dung.

Spring	**Summer**	**Fall**	**Winter**
Deciduous shrubs (early stages of growth) *Salix*	Deciduous shrubs *Salix*	Lichens	Lichens
Forbs (in early stages of growth) *Anemone* *Equisetum* *Potentilla*	Lichens	Evergreen shrubs *Ledum*	Evergreen shrubs *Vaccinium, Ledum, Empetrum*
Sedges *Carex* *Eriophorum*	Sedges *Carex* *Eriophorum*	Deciduous Shrubs *Salix*	Sedges *Carex* *Eriophorum*
Evergreen Shrubs *Empetrum* *Vaccinium*	Forbs *Saxifraga* *Astragalus* *Epilobium* *Oxytropis* *Polemonium* *Stellaria*	Sedges *Carex* *Eriophorum*	Mosses
Lichens	Grasses *Festuca* *Hierchloe*	Mosses	Forbs

Table 4. Major plant taxa in caribou diet based on a general assessment of various rumen, microhistologcal, esophigal, and observation studies. References consulted include Bergerud 1972; Bjorkvoll et al. 2009; Boertje 1984; Scotter 1967; Thomas et al. 1996; Thomas and Edmonds 1983

8.0 METHODS

8.1 Ice Patch Research Overview

Aerial surveys have identified 80 ice patches of variable size since the discovery of the dung-rich alpine ice patches in the southwest Yukon in 1997 (Hare et al. 2004; Hare 2007; Kuzyk et al. 1999). Most of these ice patches are located in the Haines Junction- Whitehorse-Carcross area of the southern Yukon (Hare 2007). Upon initial discovery of dung material in ice patches, pellets were submitted to the Habitat Nutrition Laboratory, Washington State University, for plant fragment analysis (Kuzyk et al. 1999). Analysis concluded that the high percentages of lichen indicate that caribou rather than Dall sheep (*Ovis dalli*) were responsible for the fecal pellet concentration (Kuzyk et al. 1999 and see Hoefs and McTaggart-Cowan 1979). Since then ancient DNA studies confirm the presence of caribou at ice patches (Kuhn et al. 2010).

Sixty-five ice patches have been ground-surveyed for organic materials and nearly half of these have yielded an abundance of biological specimens, while a third of the total have yielded archaeological materials (Farnell et al. 2004). In conjunction with the Ice Patch Research Project, the author conducted paleoecological investigations in the southwestern Yukon during the summers of 1998, 1999, and 2003. The Ice Patch Research Project's aerial and ground surveys, artifact collection, and paleoenvironmental sampling were the first to be carried out at these sites, documenting a unique record of previously unreported precontact land-use (Farnell et al. 2004; Hare et al. 2004).

Paleoecological samples from ice patch sites were collected as part of my field research. Two ice patches from the Whitehorse/Carcross area, Granger and Friday Creek, were chosen for intensive paleoecological sampling following archaeological surveys (Figure 10). Granger and Friday Creek ice patches were selected as sampling sites because of their large size and numerous dung-rich layers. Samples were collected from modern caribou dung to assist in the interpretation of paleoecological dung deposits. Thandlat (JdVb-2), the original ice patch site identified in the southwest Yukon (Kuzyk et al. 1999; Farnell et al. 2004; Hare et al. 2004), is included as a reference site and is used for comparative purposes in some discussion. No dung pollen was analysed from the Thandlat site. Dung from the living Ibex caribou herd who range in the area south of Carcross Road, a few kilometers southwest of Whitehorse, was collected from spring, summer, winter, and fall deposits following field methods of Farnell et al. (1991). These dung samples were analysed for pollen remains.

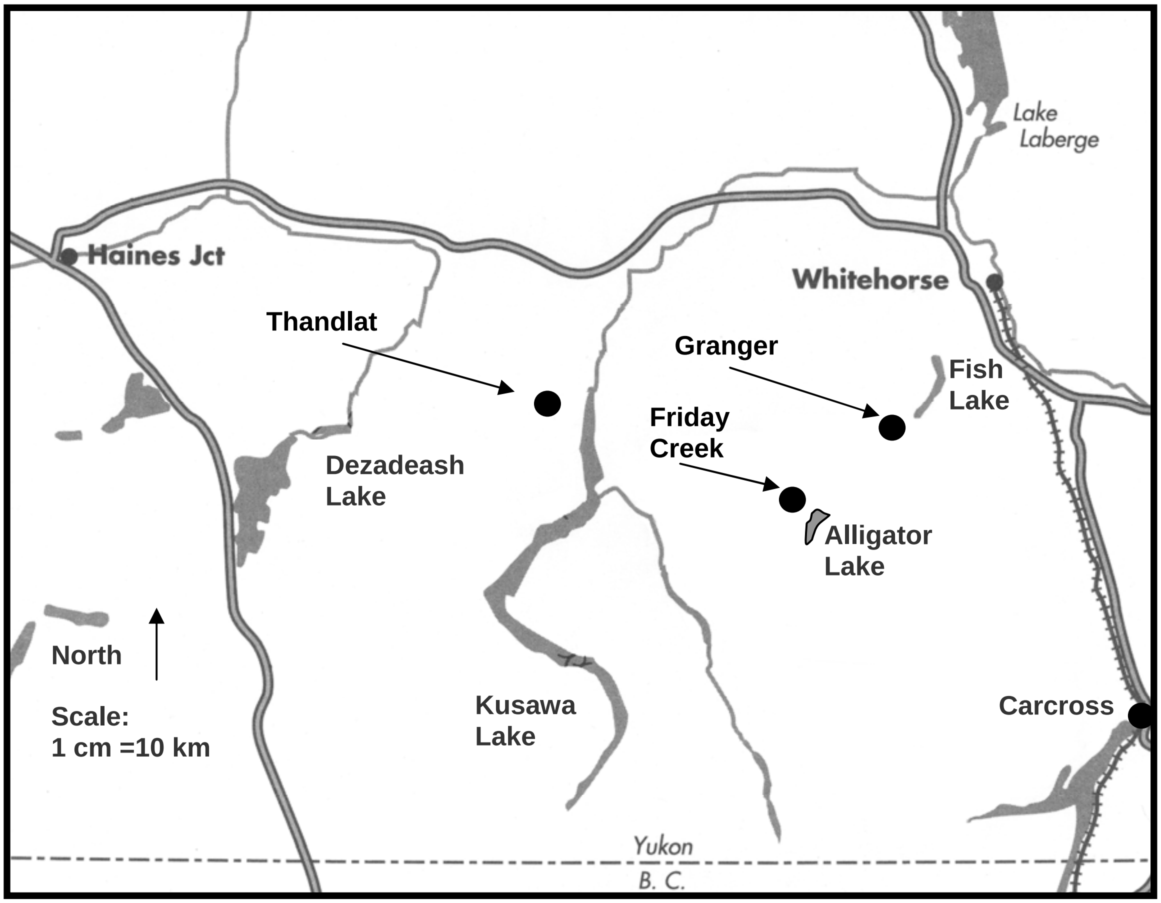


Figure 10. Map showing the sampling locations Friday Creek and Granger ice patches. Thandlat ice patch was not sampled but it is a reference site used for comparative purposes.

To become familiar with the local flora and vegetation botanical surveys of local plant communities were conducted at alpine locations including the Granger, Friday Creek and Thandlat ice patches. Plants were collected, pressed, and returned to the University of Alberta's Paleoenvironmental Laboratory, Department of Anthropology, Edmonton and curated for future reference (Rhodes 1999).

8.2 Field Methods: Sampling of Ice Patches for Paleoecological Material

Vertical measurements of stratigraphy and sample locations were made along the exposed, sloping face of the Granger and Friday Creek ice patches (Farnell et al. 2004). Blocks of dung-rich ice were cut from the ice face with a lubricant-free chain saw and kept frozen until laboratory analysis (Figure 11). Logistical procedures during sampling of ice patches were difficult given their alpine location (requiring helicopter charter) and the steep angle of the ice, which required specialized mountain climbing equipment (Figure 12). In addition, ice patches were covered in freshly melted-out dung resulting in extremely slippery and potentially dangerous sampling conditions.

Figure 11. Erik Blake sampling an ice patch using lubricant-free chainsaw to remove blocks of ice from ice face. Note mountain climbing gear.

Figure 12. Rick Farnell sampling an ice patch. Note steep angle.

Ice patch chronology is provided by 35 AMS dates on stratigraphically controlled dung pellets and buried vegetation (Farnell et al. 2004: Table 2). AMS dates were determined by University of Toronto Isotrace Laboratory; Beta Analytic Inc., Miami, Florida; and Lawrence Livermore National Laboratory, Berkeley, California. Radiocarbon dates were calibrated using CalPal 2007 online by the Cologne Radiocarbon Calibration and Paleoclimatic Research Program (Danzeglocke and Weninger 2007). All results are expressed as uncalibrated radiocarbon years (yrs BP) and calibrated years (cal yr BP), where BP is 1950 AD.

8.3 Laboratory Methods: Pollen Processing

From each sample of modern dung, a single pellet was extracted and processed for pollen. From each ice block collected at ice patches, at least five intact dung pellets were extracted, when possible. These pellets ranged in weight from 0.5 to 1.5 grams. Where intact pellets were not available the equivalent of five, 0.5 to 1.0 g sub-samples were removed from homogenized, amorphous dung mixtures. Each sample was screened and washed in distilled H_20 prior to processing. One tablet of concentrated *Lycopodium* spores (each tablet contained 13,911 spores; Batch 710961) was added to each sample prior to pollen extraction. The introduced *Lycopodium* tracer spores were counted to provide an index of the quality of pollen recovery in the processing as well as the pollen concentration (Berglund 1986). Chemical treatment of pollen samples or “pollen extraction" was conducted at the University of Alberta's Paleoenvironmental Laboratory, Department of Anthropology.

Pollen processing was done using the standard acetolysis procedure outlined by Birks and Birks (1980), Faegri and Iverson (1964), and Moore et al. (1991), and followed the steps outlined below.

i) Boil dung pellet with 10% NaOH to remove the soluble humic acids. Sieve to remove the coarse debris.
ii) Treat with cold HF for one hour to remove siliceous material.
iii) Treat with hot acetolysis mixture (9:1 proportion of acetic anhydride and concentrated H_2S04).
iv) Neutralization of sample. Dehydrating of sample with alcohol.
v) Mounting of sample with silicone oil and sealing with a coverslip and nail polish.

8.4 Pollen Analysis and Identification

Pollen identifications were done on a standard Leitz transmitted light microscope up to 400x magnification. For samples from modern dung, pollen was counted to 200 grains per sample. Where possible, pollen was counted to a miminum of 400 grains per sample from ancient dung, in order to get relatively consistent pollen sums and a representative number of plant taxa (Birks and Birks 1980). Where pollen concentration was low up to three slides were counted. When there were clusters of particular taxa (e.g. Cyperaceae), suggesting the presence of an anther, the cluster was noted and given three counts.

Pollen identifications were made to the lowest possible taxonomic level. Identifiable specimens are those that can be identified to at least the family level. In some cases it is not possible to identify taxa beyond a very broad taxonomic grouping. For instance, there are 120 documented species of sedges in the Yukon

(Cody 1996), none of which are identifiable as pollen to the genus or species level. Therefore, sedge pollen identified in this study was grouped under the family Cyperaceae. Pollen identifications were made using the extensive comparative collection housed at the University of Alberta's Paleoenvironmental Laboratory, Department of Anthropology and various reference materials and keys (Bassett et al. 1978; Habgood 1985; Kapp 1969; Moore et al. 1991). In addition, various selected papers were used in pollen identifications (Birks and Peglar 1980; Clegg et al. 2005; Cwynar 1982; Hansen and Engstrom 1985; Ives 1977). Pollen designated as Unknown is that which could potentially be identified, but for which an identification could not be made. Pollen grains that were torn, highly corroded, crumpled, obscured or that lacked diagnostic characteristics were labeled as Unidentifiable. All plant nomenclature follows Cody (1996) and Faegri and Iverson (1964).

8.5 Pollen Analytic Procedures

8.5a Diagrams

Relative percentage pollen diagrams were constructed using the computer program Core 2.0 (Kaland and Natvik 1993; unpub.). Pollen taxa of low frequency (< 5%) or identified in less than three samples were considered rare pollen. The rare pollen types were not included in the diagrams, but are recorded in Appendices A, B, and C. The pollen sum used to calculate percentages for the relative percentage diagrams consists of all identifiable pollen types.

Indeterminate and Unknown pollen were excluded from the pollen sum but their frequencies were calculated based on the pollen sum.

When there was more than one individual pellet at specific levels preserved *in situ* in the ice, multiple pellets were examined separately and the results were then pooled for diagrams. This resulted in the pollen histograms consisting of pooled multiple dung pellets from various levels. In addition, even when sample pollen counts are <100, they are included in the pollen zonation. This results in some variation in reliability between pollen counts from stratigraphic layers.

8.5b Zonation by Inspection

Pollen diagrams were constructed for Friday Creek and Granger ice patches. Pollen diagrams are complex and generally some guide is needed to aid in interpretation. The first step is to divide pollen diagrams into local pollen assemblage zones. The second step is to develop regional pollen assemblage zones, which can be established on the basis of comparison between individual pollen diagrams (Birks and Birks 1980; Gordon and Birks 1972; Lowe and Walker 1997; Moore et al. 1991). For the purposes of this study, pollen zonation was done to assist in presenting and discussing pollen assemblages but they are not meant to be interpreted as local pollen zones that can be compared on a regional basis.

Zonation of Granger and Friday Creek pollen diagrams was done by visual inspection. The main goal of zonation is to divide the pollen diagrams into a series of convenient units, each being as internally homogeneous as possible, to aid in description and discussion (Birks and Birks 1980:168; Lowe and Walker 1997; Moore et al. 1991). Each pollen assemblage zone should display recognizable pollen characteristics which can be differentiated from adjacent zones (Moore et al. 1991). While the pollen is from caribou dung, and not from lake cores, it nevertheless may reflect changing ecology through time. Therefore the pollen assemblages are zoned on the basis of comparisons over time.

The selection of zone boundaries is based on the determination of points of maximum change in the total pollen assemblage. Following Moore et al. (1991:179), the selection of zone boundaries is traditionally a subjective process and is essentially a unit of convenience (see Birks and Birks 1980; Moore et al. 1991 on the problems associated with zonation by visual inspection). All zonation systems, even "objective" methods, are merely aids to interpretation and should always be subject to critical evaluation (Lowe and Walker 1997; Moore et al. 1991).

8.6 Statistics

8.6a Ordination

Pollen analytic data sets are multivariate and complex, making it necessary to utilize statistical analysis to assist in interpretations. Ordination, a multivariate statistical technique, is generally used to seek and describe patterns in data, and assist in helping to see data more clearly (Birks and Gordon 1985; Gil-Romera et al. 2006; McCune and Grace 2002). Ordination graphically summarizes complex relationships and extracts one or two dominate patterns from an infinite number of possible patterns by seeking and displaying the strongest structure (as in the “ordinate” in the Cartesian coordinate system) (McCune and Grace 2002:102, 125). The process of extracting those dominant patterns is called ordination because it results in a placement of objects along a scale, axis (or axes) or dimension (McCune and Grace 2002).

Nonmetric Multidimensional Scaling (NMS) is an ordination technique that is well-suited to ecological data, which are typically non-normal or are on arbitrary or discontinuous scales (McCune and Grace 2002). The main advantages of NMS are: (i) it avoids the assumption of linear relationships among variables; (ii) its use of ranked distances tends to linearize the relationship between distances measured in species space and distances in environmental space; and (iii) it allows the use of any distance measure (McCune and Grace 2002:125).

The mathematics of Nonmetric Mulitdimensional Scaling is complex (McCune and Grace 2002). NMS is, at its most basic level, an iterative search for the best positions of *n* entities on *k* dimensions (axes) that minimize the stress on the *k*-dimensional configuration. “Stress” is a measure of departure from monotonicity in the relationship between dissimilarity (distance) in the original *p*-dimensional space and distance in the reduced *k*-dimensional ordination space (McCune and Grace 2002:125, 126). As such, each point in the ordination space represents a pollen sample composed of varying amounts of different plant taxa; the relationship between these samples is multidimensional and complex. NMS transforms these data through calculating dissimilarity coefficients for each sample and plotting the result in a two (or more) dimensional space to create an NMS ordination diagram.

NMS was carried out using the PC-ORD 5 computer program on pollen assemblages from modern dung of the Ibex caribou herd and the Granger and Friday ice patches. Standard settings were used on the PC-ORD 5 program including the Sorenson (Bray-Curtis) distance measure and the presence-absence transformation of pollen data to reduce differences between percentage values (following Kruskal 1964 in McCune and Grace 2002:136). Rare taxa (<5%) are included in the NMS statistical analyses but Unknown Types, Unknown Miscellaneous Types and Indeterminate Types, were not included in any statistical analyses.

8.6b Indicator Species Analysis

One of the main goals of this study is to detect and describe the value of different pollen taxa as an indicator for seasonality. In this study, different samples or groups of samples may be conceptualized as representing different seasons, making Dufrene and Legendre's (1997 in McCune and Grace 2002:198) method of calculating species (taxa) indicator values an appropriate analysis. An Indicator Species Analysis (ISA) was run on the modern Ibex caribou dung data set using PC-ORD 5 (McCune and Grace 2002) to further explore whether particular taxa were indicative of specific seasons. The Indicator Species Analysis produces indicator values for each taxon in each group and tests for statistical significance using a randomization (Monte Carlo) technique (McCune and Grace

2002:198). This analysis is a good way to contrast the performance of individual taxa across two or more groups (McCune and Grace 2002).

8.7 Macrobotanical Material from Caribou Dung

A small pilot study was undertaken to explore the analytical potential for examining macrobotanical remains from caribou dung retrieved from the ice patches. The goal of this pilot study was to determine whether larger botanical materials such as seeds and catkins were preserved in quantities that warranted a more detailed and systematic examination of samples. Three samples from Friday Creek ice patch were processed following the methods of Beaudoin (2007). Preliminary results indicate that most macrobotanical materials from ancient caribou dung was highly shredded and disaggregated. To gain maximum information from this material a microhistological study of cuticle and epidermal fragments and the identification of macrobotanical remains such as catkins, leaf fragments, stems or seeds is recommended for future study to run parallel to pollen analyses.

9.0 RESULTS

9.1 Environmental Setting of Study Sites

Caribou dung was collected from the present day Ibex herd and the ancient Granger and Friday Creek ice patches. All of these collection sites are located within the Whitehorse-Carcross-Haines Junction area of southern Yukon within the northern portion of the Coast Range (Farnell et al. 2004). Most of this terrain lies between 1000 and 1500 m a.s.l. with the highest peak being Mount Arkell at 2700 m a.s.l. Study sites fall within the Yukon Southern Lakes Ecoregion, which is characterized by broad river valleys and large lakes including Kusawa, Fish, and Alligator (Smith et al. 2004; Farnell et al. 2004; also see Oswald and Senyk 1977). Most of the lakes lie below 760 m a.s.l. and are orientated northwest-southeast or north-south (Smith et al. 2004).

Soils in this ecoregion have formed under a relatively mild, semi-arid climate. Mineral soils tend to be weakly weathered and peat accumulations are generally less than one metre in thickness. Eutric Brunisols formed on a variety of glacial parent materials dominate. Cryosols are mostly limited to upper elevations, moist north-facing slopes and some wetlands (Smith et al. 2004; Oswald and Senyk 1977). Alpine zones are typically characterized by colluvial rubble or stony moraine.

Vegetation of the study sites is altitudinally zoned above and below treeline (Figure 13). The vegetation of the ecoregion is predominantly open coniferous and mixed woodland reflecting the rainshadow climate of the area and the pattern of past forest fires. Pine is the dominant tree species because it quickly regenerates in burned areas. Gravelly river terraces that have not burned within the last hundred years are characterized by open spruce and pine forest with a *Cladina* lichen groundcover.

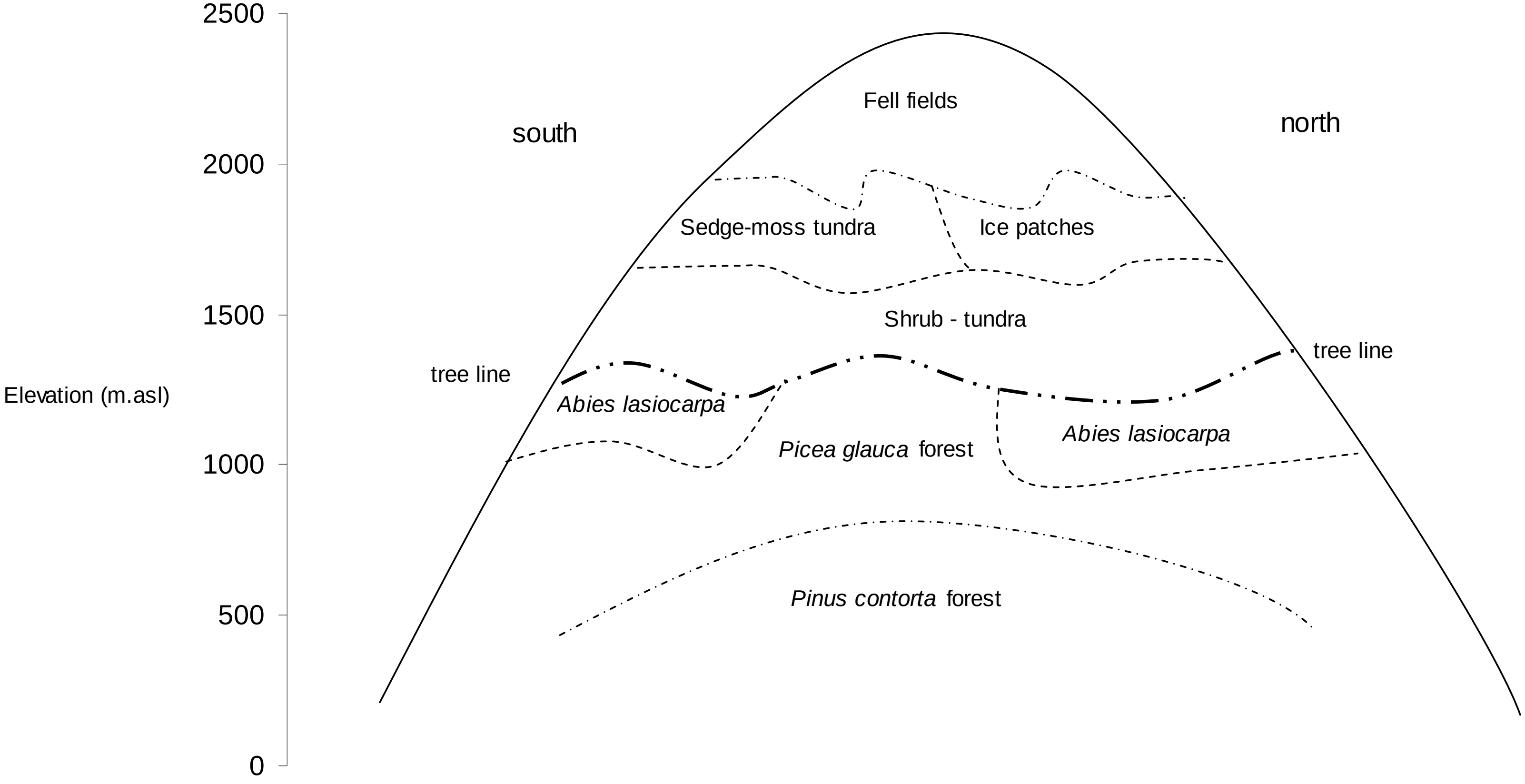


Figure13. Vegetation Zonation in the Study Region (following Rampton (1971) modified)

Black spruce has a limited distribution in this ecoregion being generally restricted to low, wet and cold sites, often associated with Cryosols and near surface permafrost (Smith et al. 2004; Oswald and Senyk 1977). Paper birch is scattered on cooler, moister sites but it is not common and is not known to form pure stands. Open areas at low elevations include grasslands on steep south-facing slopes (Smith et al. 2004; Oswald and Senyk 1977).

Medium shrubs dominate the higher elevations, while vegetation on mountain summits usually consists of dry dwarf shrub tundra (Figure 14). Around treeline, shrub birch and lichen are predominant on drier sites. Subalpine fir occurs in the subalpine region, often forming treeline at 1050-1200 m a.s.l. Alpine communities include mountain avens (*Dryas spp*.), dwarf willow, shrub birch, ericaceous shrubs, graminoid species, and mosses (Douglas 1974; McKenna et al. 2004). On moister and north-facing sites, willow and shrub birch with moss groundcover are more dominant. The alpine dwarf shrub tundra at higher elevations includes willow, a variety of Ericales, lichen and grasses. The vegetation cover is sparse on the most exposed sites.

Figure 14. Sub-alpine/alpine vegetation near Granger Ice Patch. Note *Abies lasiocarpa* and *Betula glandulosa* in foreground.

The topographically diverse Yukon Southern Lakes Ecoregion supports the highest mammalian diversity in the Yukon with at least 50 of the 60 or more species found in the area (Smith et al. 2004). Currently, management plans have restricted the human harvesting of moose and caribou. The caribou herds in the region are generally small and fragmented, ranging in size from 300 to 1400 animals (Farnell et al. 2004).

The Granger and Friday Creek ice patches are located within the alpine tundra zone (Rhodes 1999). Vegetation today is dominated by dwarf shrubs, herbs, graminoids, bryophytes, and lichens. Vegetation immediately adjacent to ice patches is generally mesic to mesic-hydric with several meltwater streams originating from the ice patch (Figure 15). Adjacent to the ice patches mosses are the dominant vegetation. Further downslope, meltwater has less influence and sedges and grasses become dominant. Well drained areas and exposed rock surfaces have lichens as a dominant growth form (Rhodes 1999).

Figure 15. Vegetation in front of the Thandlat ice patch is mesic to mesic-hydric along meltwater streams. Note people standing behind and above ice patch. The dark colour below the snow is due to the melt of ice and dung.

9.2 **Results of Pollen Analysis from Modern Dung of the Ibex Herd**

The Ibex caribou herd is located southwest of Whitehorse (see #17, Figure 9) and is resident between Carcross Road and Kusawa Lake year round with short seasonal movements to alpine areas for calving. In 1992 herd population estimates were around 150 but more recent reports indicate population levels are now up to 400 (Southern Lakes Recovery Program Report 1996; McKenna et al. 2004).

Forty-one modern dung samples (winter=10; spring=8; summer=12; fall=11) from the Ibex caribou herd were examined for pollen (Figure 16; Appendix A). Spring, summer and fall dung samples were provided by Yukon Renewable Resources and the exact collection dates and locations (i.e. latitude; longitude) are unknown. The author collected winter samples on February 18, 2002 where caribou were observed (Figures 35A, 35B, 36) northwest of Primrose Mountain (~60º 25´ N and 136º 50´ W) and southwest of Ibex Mountain near Mud Lake (~60º 25´and 136º 40´ W) at approximately 1200 m a.s.l.. These collection sites are approximately 20-30 km from the Granger and Friday Creek ice patches.

Pollen From Ibex Herd Caribou Dung

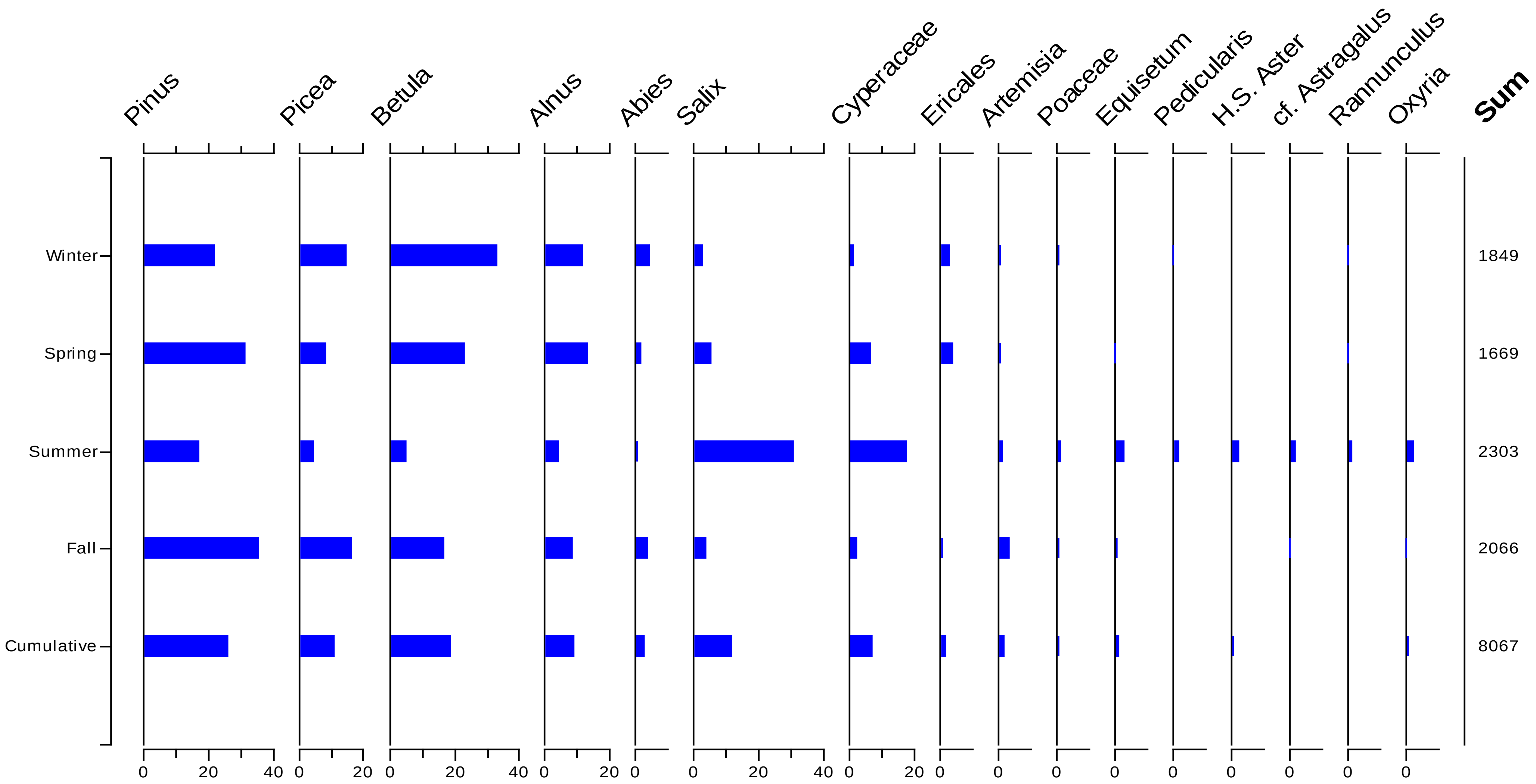


Figure 16. Ibex Caribou Herd, Yukon. Pollen percentage diagram.

It is recommended that future research involving the modern collection of dung include the systematic recording of collection dates and locations. This will provide (i) a greater understanding of the effects that seasonal variation has on pollen accumulation within dung and (ii) better control over the effects that changes in altitude and vegetation might have on collected samples. Ideally modern samples should be collected, at or in the immediate vicinity, of ice patches under study.

9.2a Winter Dung

Winter dung is characterized by high percentages of *Betula* (~40%) and *Pinus* (20%). *Picea* and *Alnus* each make up 10% of the pollen from winter pellets. *Abies*, *Salix* and Ericaceae (undiff.) are present but at <5%. Herbaceous taxa such as Cyperaceae are present in low frequencies of <2%.

9.2b Spring Dung

Pollen from spring dung consists of relatively high percentages of *Pinus* at just over 30% and *Betula* at just over 20%. *Alnus* and *Picea* are present at 10%-15%. There are low percentages of Cyperaceae and *Salix* (5%-10%), while *Abies*, *Artemisia* and Ericaceae (undiff.) are rare.

9.2c Summer Dung

Salix (~30%) and Cyperaceae (~20%) make up the main pollen types in summer dung. *Pinus* is present at just under 20%, while *Picea, Betula* and *Alnus* occur at 5%. *Abies* is rare. There is a high diversity of herbaceous pollen types in summer dung, which includes *Equisetum, Artemisia*, Poaceae, *Pedicularis*, High Spine Asteraceae, cf. *Astragalus*, cf. *Rannunculus*, and *Oxyria.* None of these taxa are present in frequencies higher than 5%. Other taxa, present in summer dung but in very low percentages includes *Epilobium, Polemonium, Caryophyllaceae, Tsuga* and a variety of Unknown Types (Appendix A).

9.2d Fall Dung

The fall pollen assemblage is marked by high percentages of *Pinus* at almost 40%. *Betula* (15%), *Picea* (15%) and *Alnus* (10%) also characterize fall pollen, whereas *Abies* and *Salix* are rare (~5%). *Artemisia* and Cyperaceae comprise 5% of the pollen in fall dung. Ericaceae (undiff.), Poaceae, and *Equisetum* are present but rare.

9.2e Summary of Pollen Analysis from the Ibex Herd

When pollen from all seasons is considered together, *Pinus* (20%) and *Betula* (30%) make up the dominant taxa in the modern caribou dung. *Picea, Alnus*, and *Salix* are each present at about 10%, while Ericaceae (undiff.) and *Abies* are consistently at less than 5%. Of the herbaceous taxa, Cyperaceae is dominant at almost 10%, while various other herbaceous taxa, such as Poaceae, *Equisetum,* High Spine Asteraceae, and *Oxyria* have percentages at 1%-2%.

Inspection of the pollen diagram from the Ibex herd suggests that there are seasonal differences between dung. Differences are apparent in the relative frequencies of certain taxa and the diversity of taxa found in each season. The most marked percent differences occur within the taxa *Salix,* Cyperaceae and *Betula* (Figure 16). Summer dung is characterized by high percentages of *Salix* (30%) and Cyperaceae (20%) but low frequencies of *Betula* pollen (10%). In contrast, *Betula* pollen is more frequent in winter (35%), spring (25%), and fall (20%) dung, but there are low percentages of *Salix* (<10%) and Cyperaceae (<10%). In addition, summer dung is dominated by a variety of herbaceous taxa such as *Equisetum,* Poaceae, *Pedicularis*, High Spine Asteraceae, *Rannunculus*, and *Oxyria*, which are either rare or absent in other seasons.

9.2f Ordination

To further explore whether dung deposited at differences seasons is detectable through pollen analysis, an ordination analysis was performed on the data. The Nonmetric Multidimensional Scaling indicates that dung is distinguishable according to season with some overlap between fall, winter, and spring dung, and a clear distinction between summer dung and all other seasons (Figures 17A and 17B).

Summer dung is most dissimilar as it reflects variable feeding behaviour during this time when a variety of taxa are consumed. This is also represented in the high intersample variability among summer dung samples. During early stages of green-up caribou continuously switch from one taxon to another. In one month caribou diet can change four and five times as they shift from *Salix spp*. to one set of forbs to the next (Russell, personal communication 2010). Ordination shows strong associations with *Populus* in winter dung, whereas *Betula,* Ericales, and *Callitriche* pollen dominate dung deposited in the fall. In contrast, a wide range of taxa explain most of the variability in summer dung with the strongest associations including cf. *Fritillaria, Polemonium, Pedicularis, Astragalus, Salix*, *Equisetum*, and Cyperaceae.

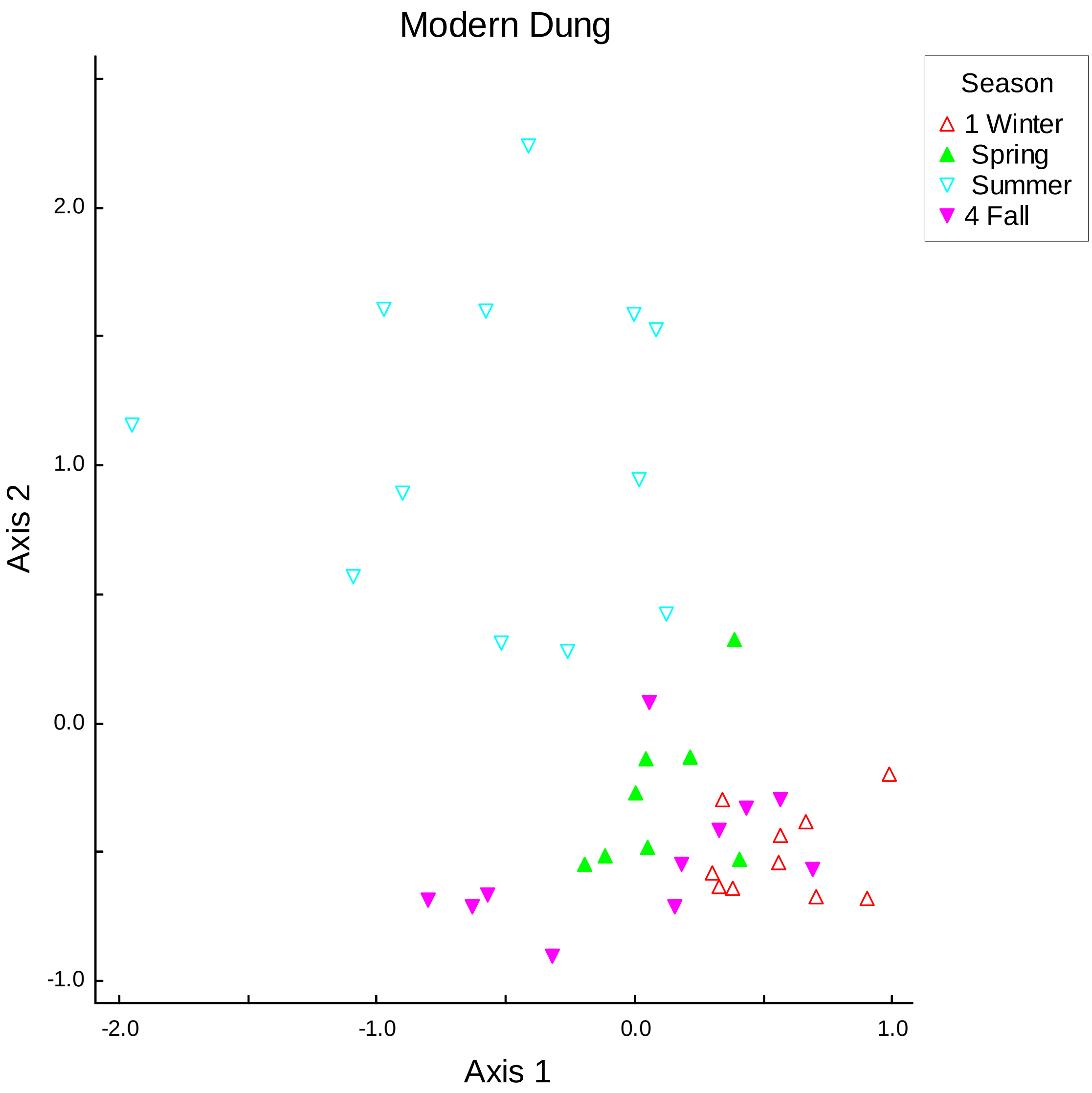


Figure 17A. NMS diagram for Ibex Herd showing separation of the 41 seasonal dung samples. Each symbol represents a sample unit. This ordination illustrates the variation in the caribou dung. The distances between the symbols in the ordination are approximately proportional to the dissimiliarity between samples.

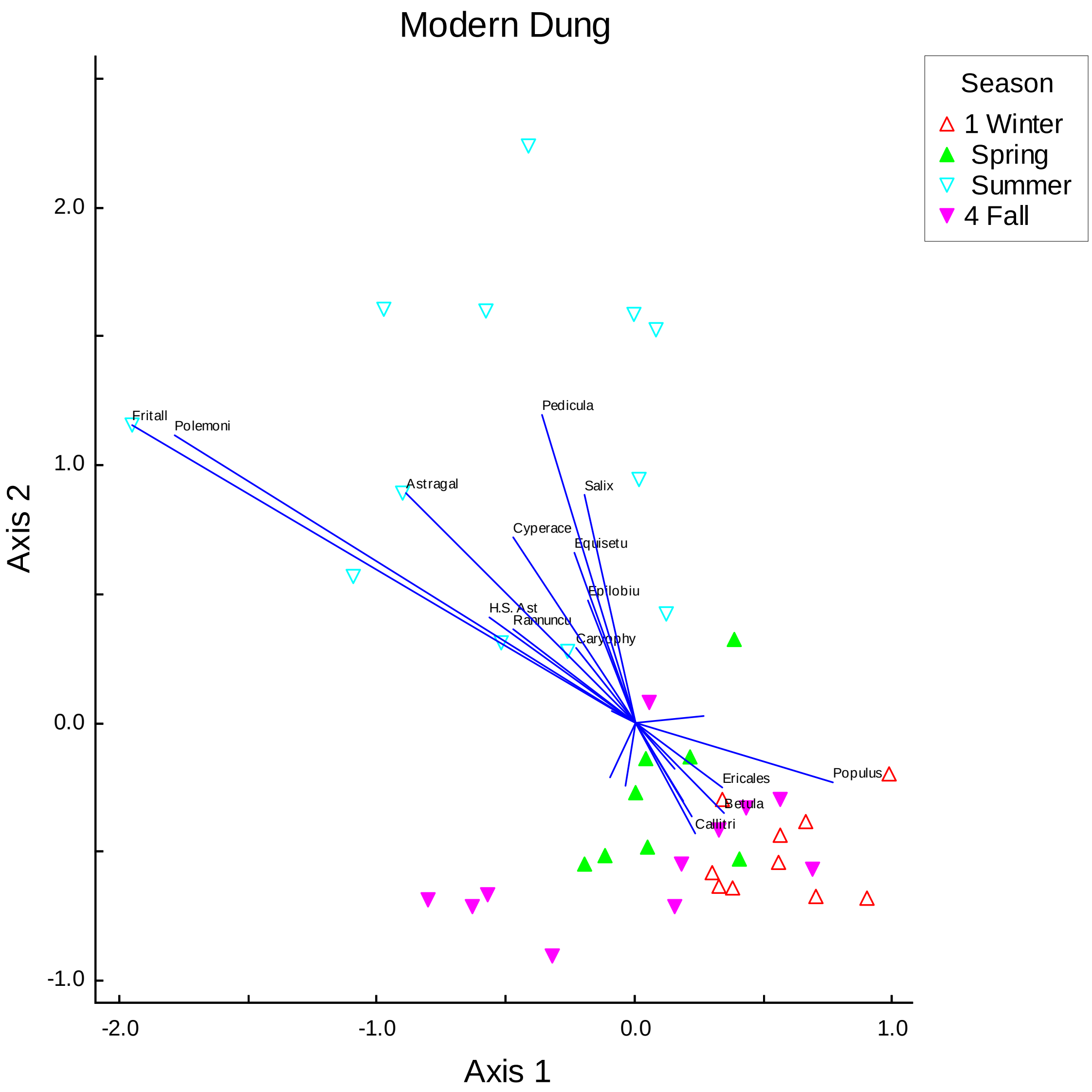


Figure 17B. NMS diagram for Ibex Herd with the pollen types explaining most of the variation in the caribou dung. Vectors with taxa indicate the taxa most strongly associated with the ancient dung or a particular season.

9.3 Granger and Friday Creek Ice Patches: Formation and Stratigraphy

Net accumulation of winter snow followed by compaction and regelation of summer melt waters formed the ice patches in the southwest Yukon (Farnell et al. 2004). Ice patches differ from glaciers in that they do not achieve sufficient mass to cause ice to flow and therefore may exhibit undeformed bands of caribou dung along exposed ice faces (Figure 18). The ice patches are confined to northwest, north, or northeast facing slopes, often within cirques or nivation hollows. Ice patches range from less than 100 m to almost a kilometer across in length and from approximately 10 m to more than 80 m in height (Farnell et al. 2004). The caribou dung varies in preservation from firm, well-formed in situ pellets to dark, amorphous organic deposits located at the edges of some ice patches (Figure 19; also see Farnell et al. 2004).

Figure 18. Granger Ice Patch with layers of caribou dung.

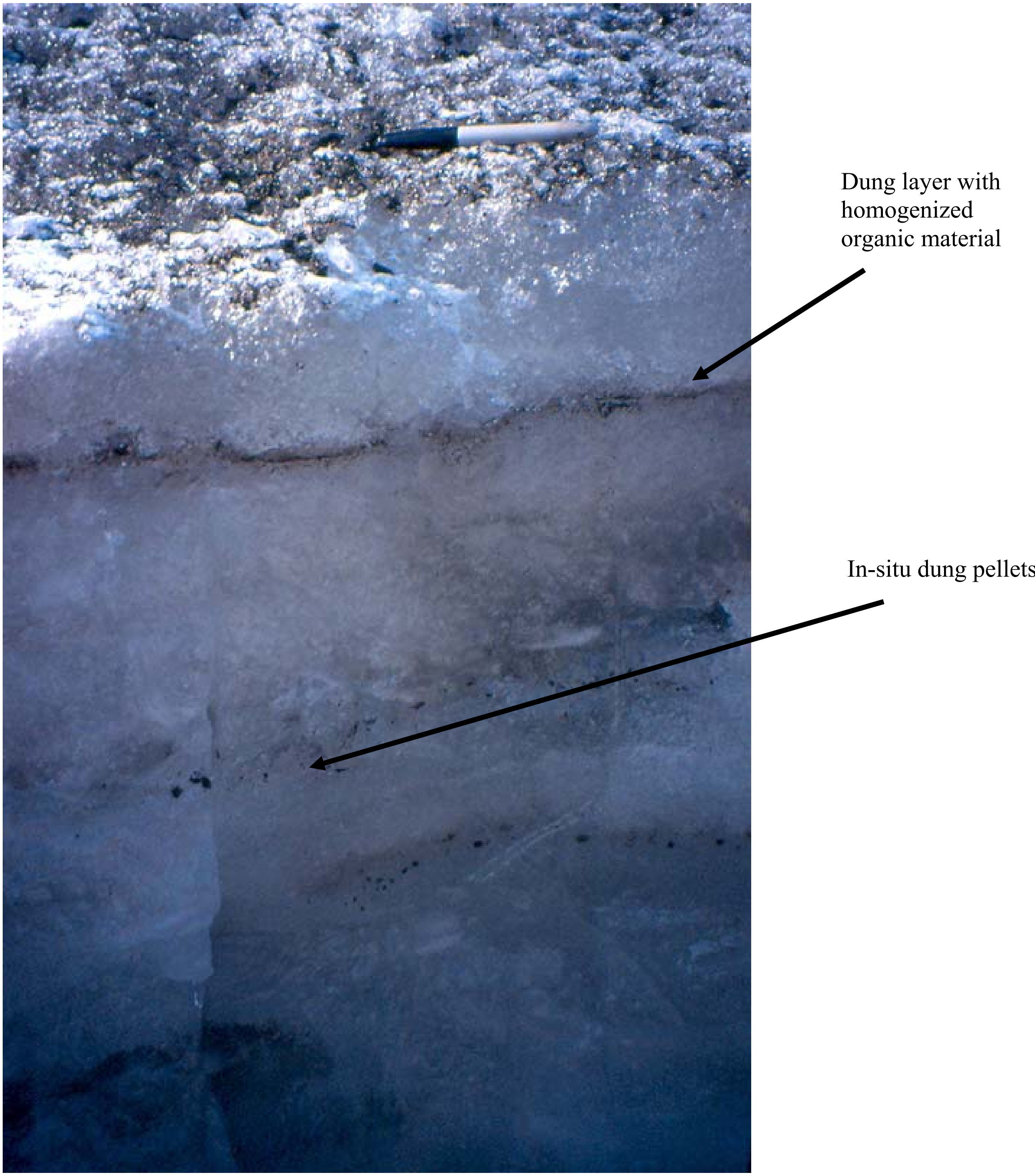
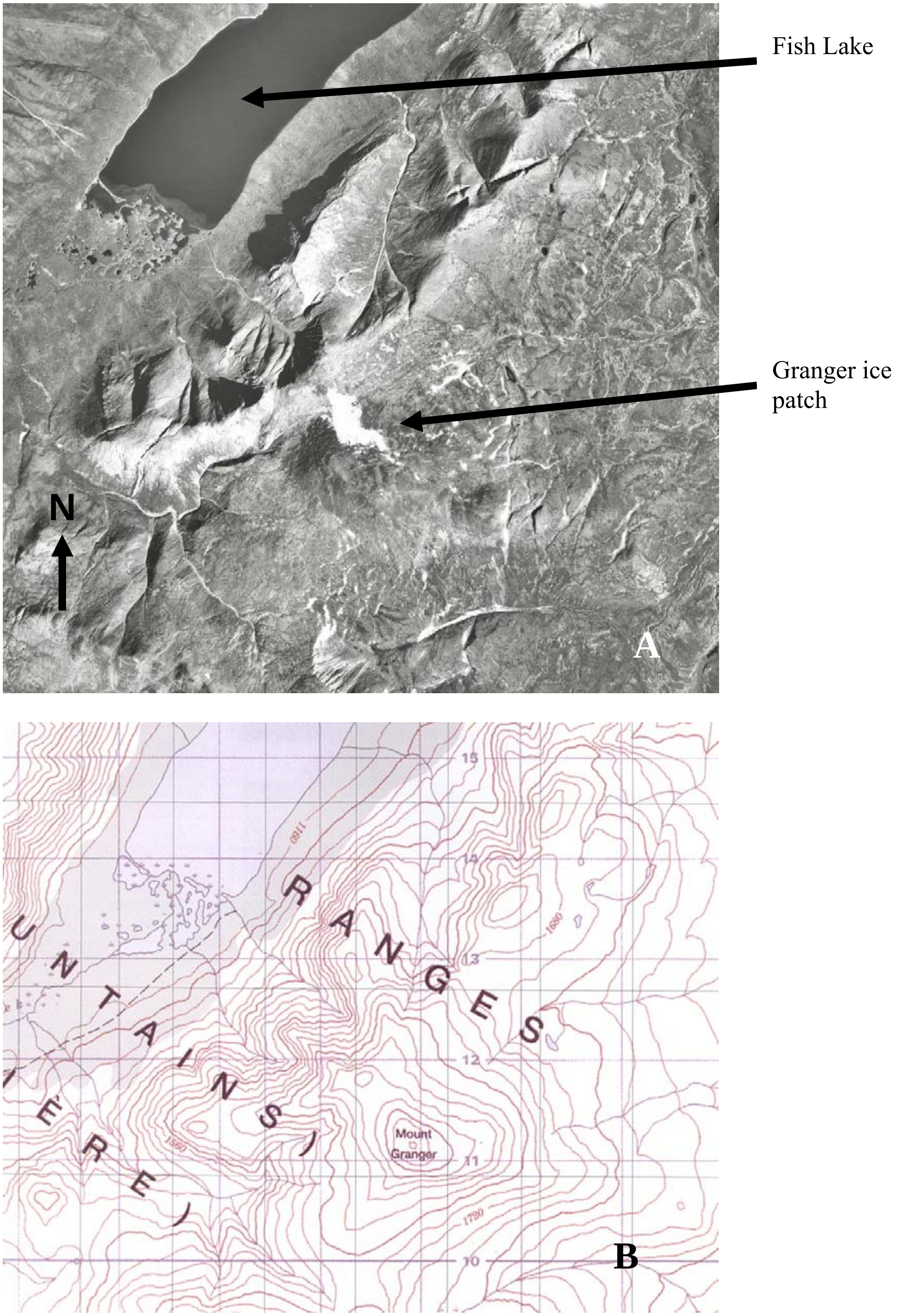


Figure 19. Note banding of dung material and individual pellets between dung-free layers.

The black and white layering of dung and ice, exposed during summer melt and visible from a distance, is the most distinguishing feature of the ice patches (Farnell et al. 2004). The discrete and near parallel layers of concentrated organic material – mostly caribou dung, but also windblown detritus, rare animal remains and even rarer artifacts – are exposed across the face of the melting ice slope. These layers, separated by clean ice, incline 5º-15º downslope, intersecting the sloping ice surface (25º-40º) at a shallow angle. Broadly, only about 100 layers are observed at any one site, and they are known to pinch out or merge (Farnell et al. 2004). This observation, along with the 14C dates indicates that the layers of dung and detritus are not annual, but concentrations of organic material deposited on the ice patch surface over decades or centuries and then concentrated again during melt periods into "super layers".

9.4 Granger Ice Patch (JdUt-17) General Site Description

Granger (JdUt-17) ice patch is located on Granger Mountain at coordinates 60º 32' 28" N and 135º 15' 25" W, approximately 15 km southwest from Whitehorse (Figures 20A and 20B). The ice patch is situated at an elevation of 1890 m, is northeast-facing, and is approximately 650 m long and 14.2 m in height (Farnell et al. 2004). Granger is associated with a number of well-preserved artifacts and a hunting blind located above the ice patch (Figure 21).



Figures 20A and 20B. Air photo and topographic map of Granger ice patch. Air photo A25047-158 (2-1-0), 1978.

Figure 21. Tagish Johns standing in a hunting blind at the Granger Ice Patch. Note the lichen-free zone surrounding the ice (with Fish Lake in distant background). This zone probably marks the maximum extent of the ice patch in recent centuries.

Vegetation down slope of the ice patch is influenced by ice patch meltwater and is therefore mesic to mesic hydric. Dominant vegetation includes the bryophytes *Distichium inclinatum*, *Ditrichum flexicaule*, and *Polytrichum juniperinum*. About 15 m downslope *Carex microchaeta, Luzula wahlenbergii, L. confusa, Juncus biglumis, Polytrichum juniperinum*, and Poaceae dominate. Exposed rock surfaces are dominated by the lichen *Umbilicaria hyperborea* (Rhodes 1999).

9.5 Radiocarbon Dating

Twenty-three AMS radiocarbon dates have been run on material recovered from stratigraphically controlled dung pellets and buried vegetation from under the Granger ice patch (Table 5; also see Farnell et al. 2004: Table 2:251).

Location (m from the base)	Uncalibrated 14C Date #1	Calibrated Cal BP Cal AD, BC*	Lab No.	Uncalibrated 14C Date #2	Calibrated Cal BP Cal AD, BC	Lab No.	Pollen Zone
14.2	970+/-50	872+/-57 1078+/-57*	TO-7563				No pollen samples
11.3	1030+/-50	950+/-52 1000+/-52*	TO-7564				No pollen samples
10.6	No radiocarbon dates						GM IV
10.3	1600+/-50	1485 +/-56 465+-56*	TO-7565	1460+/-40	1355+/-32 595+/32*	Beta-162356	GM III
9.2	No radiocarbon dates						
8.6	1920+/-50	1871+/-54 79+/54*	TO-7566	1650+/-40	1547+/-58 403+/-58*	Beta-140619	
7.4	1620+/-40	1498+/56 452+/-56*	Beta-140621				
6.0	No radiocarbon dates						
6.4	1770+/-60	1699+/-82 251+/-82*	TO-7567	1980+/-40	1938+/-42 12+/-42*	Beta-140620	No pollen samples
5.3	1910+/-60	1850+/-73 100+/-73*	TO-7568				No pollen samples
4.6	2240+/-40	2252+/65 302+/65*	Beta-140622				No pollen samples
4.8	No radiocarbon dates						
3.7	3850+/-50	4279+/-91 2329+/-91*	Beta-136360				GM III
3.3	Modern	n/a	Beta-136359	4180+/-40	4728+/-81 2778+/-81*	Beta-140624	No pollen samples
2.9	3030+/-50	3242+/-76 1292+/-76*	TO-7569	2380+/-40	2425+/-60 475+/-60*	Beta-162355	No pollen samples
2.6	4780+/-80	5483+/-103 3533+/-103*	Beta-136358				GM II
2.3	7500+/-60	8303+/-69 6353+/-69*	Beta-136357				
1.5	8330+/-60	9395+/-70 7445+/-70*	Beta-136356	7850+/-50	8670+/-72 6720+/-72*	Beta-140623	
0.7	7890+/-80	8769+/-144 6819+/-144*	Beta-136355				GM II
0	6730+/-70	7591+/-60 5641+/-60*	TO-7570	7460+/-40	8449+/-40 6499+/-40*	Beta-162357	No pollen samples
-0.1 below the ice patch	7990+/-70	8847+/-119 6897+/-119*	Beta-136354				GM I

Table 5. AMS Radiocarbon dates from Granger Mountain Ice Patch. All calibrated dates were calibrated using CalPal – 2007 online (Danzeglocke and Weninger 2007).

Dates from vegetation beneath the ice patch and from dung at the base (Layer 0) of the Granger ice patch place its formation between 8000 - 6700 years BP (Table 4). The most recent date of 970 +/-50 years BP, comes from the top of the ice patch (also see Farnell et al. 2004:Table 2:25). Paired AMS dates, labeled as “Uncalibrated Date #1” and “Uncalibrated Date #2” in Table 4, on separate dung pellets from the same level indicate the composite nature of the layers (Farnell et al. 2004). Overall, the lack of distortion, good quality preservation of many of the dung pellets, and the broad agreement between stratigraphic levels and 14C dates, indicates that little internal movement or associated shear has taken place in the ice patches over time (Farnell et al. 2004).

There are several inverted dates to note in the stratigraphic sequence from Granger ice patch. The base (Layer 0) of the ice patch dates to 6730 +/- 70 years BP, whereas layers above it date to 7890+/-80 years BP (Layer 0.7), 8330 +/-60 years BP (Layer 1.5), and 7500 +/- 60 years BP (Layer 2.3), which all indicate an inversion in dates. There is also an inversion in dates at 3030 +/-50 years BP (Layer 2.9) and 3850 +/-50 years BP (Layer 3.7) and a “Modern” date was recored from Layer 3.3. Even if the majority of dates are in chronological sequence, one can not rule out deposition and regelation of contaminating organic matter transported by present day meltwater along cracks or the organic layers. In addition, despite the relatively coherent chronological stratigraphy demonstrated at the Granger ice patch, temporal gaps are evident. The temporal gap at Granger, from Layers 2.3 to 2.6 m, is between 7500 +/-60 and 4780 +/- 80 years BP. The presence of inverted dates and temporal gaps in the Granger ice patch stratigraphic sequence indicates the need for further stratigraphic description, careful sampling, and dating.

9.6 Pollen Zone Descriptions for Granger Ice Patch

Nineteen samples from twelve stratigraphic layers were processed and examined for pollen from the Granger Mountain (GM) ice patch (Figure 22; Appendix B). Four samples were from buried vegetation beneath the ice patch. Dung samples were of two types. Six samples consisted of disaggregated, homogenized organic material, possibly representing several dung pellets. However, dung of this consistency may be deposited directly by caribou (R. Farnell personal communication, 2002).

Granger Ice Patch (JdUt-17), Yukon

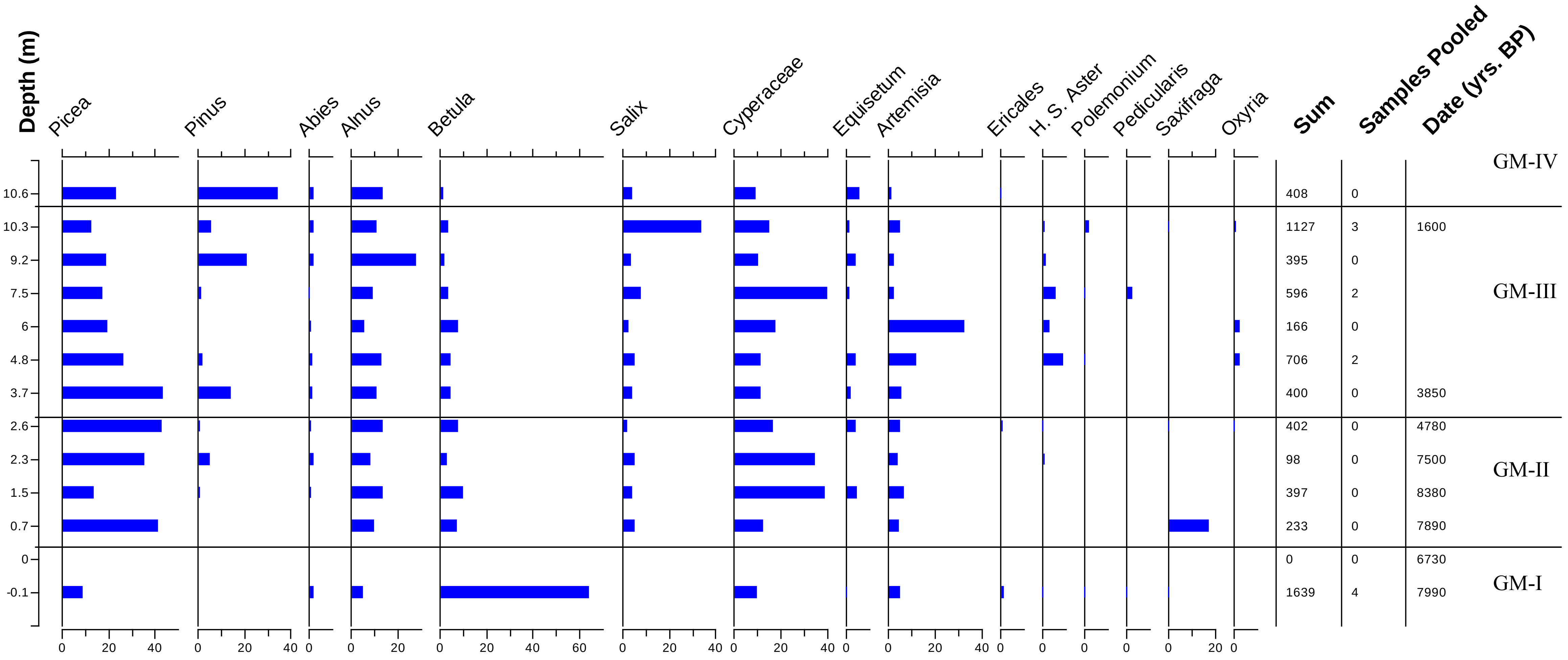


Figure 22. Granger Ice Patch, Yukon. Pollen Percentage Diagram. Note that depths are recorded from the base of the ice patch and presented in this way to maintain continuity with previous publications (see Farnell et al. 2004:251).

It is also possible that the homogenized condition of some of the pellets is the result of thaw/freeze episodes in which several dung pellets, exposed on the ice surface, have thawed and re-frozen together into a mass of organic material. Nine samples were individual dung pellets that were extracted *in situ* from the ice. These pellets come from Layers 4.8 m to 10.3 m and occur in the levels above the radiocarbon dated level 3.7 m which dates to 3850+/-50 years BP. In addition, where there were multiple individual pellets from a single layer, the results of the analysis of each pellet were pooled (see Methods section). Combining the analysis of individual pellets resulted in considerably higher pollen counts for certain levels (e.g. see Layers 10.3, 7.5, and 4.8) (Figure 22).

9.6a Pollen Zone GM-I; (Betula Zone); Vegetation from under the ice patch; 7990 years BP

Description: Zone GM-I is dominated by *Betula*, which reaches its maximum value at 65%. *Picea* and *Alnus* are at their lowest frequencies at just under 10% in this zone and there are trace amounts of *Abies.* Cyperaceae, *Artemisia*, and Ericales are present at 5% or less.

Remarks: This pollen zone is based on organic material preserved under the base of the ice patch. GM I pollen was abundant with excellent preservation. Several clusters of *Betula* pollen were observed in this assemblage and may be anther parts. This zone is associated with a radiocarbon date of 7990+/-70 years BP.

Given that this pollen is not from dung material but represents the vegetation buried beneath the Granger ice patch, these samples are excluded from further statistical analysis and discussion.

9.6b Pollen Zone GM-II; (Picea – Cyperaceae Zone); 0 – 2.6 m; 7890 – 4780 years BP

Description: *Betula* is less abundant in this zone at less than 10%. *Picea* and Cyperaceae reach their highest values in this zone ranging from 10% to just 40%. *Alnus* is present at about 5%-10%, while *Abies* is rare. *Salix* and *Equisetum* first appear in this zone at frequencies just below 5% but *Equisetum* is sporadic in its occurrence. *Artemisia* occurs at 5%-10%, but in one sample reaches levels of up to 30%. *Saxifraga* is rare but reaches 20% of the pollen in one sample. The upper boundary of this zone is placed at between 2.6/3.7 m where there is a spike in *Pinus* at 15%.

Remarks: The two radiocarbon dates, 6730+/- 70 years BP (Layer 0) and 8380 +/- 60 years BP (Layer 1.5) are inverted stratigraphically, suggesting that mixing and re-deposition of material has likely occurred. *Picea* and *Pinus* pollen was often degraded and high bissacate fragments were abundant. One sample from this zone contained a *Betula* cluster/aggregate, suggesting the presence of an anther fragment.

9.6c Pollen Zone GM III; (Picea – Pinus - Cyperaceae Zone); 3.7 – 10.3 m; 3850 – 1600 years BP

Description: *Picea* dominates this zone ranging from 20% to over 40%. *Pinus* becomes significant at 5%-20%. Cyperaceae also remains significant, up to 40%. *Abies* and *Betula* are also present but never at more than 5%. Some of the highest levels of *Salix* (40%) occur in this zone. *Alnus* is also present at high levels of 25%-30% in this zone. A variety of herbaceous taxa are found, such as *Equisetum, Artemisia,* High Spine Asteraceae, *Oxyria*, *Polemonium*, and *Pedicularis* but are rare and sporadic in occurrence.

Remarks: GM III, Layer 3.7 m dates to 3850+/-50 years BP. Some of the *Pinus* from this zone is very faded and degraded. *Salix* and Cyperaceae clusters/aggregates were present suggesting possible anther fragments in this zone.

9.6d Pollen Zone GM IV; (Pinus Zone); 10.6 – 14.2 m; > 1600 years BP

Description: *Pinus* is the dominant taxon in this single assemblage zone at almost 40%, while *Picea* drops to 25%. *Alnus* is present at just over 10%. *Abies, Betula*, and *Salix* are present but at 2%-10%. Cyperaceae, *Equisetum*, and *Artemisia*, are the only herbaceous taxa never occurring at more than 10%.

Remarks: *Pinus* pollen from this zone is often very faded and degraded.

Rare Taxa: There are several rare taxa in the Granger ice patch pollen assemblage not included in the pollen diagram. *Epilobium*, Caryophyllacae, *Chenopodium, Callitriche*, and *Rumex* are all present but at less than 1% (Appendix C).

9.6e Summary of Pollen Analysis for Granger Ice Patch

The Granger pollen assemblage is characterized by moderate to high percentages of *Picea* (~20-40%), Cyperaceae (10%-40%), and *Alnus* (10%-25%). Generally, there are low percentages of *Betula* and *Salix* (<10%) but these pollen types are well-represented throughout the stratigraphic sequence. *Artemisia* (less than 30%) pollen is not present in high percentages, but is a consistent component of the assemblage. *Equisetum* is present but sporadic. *Pinus* is significant at 40% in the pollen spectra, but not until after 3000 years BP, whereas *Abies* is consistently rare throughout the sequence.

9.6f Ordination

To establish at what time of year dung was deposited at the Granger ice patch an ordination analysis was run on the modern Ibex and the Granger pollen assemblages for comparison. NMS analysis shows that Granger dung does not fit any of the modern dung samples (Figures 23A and 23B). Outliers are indicated by isolated points on the ordination diagram for Granger and may be the result of including rare taxa in the data set (McCune and Grace 2002:59). As a consequence, the rare taxa can create “noise” in the ordination (McCune and Grace 2002:6, 73, 75). The role that rare taxa have in creating outlier patterns in the Granger ordination requires further evaluation in future analyses (see McCune and Grace 2002:75). Named vectors with taxa indicate the taxa associated with ancient dung (Figure 24B). Ordination shows that the most important pollen types that are most strongly correlated with the Granger dung include *Polemonium, Chenopodium, Epilobium,* Caryophyllaceae*, Oxyria,* and *Saxifraga*.

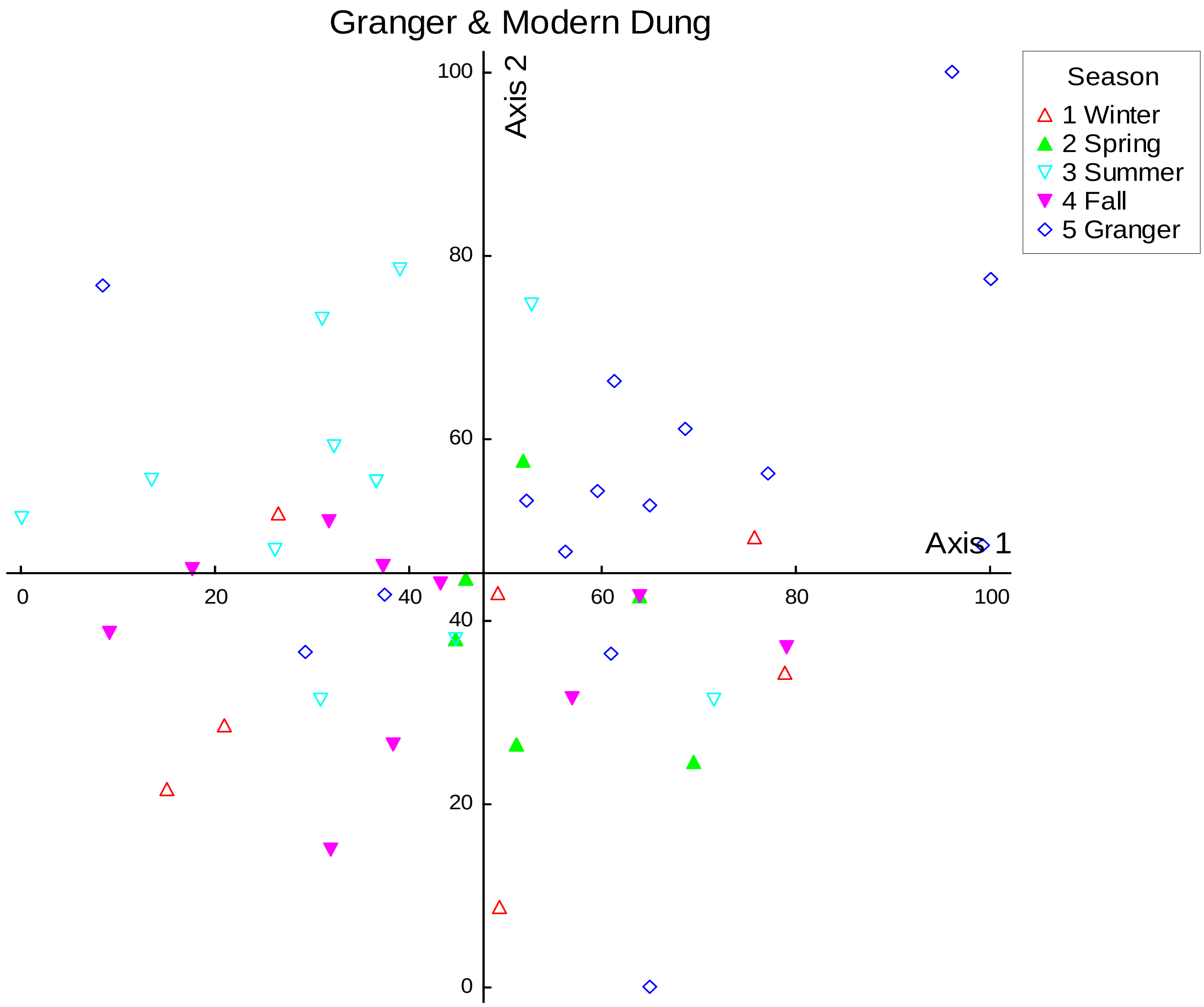


Figure 23A. NMS diagram for Granger ice patch showing separation of the dung samples. Each symbol represents a sample. This ordination illustrates the variation reflected by dispersion in the caribou dung. The distances between symbols in the ordination are approximately proportional to the dissimarity between samples.

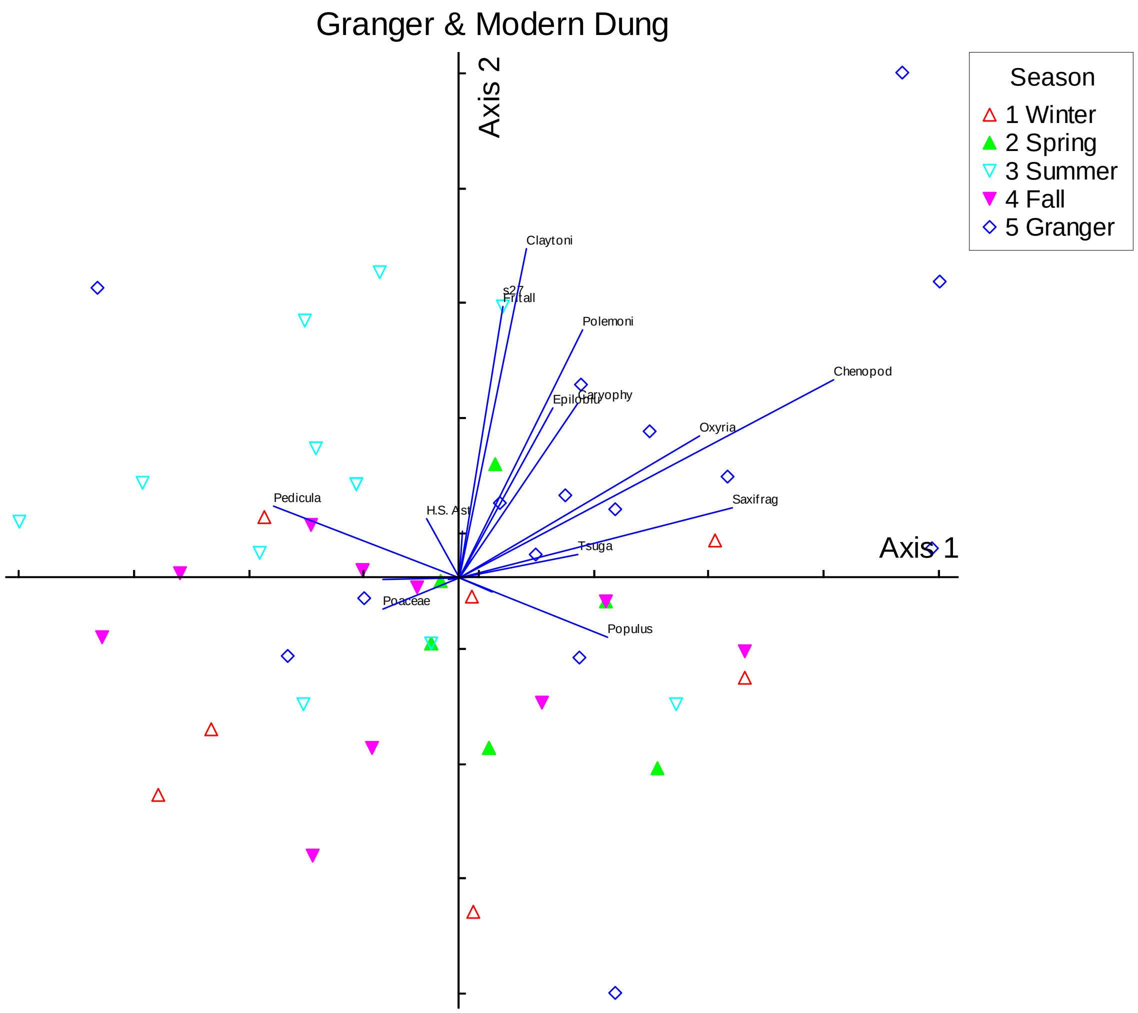
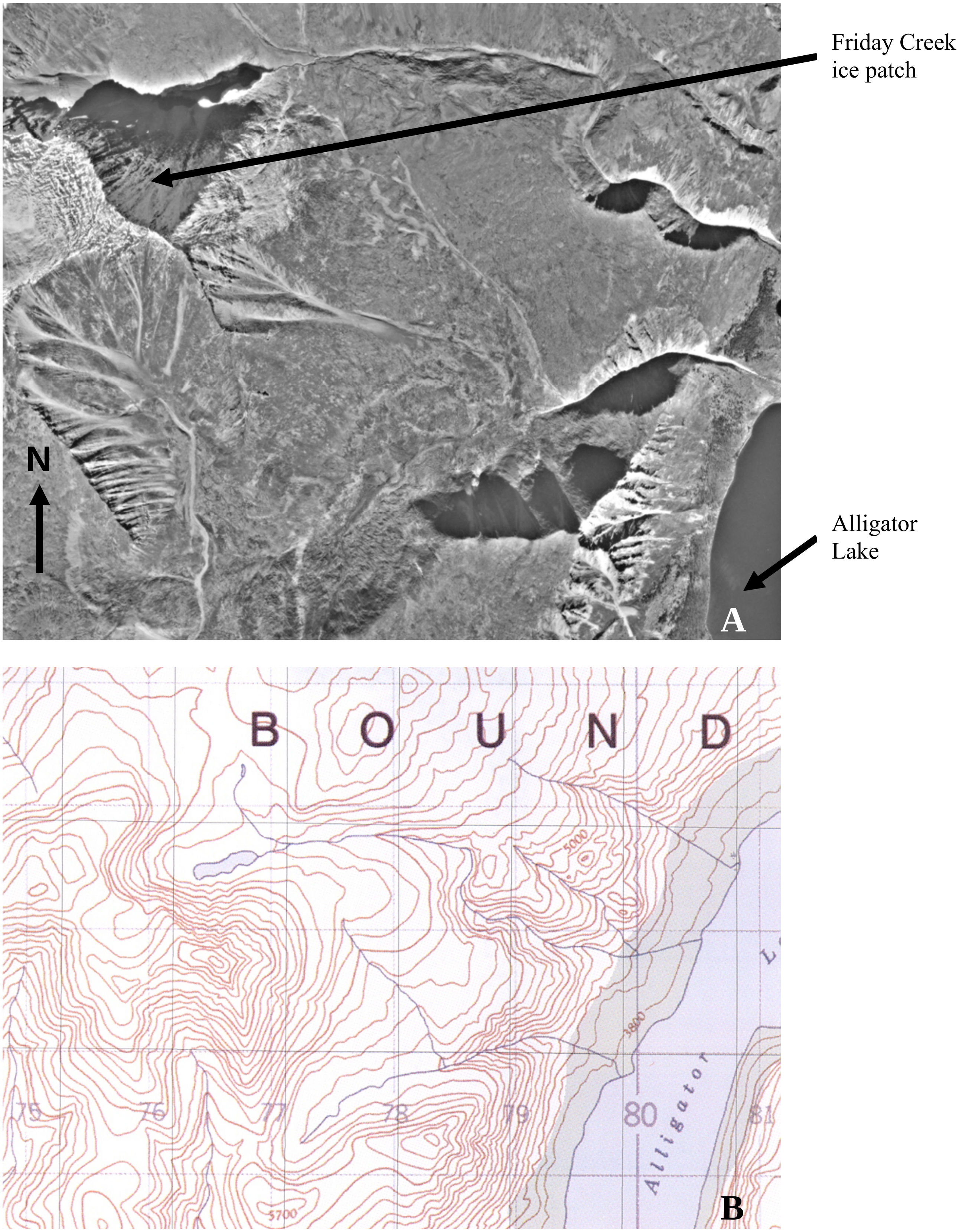


Figure 23B. NMS diagram for Granger ice patch with pollen types explaining most of the variation in the caribou dung. Vectors with taxa indicate taxa associated with ancient dung or a particular season.

9.7 Friday Creek Ice Patch (JcUu-1) General Site Description

The Friday Creek (JcUu-1) ice patch is located on the Friday Creek Plateau at 60º 23’ 26”N and 135º 26’ 30” W, north of the Watson River, near Alligator Lake. (Figures 24A and 24B). Friday Creek is northeast-facing (Figure 25). The ice patch is at 1960 m a.s.l., and is 720 m long and 88 m in height. To date the Friday Creek ice patch is one of the most productive archaeological sites yielding 25 artifacts (Farnell et al. 2004; Hare et al. 2004). Artifacts include throwing darts, stone projectile points, and bow and arrows. In addition, several hunting blinds on the Friday Creek plateau between the Friday Creek and Alligator ice patches were shown to the author, members of the Yukon Heritage Branch, and Natural Resources by Mr. Art Johns of Tagish (Figure 26).



Figures 24A and 24B. Air photo and topographic map of Friday Creek ice patch.Air photo A 28238 – 108, 1995.

Figure 25. Tagish Johns at the Friday Creek Ice Patch.

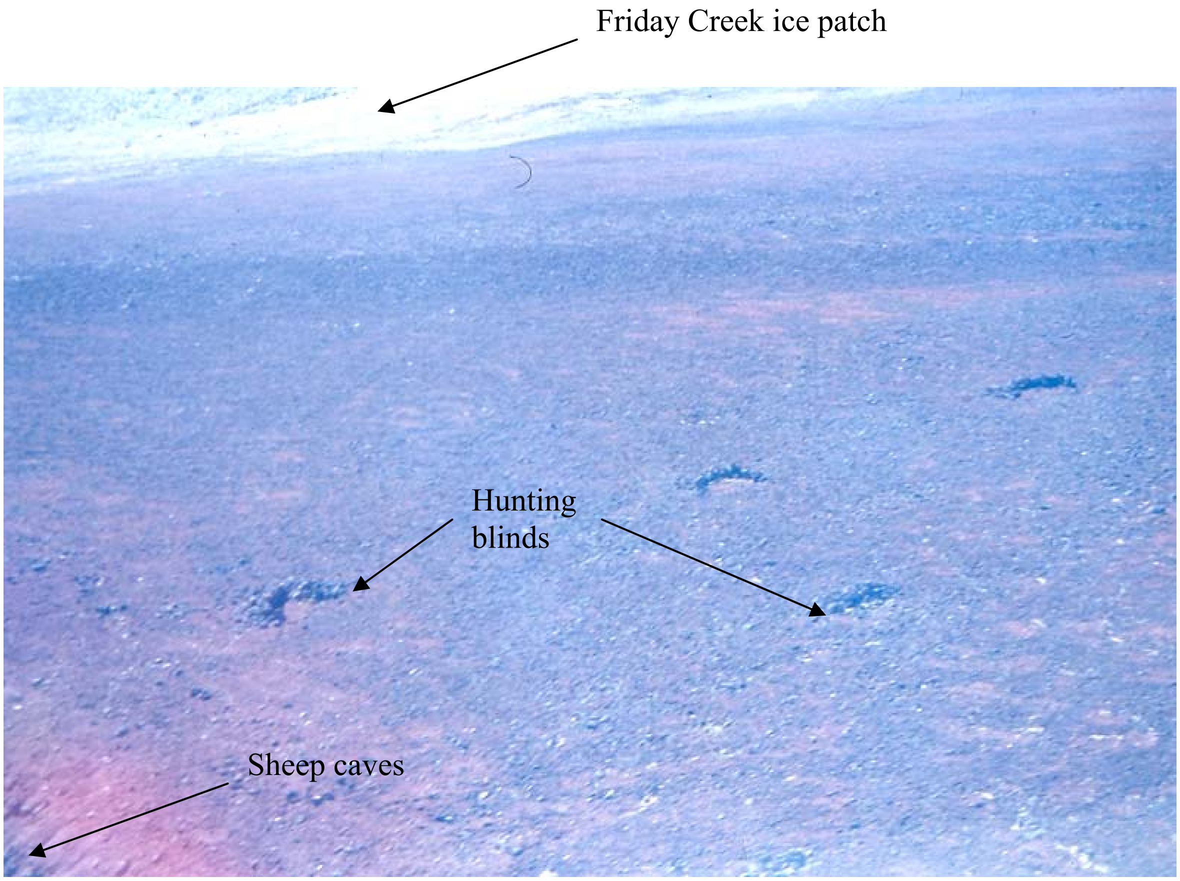


Figure 26. Hunting blinds on the Friday Creek Plateau between the Friday Creek and Alligator Ice Patches. Friday Creek ice patch in background and sheep caves below the plateau.

Run-off from the ice patch contributes to a mesic-hydric to hydric habitat in front of and downslope from the ice patch. Areas immediately adjacent to the ice patch are influenced directly by flowing meltwater and consequently are dominated by bryophytes. Exposed rock surfaces possess about 70% lichen cover, with *Umbilicaria hyperborea* as the dominant species. Ground cover is approximately 90% lichen. The moss *Polytrichum juniperinum* and other bryophytes are predominant in mesic and hydric areas. The lichens *Cetraria cucullata* and *Cladonia chlorophaea* are also present at about 5% (Rhodes 1999).

Adjacent south-facing upper slopes are xeric. Vegetation ground cover in these areas is approximately 5%, consisting of members of Poaceae and *Saxifraga* species. Exposed rock surfaces are colonized by the lichens *Umbilicaria hyperborea*, *Rhizocarpon geographicum*, and *Pseudophebe pubescens* with a total cover value of about 60%. Also present, at less than 5% total cover, are *Festuca hyberborea, Papaver radicatum, Salix polaris*, various *Saxifraga spp*., and *Stellaria longipes* (Rhodes 1999).

9.8 Radiocarbon Dating

Twelve radiocarbon dates provide chronology for the Friday Creek ice patch (Farnell et al. 2004: Table 2:251). Paired radiocarbon dates ("Uncalibrated Date #1" and "Uncalibrated Date #2") from the base of the ice patch place its formation at 4200 years BP (Table 6). There radiocarbon dates suggest some mixing of deposits. The base of the ice patch (Layer 0) dates to 4200 +/-80 years BP, whereas Layer 3 (4410 +/- 50 years BP) and Layer 33 (4520 +/-50 years BP) have older dates even though these layers are higher in the stratigraphic sequence. The most recent date at the top of the ice patch is 460+/-60 years BP (Table 6; also see Farnell et al. 2004:Table 2:251).

Location (m from the base)	Uncalibrated 14C Date #1	Calibrated Cal BP Cal AD, BC*	Lab No.	Uncalibrated 14C Date #2	Calibrated Cal BP Cal AD, BC*	Lab No.	Pollen Zone
88	460+/60	486+/-52 1464+/-52*	Beta-136346				FC IV
83	No radiocarbon dates						FC IV
80	No radiocarbon dates						FC IV
77	1650+/-60	1548+/-88 402+/-88*	Beta-136347				FC III
74	No radiocarbon dates						FC III
70	No radiocarbon dates						FC III
67	1660+/-50	1569+/-72 381+/-72*	Beta-136348				FC III
61	No radiocarbon dates						FC III
54	2850+/-50	2978+/-75 1028+/-75*	Beta-136349				No pollen samples
50	No radiocarbon dates						FC III
45	No radiocarbon dates						FC II
40	3550+/-70	3841+/-98 1891+/-98*	Beta-136350				FC II
36	3830+/-40	4256+/-82 2306+/-82*	Beta-152447				FC I
33	4520+/-50	5178+/-97 3228+/-97*	Beta-136351	4310+/-40	4861+/-4 2911+/-4*	Beta-152448	No pollen samples
3	4410+/-50	5053+/-139 3103+/-139*	Beta-136352	4440+/-40	5102+/-126 3152+/-126*	Beta-152449	No pollen samples
0	4200+/-80	4718+/-109 2768+/-109*	Beta-136353	4190+/-40	4736+/-81 2786+/-81*	Beta-152450	FC I

Table 6. Radiocarbon Dates from the Friday Creek Ice Patch. All calibrated dates were calculated using CalPal – 2007 online (Danzeglocke and Weninger 2007).

9.9 Pollen Zone Descriptions

Thirty-six samples were examined from sixteen stratigraphically controlled layers at the Friday Creek ice patch (Figure 27; Appendix C). Thirty of these samples were individual, *in situ* dung pellets extracted from the ice, while the remaining six consisted of homogenized, amorphous organic material. The examination of multiple pellets and pooled results from certain stratigraphic layers (see Methods section) yields considerably higher pollen counts for some stratigraphic layers over others (e.g. see Layers 88, 83, 80, 50, 45, 36 and 0) (Figure 27).

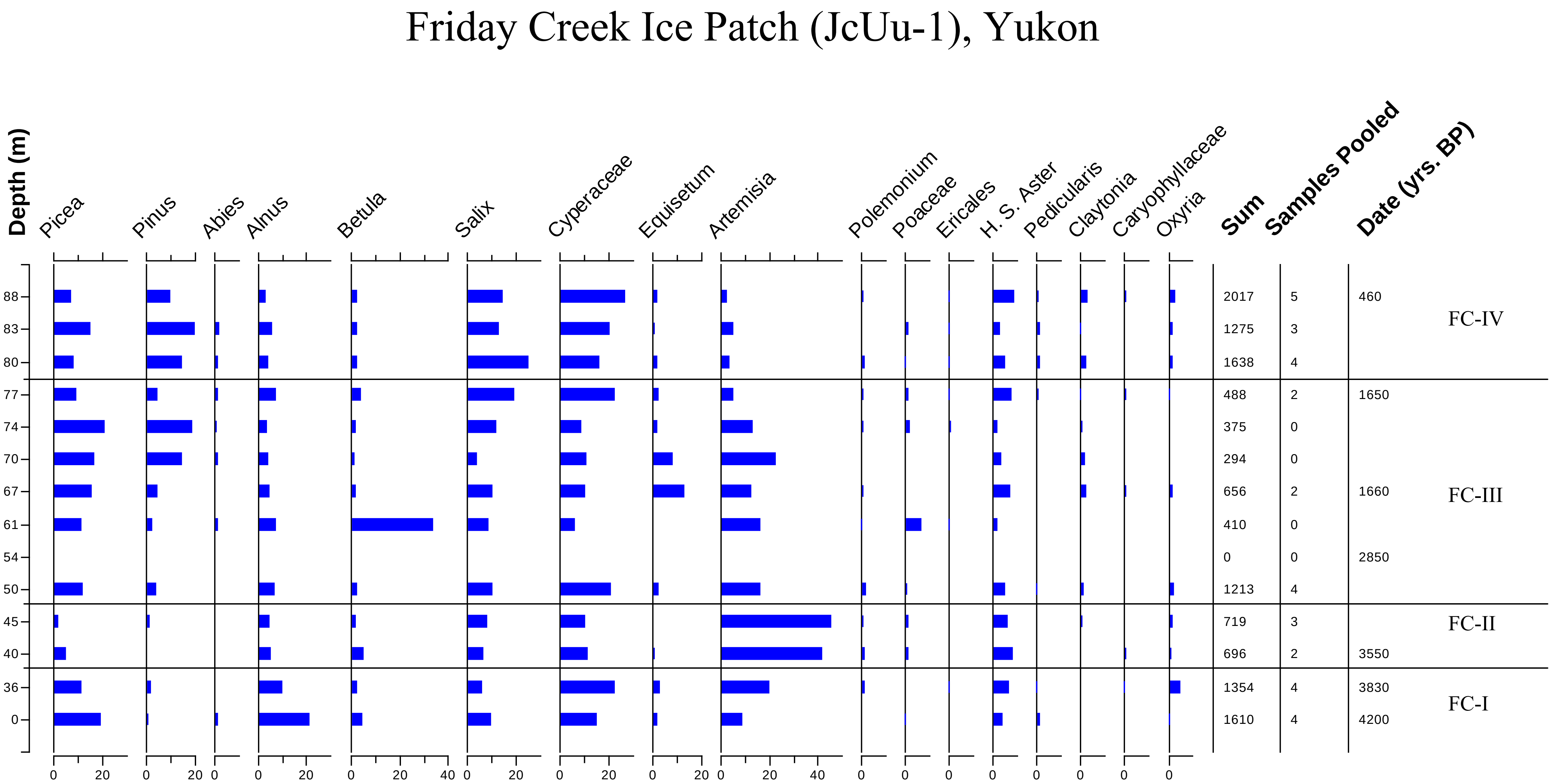


Figure 27. Friday Creek Ice Patch, Yukon. Pollen Percentage Diagram. Note that depths are recorded from the base of the ice patch and presented in this way to maintain continuity with previous publications (see Farnell et al. 2004:251).

9.9a Pollen Zone FC-I; (Picea-Alnus); 0 - 36 m; 4200 – 3830 years BP

Description: This zone consists of relatively high percentages of *Picea* and *Alnus*, each ranging from 10%-20%. *Salix*, Cyperaceae and *Artemisia* also reach significant percentages (10-20%) in this zone. *Pinus*, *Abies,* and *Betula* are each at low values of less than 5%. Among the herbaceous taxa *Equisetum*, *Polemonium, Pedicularis*, High Spine Asteraceae, and *Oxyria* never reach more than ~5%.

Remarks: Seven out of the eight samples making up this pollen zone are from individual pellets and not homogenized material. The basal date of 4200 +/- 80 years BP is slightly younger and below the date of 4410 +/-50 from Layer 3. Surprisingly, the date of 4520 +/- 50 from Layer 33 is 33 m above organic material over the lower portion of the ice patch suggesting that some material has been mixed and re-worked. Some of the *Picea* and *Pinus* pollen from these samples is degraded and faded. Cyperaceae clusters/aggregates were observed for this zone.

9.9b Pollen Zone FC-II; (Artemisia); 40 – 45 m; 3550 years BP

Description: *Artemisia* reaches its highest levels at just over 40%. This zone is also marked by low percentages of *Picea* and *Alnus* at just below 10% each. *Salix* and Cyperaceae occur at 10% - 20% each. *Pinus* and *Betula* are also present but percentages are low. There is a diversity of herbaceous taxa, including *Equisetum,* *Polemonium*, High Spine Asteraceae, *Claytonia,* Caryophyllaceae, Poaceae and *Oxyria*, but these occur at very low percentages.

Remarks: This zone is based on counts from five dung pellets. Clusters/aggregates of Cyperaceae were found in one of the dung pellets from this zone.

9.9c Pollen Zone FC-III; (Picea-Artemisia); 50 – 77 m; 2850 – 1650 years BP

Description: *Artemisia* is less abundant in this zone but continues to dominate at about 20%, while *Picea* is also present at 20%. *Pinus* fluctuates between 5% and 20%, while *Abies* is present in trace amounts at less than 5%. Cyperaceae and Salix are present each at 10%-20%, whereas *Equisetum* is present at 5%-10%. There is a spike in *Betula* in one sample at almost 40%, which is at its highest for the entire pollen assemblage from Friday Creek. *Polemonium*, Poaceae, High Spine Asteraceae, *Claytonia*, Caryophyllaceae, and *Oxyria* continue to appear throughout this zone but in very low percentages.

Remarks: The majority of pollen in this zone is from several individual dung pellets rather than homogenized, disaggregated material. Pollen exhibits a range of preservation as some of the *Pinus* looked faded and degraded, while other grains displayed excellent preservation. An aggregate of *Salix* was identified as were several clusters of Cyperaceae pollen.

9.9d Pollen Zone FC-IV; (Cyperaceae-Pinus); 80 – 88 m; 1650 - 460 years BP

Description: This zone is characterized by Cyperaceae (20%-30%) and *Salix* (15%- 25%). *Picea* drops to some of its lowest percentages (<20%) in this zone. *Pinus* is also present at about 20%. *Betula, Alnus*, and *Abies* occur in minimal amounts at less than 5% each. *Artemisia,* is rare and at its lowest in this zone at 5%. Herbaceous taxa in this zone include High Spine Asteraceae at 5% and trace amounts of *Polemonium*, Poaceae, *Pedicularis*, *Claytonia*, *Oxyria* and Caryophyllaceae.

Remarks: The majority of pollen from this zone is from individual dung pellets. Some of the *Pinus* is degraded.

Rare Taxa: Several rare taxa (<1%) are present in the Friday Creek pollen assemblage (Appendix C). These taxa include Low Spine Asteraceae, *Epilobium, Tsuga,* Roseaceae, *Saxifraga, Rumex*, and *Chenopodium*. These taxa are not included in the pollen diagrams.

9.9e Summary of Pollen Analysis for Friday Creek Ice Patch

The Friday Creek pollen assemblage is characterized by high percentages of Cyperaceae, *Salix*, and *Artemisia* (~10 %-40%). *Picea* and *Pinus* pollen are each present in low to moderate (~3 %-20%) frequencies but make up a significant portion of the assemblage. *Betula* and *Alnus* pollen are present in low percentages at less than 10%, whereas *Abies* is rare or absent. *Artemisia* pollen is well-represented being present in percentages ranging from 5%-40%. High Spine Asteraceae occurs in low percentages (2%-5%), but it is consistently present throughout the sequence. A wide variety of herbaceous pollen, such as *Equisetum*, *Polemonium*, Poaceae, *Pedicularis, Claytonia*, Caryophyllaceae, and *Oxyria* are present but they occur in percentages of less than 5%.

9.9f Ordination

Ordination analysis was carried out on the Friday Creek and Ibex herd pollen assemblages in order to discover any correlations that may be indicative of seasonal use of the Friday Creek ice patch by caribou. Results show that there is minimal overlap between the dung from the Friday Creek ice patch and summer dung from the Ibex herd (Figures 28A and 28B). The closeness of the sample units on the ordination diagram indicates similarity between samples, while samples with great distances are more dissimilar in taxa composition. Named vectors show correlations between various taxa between samples (Figure 24B). Ordination analysis indicates that Low Spine Asteraceae, Roseaceae, *Rannunculus, Rumex, Oxyria, Chenopodium, Claytonia, Polemonium*, and *Saxifraga* are among the important taxa in the Friday Creek pollen assemblage.

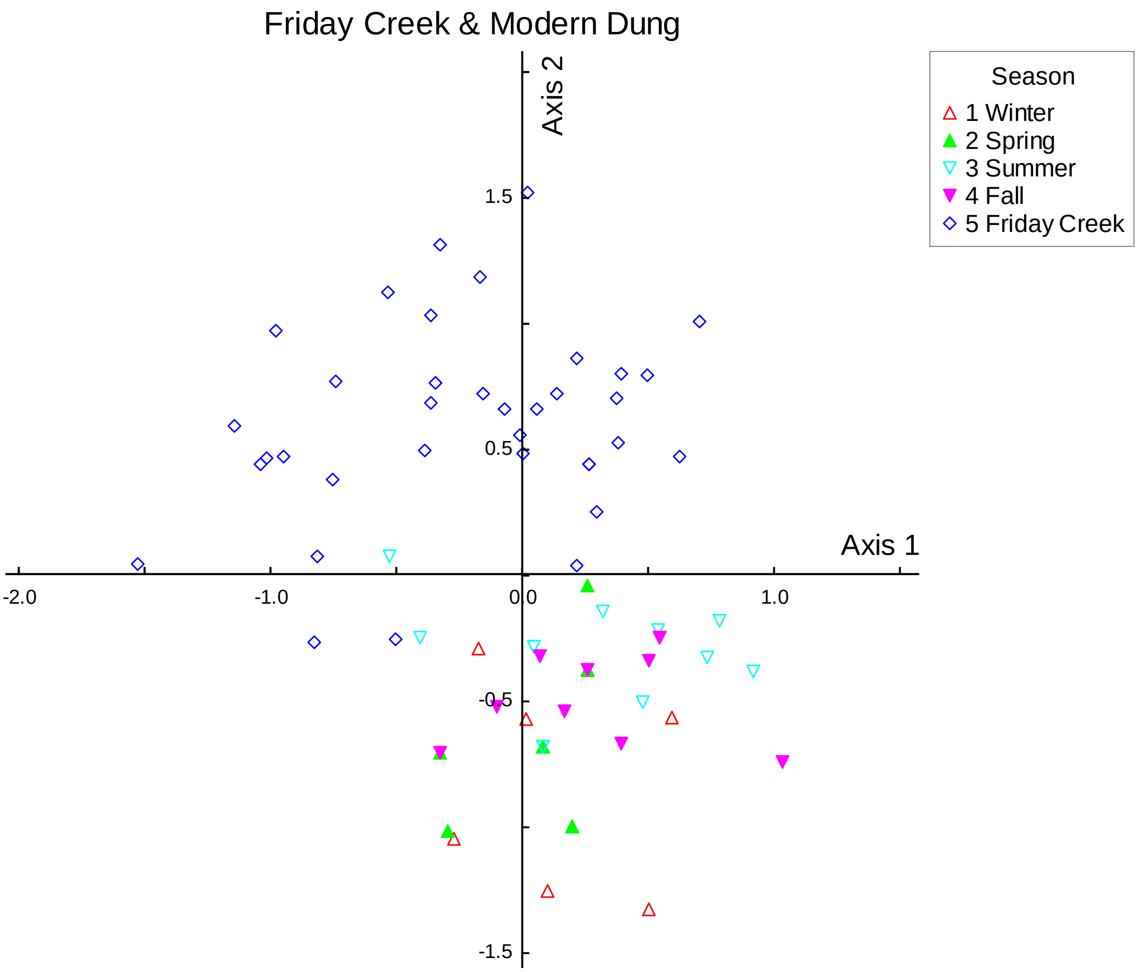


Figure 28A. NMS diagram for Friday Creek ice patch showing separation of the dung samples. This ordination illustrates the variation in the caribou dung. Each symbol represents a sample. The distances between symbols in the ordination are approximately proportional to the dissimarity between samples.

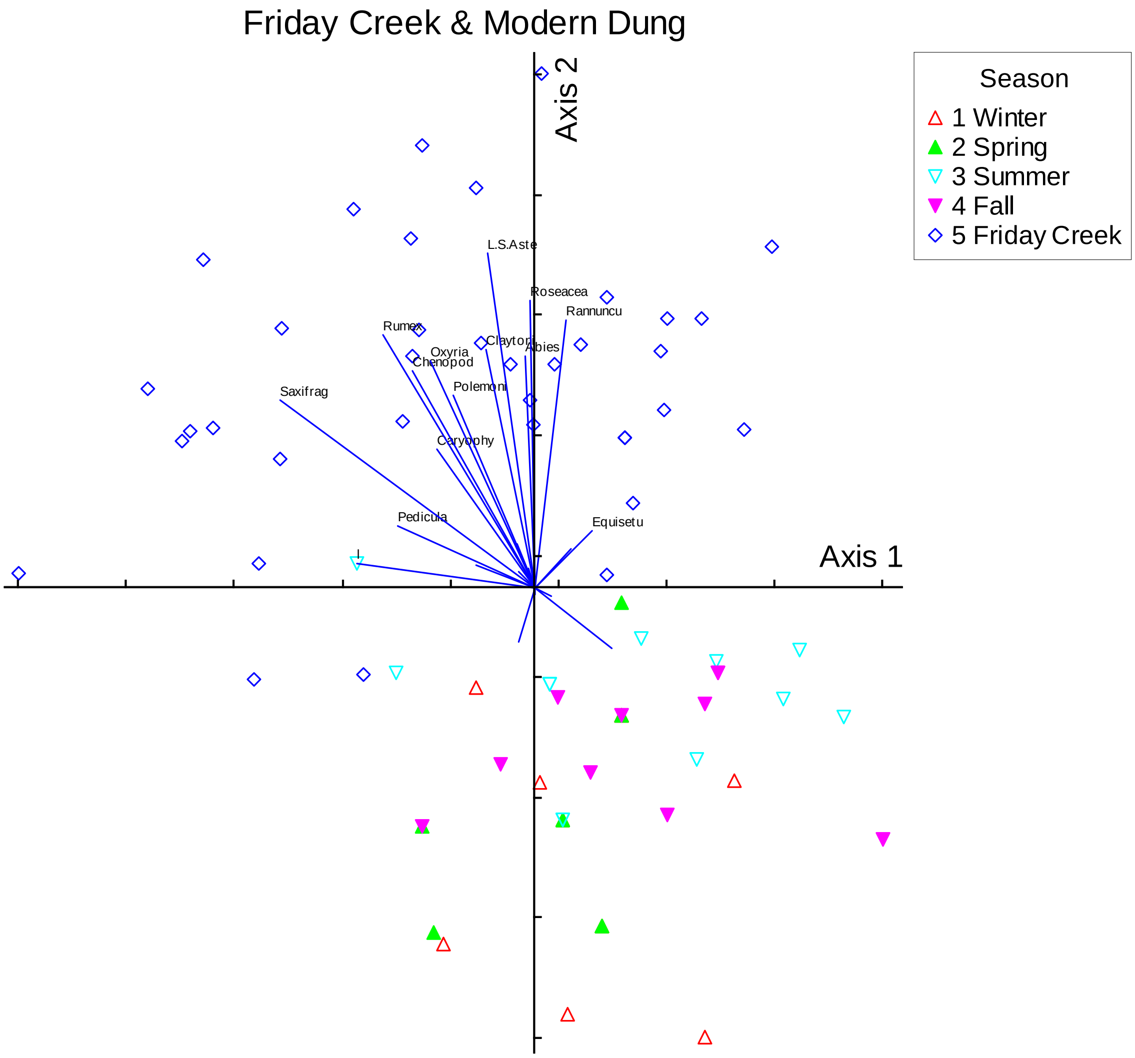


Figure 28B. NMS diagram for Friday Creek ice patch with pollen types explaining most of the variation in the caribou dung. Each symbol represents a sample unit. Short vectors may suggest little variability within a sample. Vectors with taxa indicate the taxa most strongly associated with ancient dung.

10.0 DETERMINING SEASONALITY

10.1 Overview

Biological literature indicates that caribou are predictable in their use of ice patches during summer months to seek relief from insect harassment and for thermal regulation (Andersen and Nilsen 1998; Ion and Kershaw 1989; Kelsall 1968; Weladji et al. 2003). Importantly, reports on caribou behaviour also indicate that caribou consume high quality forage around ice patches during summer months (Hagemoen and Reimers 2002; Ion and Kershaw 1989; Toupin et al. 1996). Independently collected palynological data sets from ancient dung from the Granger and Friday Creek ice patches were used to test this seasonality model. Based on caribou biology it is expected that pollen spectra should reflect summer use of ice patches. Pollen from dung of the modern Ibex caribou herd is used as a baseline for interpreting seasonality of ancient pollen assemblages.

10.1a Ibex Herd - Winter Dung

Examination of the pollen diagram for the Ibex caribou herd indicates that winter pellets are dominated by *Betula, Pinus, Picea,* and *Alnus* but these taxa do not represent winter diet (Appendix A; Figures 18A and 18B). *Betula, Pinus, Picea,* and *Alnus* produce great quantities of wind-transported pollen that adhere to leaves, stems and lichen surfaces. The appearance of these taxa in winter dung indicates their accidental ingestion by caribou while foraging. Instead of diet, these pollen represent regional pollen rain, the result of long-distance transport, which are incidentally ingested during the consumption of forage.

Microhistological studies done on the Wolf Lake, Little Rancheria, and Klaza herds of the southern Yukon (see Figure 9) show some consumption of *Pinus* and *Picea* but their presence is attributed to the incidental ingestion of forest floor detritus while seeking out lichens in ground based vegetation (Farnell and MacDonald 1990:24). In addition, diet studies done on barren ground caribou in arctic Canada recovered high percentages of *Betula glandulosa* leaves in rumen contents but the animals ingested *Betula* leaves as dry fallen material along with lichen forage (Scotter 1967:34). *Betula* is not known as a preferred forage among caribou as it contains phenols, which are a major defense against heavy browsing by ruminants. Phenolic extracts within *Betula* reduce digestibility and have toxic properties (Guthrie 2006; Palo 1985; Palo et al. 1985).

By the time winter approaches, the diet of caribou consists almost entirely of lichens, which are very high in carbohydrates and are rapidly digested by caribou (Holleman and Luick 1977). Caribou take many species of terrestrial lichens (crustose, foliose, and fruticose), such as *Cladonia* spp., *Cetraria* spp. and *Peltigera* spp., and less commonly arboreal lichens (Bergerud 1972; Edwards and Ritcey 1959; Farnell and MacDonald 1989, 1990; Farnell et al. 1991; Scotter 1967). Microhistological studies done on the Klaza, Wolf Lake and Little Rancheria caribou herds suggest that lichens are the predominant food source for these animals during winter (Farnell and McDonald 1989, 1990; Farnell et al. 1991). Since lichens do not produce pollen, this large portion of the caribou's diet is not represented in winter pollen assemblages (Holleman and Luick 1977; Kelsall 1968).

According to the pollen data base (Appendix A), almost 70%, or 23 out of the 33 of the taxa recorded (including Unknown Types) for the Ibex pollen assemblage, is present in winter dung. Examination of the pollen diagram indicates that winter dung includes low pollen frequencies of *Salix*, Poaceae, Cyperaceae, and Ericales, which are known to be caribou forage during this season. For instance, some species of *Salix* flower early in spring but their flowerbuds, containing already developed pollen lie below the snow during winter. Where spring snow is shallow, caribou are able to reach and consume *Salix* buds also consuming the pollen (Strasburger et al. 1976 in Bjune 2000).

Trace amounts of Poaceae and Cyperaceae pollen suggest these taxa were part of the Ibex caribou winter diet. The grasses *Poa* and *Festuca,* and the sedges *Carex* and *Eriophorum* have been identified in plant fragment analyses of winter diet for the Little Rancheria, Wolf Lake, and Klaza caribou herds. The winter consumption of grasses and sedges by these herds is thought to provide an important source of protein and nitrogen for these animals (Farnell and McDonald 1990; Farnell et al. 1991). Among the Mount McKinley herds of Alaska and Yukon, grasses and sedges were eaten extensively when lichens were not in abundance (Scotter 1967). Peary caribou herds are known to select high percentages of sedges in winter when available (Bergerud 1972; Boertje 1984; Thomas and Edmonds 1983).

Ordination suggests that Ericales represents part of the winter diet for the Ibex herd (Figure 18B). Perennial shrubs are commonly reported as a winter food among caribou and residual pollen remaining on Ericales leaves and other plant parts may have been incidentally ingested (Bergerud 1972; Kelsall 1968; Rominger and Oldemeyer 1990; Scotter 1967; Thomas et al. 1996). Winter diet studies done on the Wolf Lake, Klaza and Little Rancheria herds indicate consumption of Ericales such as *Ledum*, *Vaccinium*, *Cassiope*, and *Empetrum,* supporting this interpretation (Farnell and MacDonald 1989, 1990; Farnell et al. 1991).

Although lichens provide important carbohydrates for caribou during the winter, the animals require green vegetation to maintain adequate protein levels for healthy survival (Kelsall 1968:72; Scotter 1967:36; Thomas and Edmonds 1983). During years when snow accumulation is slower, evergreen shrubs, such as the Ericales are among the most important early winter forage for caribou in the Selkirk Mountains of British Columbia (Rominger and Oldemeyer 1990). *Vaccinium spp*. (mostly berries) are also known to make up large portions of fecal fragments in some caribou herds (Thomas et al. 1996).

10.1b Ibex Herd - Spring Dung

Examination of the pollen diagram and Appendix A, shows that spring dung has the lowest diversity, with only 19 out of the 33 taxa, or 60%, of all of the taxa (including Unknown Types) recorded. The low diversity of taxa reflects the absence of blooming taxa in the diet and the continued reliance on lichens during this time. The presence of *Salix* pollen compares well with other studies in which the catkins and buds of willows were identified (Bergerud 1972; Boertje 1984; Staaland 1984).

The pollen diagram also shows the presence of Cyperaceae. Young shoots of Cyperaceae during spring, such as *Carex spp*. are especially desirable as they contain high amounts of protein, which is important for caribou body growth and repair. Sedges are among the first food consumed during the spring by Newfoundland caribou (Bergerud 1972). Among woodland caribou populations in west-central Alberta, sedges were used as early as mid-April along valley bottoms (Thomas et. al 1996).

10.1c Ibex Herd - Summer Dung

Summer dung is characterized by a diversity of pollen types (Figure 16; Appendix A). Of the 33 taxa types identified (including Unknown Types), 26 or almost 80% of these, are present in summer dung. This variability likely reflects the wide variety of flowering taxa available and consumed by caribou during summer months. Ordination also demonstrates this pattern with a strong association of several pollen types including *Polemonium,* cf. *Fritillaria, Astragalus*, *Pedicularis,* Cyperaceae, *Salix*, High Spine Asteraceae, *Equisetum*, Caryophyllaceae, and *Rannunculus* (Figure 18B). The diversity of summer dung pollen is attributed to the number of taxa combined with selective grazing of taxa in early stages of development (Bjune 2000:190; van der Knapp 1989). The strong association between insect-pollinated plants such as *Pedicularis, Salix, Astragulus*, *Epilobioum*, and *Rannunculus* in the dung provides additional support for interpretation that pollen represents the direct consumption of flower heads during summer months.

Summer dung (Figure 16) is dominated by *Salix* and Cyperaceae, which compares favourably with what is known about caribou diet elsewhere in the region. Microhistological studies of pellets for summer diet from the Aishihik, Finlayson and Ibex Yukon caribou herds indicate high percentages of shrubby material such as *Salix* leaf and stem fragments (Farnell and McDonald 1989, 1990; Farnell et al. 1991). A variety of prostrate willows made up a major portion of the *Salix* component of the diet in the summer, especially when caribou retreat to high slopes and wind-exposed ridgetops to avoid insects (Boertje 1984:163). Oosenbrug and Theberge (1980) recorded that over 40% of the identifiable summer food was willow for the woodland caribou in the Kluane Ranges. Among the Denali herd in Alaska, willow makes up at least 50% of the total food intake during spring and summer diet (Boertje 1984; Oosenbrug and Theberge 1980; Thomas et al. 1996). Deciduous shrubs, including *Salix*, are commonly reported food items for caribou in Newfoundland (Bergerud and Nolan 1970). Sedges (Cyperaceae) are important to caribou during the summer months (Holleman et al. 1979; Thomas et al. 1996). Plant fragment analysis of summer pellets from the Aishihik, Finlayson, and Ibex caribou herds indicate high percentages of *Carex*, *Eriophorum* and *Juncus* (Farnell and McDonald 1989, 1990; Farnell et al. 1991). Among the woodland caribou herd in the Burwash Uplands in southern Yukon, sedges were the main component of summer diet (Oosenbrug and Theberge 1980).

10.1d Ibex Herd - Fall Dung

Ordination indicates that Ericales pollen is one of the taxa most strongly associated with fall dung. As autumn progresses caribou switch from a diet of forbs and graminoids, as plant tissues becomes tough and upalatable, to evergreen shrubs and lichens. Inspection of the pollen diagram (Figure 17) shows trace amounts of *Salix*, Cyperaceae, Poaceae, *Equisetum*, and *Artemisia* pollen as their consumption declines as the vegetation becomes mature and tough (Bergerud and Nolan 1970; Kelsall 1968). Among Alaska's Fortymile and Nelchina barren ground caribou herds, willows remain important well into the fall, which differs slightly from the woodland caribou herd in the Kluane Ranges where sedges were of greatest significance.

10.1e Indicator Species Analysis

To determine whether certain taxa are strongly associated with specific seasons an Indicator Species Analysis was run on the pollen assemblages from the Ibex caribou herd dung. This method combines information on the concentration of species abundance in a particular group and the faithfulness of occurrence of that species (i.e. taxa) in a particular group. A perfect indicator of a particular group is always exclusive to that group (Dufrene and Legendre 1997 in McCune and Grace 2002:198). The analysis indicates that taxa such as *Pinus, Picea, Betula, Alnus,* and to some extent *Abies* are poor indicators of season as they are present in all or nearly all samples across all seasons (Table 7).

Taxa	**Winter**	**Spring**	**Summer**	**Fall**
Pinus	100	100	100	100
Picea	100	100	100	100
Betula	100	100	100	100
Alnus	100	100	100	100
Abies	100	100	83	91
Fritillaria	0	0	8	0
Epilobium	0	0	33	0
Polemonium	0	0	25	0
Callitriche	20	0	0	36
Populus	20	0	0	0

Table 7**.** Indicator Species Analysis. Relative frequency of taxa according season (percent of samples in a given season where given taxa is present). Monte Carlo test of significance using 1000 permutations.

According to the Indicator Species Analysis *Polemonium, Epilobium,* and cf. *Fritillaria* pollen are only present in summer dung and are therefore strong indicators of this season. *Callitriche* pollen is limited to winter and fall dung, whereas *Populus* is only found in winter dung. Ordination analysis also indicates that *Populus* is strongly associated with winter caribou dung. I found no reference to *Populus* as a food item by caribou. *Populus* is one of the earliest trees to leaf out in the spring and its presence in winter dung may be the result of its incidental ingestion during its flowering period in late winter/early spring.

10.2 Ancient Caribou Dung from Granger and Friday Creek Ice Patches

Inspection of pollen and ordination diagrams from ancient ice patches indicates a diversity of taxa in many of the pellets, especially at Friday Creek (Figures 24B and 29B). The presence of *Salix*, Cyperaceae, *Pedicularis*, and *Oxyria, Epilobium*, *Rannunculus, Polemonium* compares well with the results for summer dung from the Ibex herd and suggests that some ancient pellets from Granger and Friday Creek were deposited by caribou during warm months. van der Knapp (1989) also argues that summer dung is characterized by many pollen types. A variety of palatable plants with high biomass is important during the summer and is reflected in the variety of pollen types identified. Flowering in the alpine tundra starts immediately with snowmelt (Mordant 1997) and as the snow melts caribou graze on the newly exposed fresh plants. Although many of these are small plants that tend to be comparatively poorly represented in dung, these early flowering plants are attractive forage for caribou after a long winter with only old vegetation to graze (Bjune 2000).

The mixed summer diet is more nutritious than that of fall and winter, or that of largely single item diets (Bergerud 1972). Caribou diet in the summer consists of young vegetation which restores their depleted body reserves and accumulated fat lost over the winter months. Male caribou may loose as much as 50% of their maximum body weight during the winter. As a result caribou respond by selecting forage that enhances growth and the fattening process which, during the growing season, consists of a mixture of plant species (Staaland 1984). Fattening relies on spring and summer plants with high digestibility and high nutrient content and includes taxa with significant levels of protein and micro- and macro-minerals (Staaland 1984).

Ordination analysis shows a strong association between ancient dung and *Saxifraga, Oxyria, Chenopodium, Claytonia*, and Caryophyllaceae (Figures 24B and 29B). *Oxyria*, which is known to be a high quality and easily digestible plant grazed by some caribou herds, including those in Norway, is an important taxon at Friday Creek and Granger ice patches (Staaland 1984; Staaland, et al. 1983 in Bjune 2000). This taxon is also important in the summer dung of the Ibex herd and its significance in the ancient dung is demonstrated in the ordination analysis.

The strong association of *Artemisia* and *Equisetum* in the Friday Creek pollen assemblages (Figure 28) also indicates summer use of ice patches. *Artemisia* and *Equisetum* are present in modern Ibex caribou herd summer dung and are heavily grazed during early phenological stages of development by the Denali barren ground caribou herd in Alaska. These taxa are reported as important summer forage of caribou herds in Norway (Boertje 1984).

Cyperaceae makes up an important component of the Granger and Friday Creek pollen assemblages. This compares well to pollen and plant fragment analysis from dung of the Ibex herd and from plant material identified in microhistological studies of summer dung from the nearby Aishihik and Finlayson herds. Summer foraging behaviour of caribou in the Kluane Ranges shows strong preference for sedges. Sedges are the main component of the summer caribou diet, influencing habitat choice with the most preferred habitats being those rich in sedges (Oosenbrug and Theberge 1980:70). Studies in the

Kluane Ranges indicate that over the entire summer, caribou prefer forage dominated by sedge. As snow melts, caribou in the Kluane Range move to higher elevations selecting primarily sedge meadow and *Dryas*-sedge meadow vegetation. The *Dryas* -sedge meadow community, a sedge rich community in the ranges, was favoured over the *Dryas* upland community, which lacked a sedge component. In addition, the preference by caribou for slopes less than 20º with northern aspects may in part reflect abundance of sedges in those hydric sites (Oosenbrug and Theberge 1980). Boertje (1984) notes that among the Denali (also known as the Mt. McKinley) barren ground caribou, sedges were especially important when the animals were restricted to ridgetops and upper slopes by insect harassment.

Surface fecal pellets were collected from the Thandlat (JdVb-2) and Friday Creek ice patches and submitted to the Habitat Nutrition Laboratory at Washington State University for plant fragment analysis (microhistological studies) (Kuzyk et al. 1999; Farnell et al. 2004). The Thandlat ice patch is located near Kusawa Lake at approximately 1830 m a.s.l. (see Figure 1). Caribou dung from the Thandlat ice patch dates back to 7440 ± 60 yrs BP and is associated with archaeological materials. Caribou biologists collected small quantities of fecal pellets at various localities on the surface of the Thandlat ice patch for dietary analysis and the results of that analysis are included in the following discussion for comparative purposes.

Analysis of dung from Thandlat indicates that caribou foraged off of predominantly sedges (36%), some lichen (23%), moss (11%) and grass (10%).

No direct comparisons were made to the summer diet of local caribou herds but comparisons to the Porcupine Caribou Herd in northern Yukon indicate that during the insect harassment period (June-August), animals feed mainly on emergent willow leaves (47%) and herbs (36%), with a minor component of lichens (10%) (Kuzyk et al.1999; see Russell et al. 1993). In a study by Mr. Don Russell (personal communication, 2010) modern dung samples collected in the summer (July 19 – August 4) for the Ibex and Aishihik herds are dominated by shrubs (e.g. *Salix*) at 37%, lichens at 25%, sedges at 19% (*Carex spp*.and *Eriophorum*), and forbs at 5% (e.g. *Astragalus* and *Oxytropis*).

For comparison, modern dung samples were collected from the immediate tundra surface at Friday Creek ice patch and from the Ibex herd's winter range (Kuzyk et al. 1999; Farnell et al. 2004). According to these analyses there is little difference in average dietary composition between ancient Holocene caribou at Friday Creek ice patch and the summer diet of the present day Ibex herd. In both cases, diets are dominated by shrubs with smaller proportions of lichens and sedges. Caribou biologists did find slightly higher percentages of forbs in the modern Ibex caribou herd (Farnell et al. 2004). In contrast, the diet of caribou on ice patches differed markedly from the modern winter diet of the Ibex here, which is dominated by 86% lichens. Similar results are reported for other herds wintering on lichen-rich ranges (Russell and Marell 1984). These analyses indicate that the ice patch dung was deposited during the summer (Farnell et al. 2004).

Two additional lines of evidence suggest that some of the ancient dung at ice patches was deposited in summer months. Indicator Species Analysis of modern Ibex herd dung shows that *Polemonium* and *Epilobium* are good indicators of summer dung. *Polemonium* pollen is found in 31/37 (84%) of the samples examined from Friday Creek ice patch and *Epilobium* pollen is present in 5/37 samples. This analysis makes a strong case for many of the dung pellets at Friday Creek being deposited in warm summer months. In addition, several of the taxa identified in dung at Granger and Friday Creek ice patches, such as *Polemonium, Pediculars, Epilobium,* some species of *Salix*, Caryophyllaceae, *Claytonia,* and *Saxifraga*, are insect-pollinated, which can only take place during warmer months. Similar results were found in dung deposited on ice patches in the Northwest Territories. Galloway (2009) identified insect-pollinated taxa *Polemonium* and *Epilobium,* and pollen types from the Saxifragaceae and Caryophyllaceae families, from caribou dung, suggesting some summer deposition at these locations.

Inspection of pollen diagrams (i.e. the type and variety of taxa), Nonmetric Multidimensional Analysis (ordination), Indicator Species Analysis, the presence of insect-pollinated taxa and cluster aggregates demonstrate similarities between modern and ancient dung pollen assemblages, which suggest some use of ice patches in the summer. However, ancient dung cannot be unequivocally assigned to a season based on comparing the ordination analyses of modern and ancient pollen assemblages. It is not straightforward to conclude that all of the caribou dung at the Friday Creek or Granger ice patches was deposited at one particular season. To be prudent, a number of taphonomic factors must be considered to fully understand and interpret the pollen spectra from Friday Creek and Granger ice patches.

11.0 TAPHONOMIC PROCESSES & THE INTERPRETATION OF DUNG POLLEN

11.1 Overview

Pollen assemblages of any origin have inherent biases and limitations which must be considered prior to any interpretations (Jacobson and Bradshaw 198; Lebreton et al. 2010; Pelankova and Chytry 2009; Tweedle and Edwards 2010). Pollen grains contained within dung have been produced, transported, deposited, and degraded differentially by a suite of natural, biological, chemical and physical processes (Faegri and Iversen 1964; Geib and Smith 2008; Lebreton et al. 2010). In all cases it is necessary to distinguish between the data that is most useful and that which is considered "noise" in relation to the information being sought (Jacobson and Bradshaw 1981). Interpreting pollen spectra from dung requires an understanding of the various pathways of pollen to the plants being ingested, and then a thorough consideration of the various factors that influence the pollen in the dung itself (Figure 29).

11.2 Pollen Productivity and Modes of Dispersal

It is important to recognize modes of transport, dispersal properties, and pollen productivity of plant taxa that appear as pollen types in order to evaluate the sources of pollen at a collection site (Birks 1980; Jacobson and Bradshaw 1981). Plants differ in their pollen productivity, which varies from several thousand to several million pollen grains (Moore et al. 1991). For instance, *Alnus*, a prolific pollen producer, is generally over-represented at paleoecological sites and in modern pollen assemblages of the southern Yukon (Birks 1977, 1980).

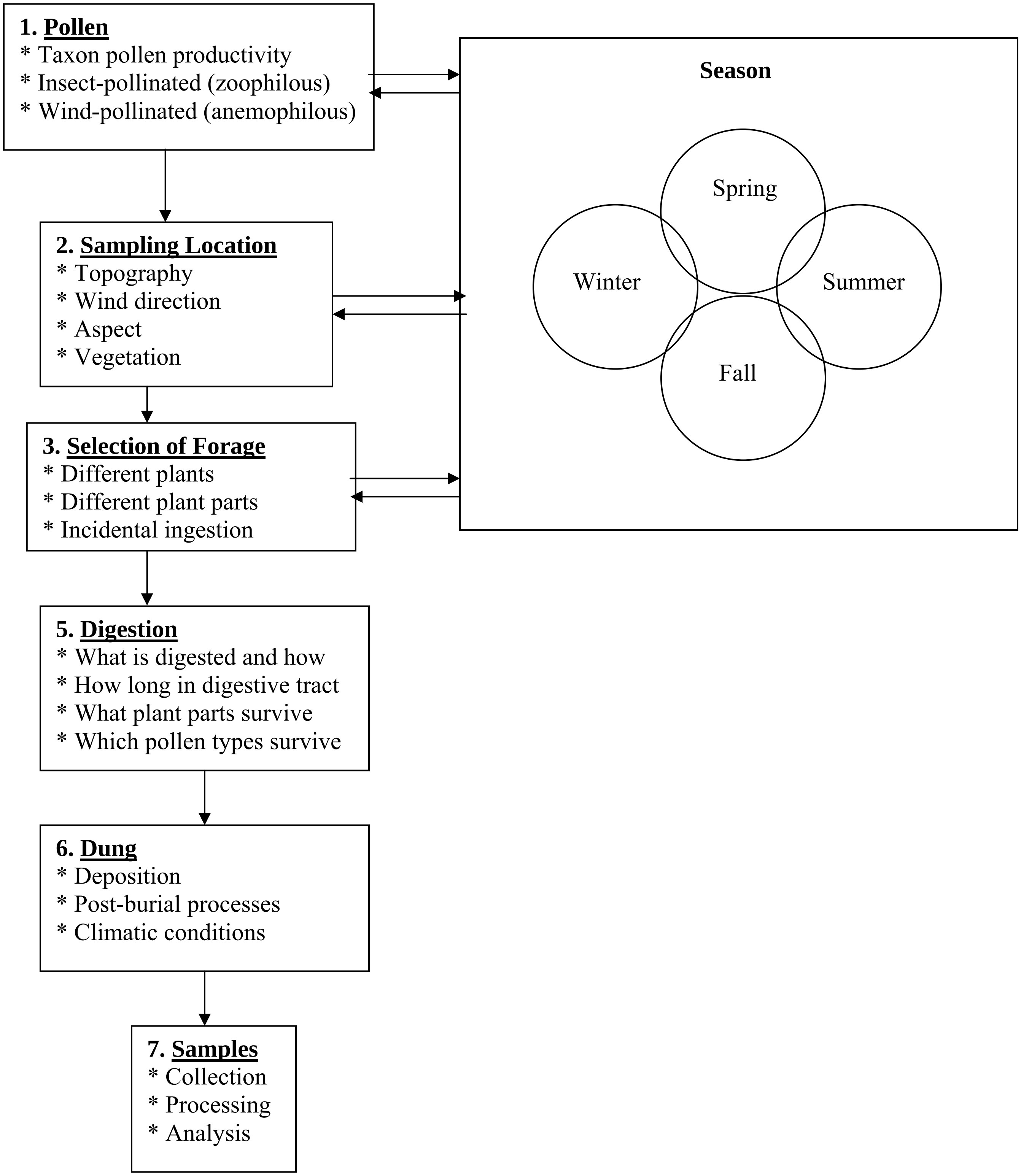


Figure 29. Processes affecting the dispersion, modification and presentation of pollen and therefore the interpretation of pollen assemblages from dung.

In moss polsters collected from the St. Elias Mountains, *Alnus* represented up to 18% of the pollen even though this taxon does not grow in tundra. In the same study, Birks (1977) found that the *Dryas* tundra had consistently high (up to 30%) values as did *Betula* (up to 20%) for the St. Elias Mountains, even though these taxa do not grow in the tundra (above 1700 m altitude) today. In contrast, wind-pollinated *Populus* is rarely found in modern pollen rain studies at alpine tundra sites (Birks 1977).

Pollination is largely accomplished through zoophilous/entomophilous or insect pollination and anemophilous or wind pollination (Faegri and Iverson 1964). The distance of pollen transport can range from virtually none for some animal-pollinated (zoophilous/entomophilous) species to hundreds of kilometers for wind-pollinated (anemophilous) taxa such as *Pinus* (Carrion 2002; Davis and Anderson 1987; Faegri and Iverson 1964; Mead et al. 1986). Dispersal characteristics create situations where species may be over- or under- represented (Birks 1973; Birks and Birks 1980; Lowe and Walker 1997; Moore et al. 1991; Prentice 1986:799; Wang and Guerts 1991a and 1991b). Conifers and several shrubs are wind-pollinated and produce abundant, aerodynamic pollen that can travel up to hundreds of kilometers. Insect-pollinated plants include many herbs and forbs that produce small amounts of heavy, more ornamented pollen designed to travel short distances on insects, or remain with the parent flower (Geib and Smith 2008). A single pine tree may produce more than a billion wind-transported grains, whereas herbaceous taxa may produce fewer than 100 pollen grains (Faegri and Iversen 1964; Geib and Smith 2008). In addition, wind-pollinated and insect-pollinated taxa are not exclusive categories and some plant species employ both methods (e.g. *Salix*).

Pollen dispersal depends on the distance from the vegetation source area to the sampling location (i.e. local 0-20 m, extra-local 20-1000 m and regional > 1000 m) (Birks and Birks 1980; Jacobson and Bradshaw 1981; MacDonald and Cwynar 1991). The proximity of forests and the openness of the sampling site are other conditions which affect pollen dispersal (Birks and Birks 1980; Jacobson and Bradshaw 1981; Tauber 1977 in Jacobson and Bradshaw 1981). Where vegetation consists of groundcover or where plants are not very tall, the possibility of pollen dispersal is reduced.

In the mountainous region of the southwest Yukon, where valley floors are below tree line and the horizontal distances between major ecozones are compressed, the regional pollen rain is related to the relative pollen productivity of vegetation zones (see Rampton 1971). Generally, local pollen production in the alpine tundra zone is low, which results in the regional pollen component from the lower arboreal vegetation zones dominating the pollen assemblages deposited in the tundra (Birks 1977:2376; Birks and Birks 1980; Rampton 1971:964). Tree pollen such as *Picea*, *Alnus* and *Pinus* tend to be greatly over-representeed in pollen above tree line in the southwest Yukon (Birks 1977; Rampton 1971).

Another way in which pollen productivity affects dung pollen is through the consumption of ice, snow and water by animals. Caribou are known to eat snow on ice patches when seeking relief from heat and insects and foraging around ice patches. The accidental ingestion of pollen while drinking water and eating snow are probable vectors for many pollen types in dung (Thompson et al. 1980). In looking at long-distance transport of pollen and seasonality from snow collected from the Arctic, Bourgeois (2001; Gajewski 2006) found that tree pollen made up significant portions of the samples. As part of the ice patch research, I carried out a preliminary analysis of pollen from "clean ice" (layers of ice in which dung is absent) which showed that these samples are primarily comprised of *Pinus, Picea* and *Alnus* (also see Farnell et al. 2004). The predominance of these wind-dispersed taxa suggests that they were deposited on to the ice in the early winter prior to snowfall, when pollen production is low (Bourgeois 2001; Farnell et al. 2004:254; Haeberli et al. 1983; Janzon 1981). Caribou may eat snow on ice patches that contains *Pinus, Picea*, *Alnus, and Abies* but these taxa were deposited during the previous winter (or winters), and as a consequence have nothing to do with caribou forage or the seasonality of the ice patch use.

Pollen grains of early pollinators are deposited on the surface of ice patches, usually one week or two weeks after the beginning of flowering (Ambach et al. 1966). The consumption of snow and ice at this time may result in some of the early pollinators being ingested (Toupin et al. 1996:381). Once the snow and ice has melted, pollen from early pollinators may be deposited into small meltwater streams at the base of ice patches where caribou drink, also resulting in their ingestion. The selective recruitment of pollen, into glacial meltwater and into outlet streams of small glaciers, in association with favourable habitat for taxa such as *Salix* has been documented (Pennington and Tutin 1996). Some of the pollen that is deposited on the ice patches over the winter, early spring, and previous summer months remains as a residue and may get mixed through meltwater transport once the snow and ice begin to melt (Pennington and Tutin 1996). Further studies that identify and quantify pollen from within the ice will assist in assessing pollen in caribou dung from ice patches. These studies should include the systematic collection of non-dung samples from ice patches and from surrounding meltwater streams (also see Farnell et al. 2004: 253).

11.3 Wind-Pollinated Taxa

Pollen assemblages may be divided into various components that represent the source of the pollen. Pollen, primarily wind pollinated types, may be deposited in the vegetation where it can be ingested along with the forage. However, caribou also consume flowers containing the pollen specific to these taxa (also see Bjune 2000). Separating these two sources of pollen is difficult. As discussed above, there is a constant atmospheric rain of pollen grains composed of a mixture of species from the surrounding local to regional vegetation (scale of meters to kilometers). In addition, the composition of this pollen rain changes with the seasons according to which species are flowering and climatic conditions (Geib and Smith 2008).

Wind-transported pollen from trees may be incidentally consumed with the forage on which it adheres. Tauber (1977 in Thompson et al. 1980:369) notes that large numbers of pollen grains, for example up to 280,000 grains on a 15 cm twig, collect on the vegetative parts of plants. The pollen remains on these surfaces until the next heavy rain when most, but not all, of the pollen washes away. In addition, many of the pollen grains found in winter and autumn dung are produced and deposited during the preceding summer and then incidentally ingested at a later time (Bjune 2000; Moe 1983). For instance, *Betula* pollen exists in the atmosphere when pollen emission has been terminated for many months and there is snow on the ground (Janzon 1981:183).

The correspondence between specific vegetation and its pollen spectrum can be complicated. Granger and Friday Creek ice patch pollen spectra are masked by high peaks in long-distance wind dispersed pollen such as *Picea, Pinus* and *Alnus,* and *Betula*. Dung samples from Granger and Friday Creek ice patches consistently show percentages ranging from 5 to 35% even though none of these taxa are in the alpine tundra and do not represent caribou forage. The high peaks of anemophilous *Picea* and *Pinus* (up to 40%) pollen at ice patches can be attributed to its over-representation at alpine locations in general (Birks 1977). The pollen of these taxa is then inadvertently ingested by caribou when foraging. In addition, great quantities of wind-pollinated pollen grains can blanket an area and mask the presence of insect-pollinated taxa (Murray et al. 2008).

11.4 Insect-Pollinated Taxa

There is a preference among ungulates for flowering plants, which results in insect-pollinated plants being ingested and represented in the pollen spectra (Mead et al. 1986; Moe 1983). Insect-pollinated taxa such as *Saxifraga, Polemonium, Oxyria*, and *Claytonia* are generally indicative of direct consumption of flowers by caribou (Mead et al. 1986). Pollen content of animal dung can provide information on what the animals have eaten (Moe 1983; Rasmussen 1993; Thompson et al. 1980; van der Knapp 1989), although it does not necessarily present an accurate picture of diet (Bjune 2000; Carrion 2002; Kropf et al. 2007; Mead et al. 1986). Animals may ingest pollen directly through the consumption of flowers, potentially resulting in large pollen concentrations of certain taxa (Kropf et al. 2007; Thompson et al. 1980). However, if foraging occurs when few plants are flowering, or if the plants consumed have low pollen production, such as insect-pollinated taxa like *Polemonium* sp., then these taxa may be under-represented or absent from pollen spectra. For instance, insect-pollinated *Polemonium, Pedicularis* and *Claytonia* are low pollen producers compared to the arboreal wind-pollinated *Pinus, Picea* and *Alnus* (Bjune 2000; Moe 2001). As a result it can be expected that low pollen producing, insect-pollinated forbs will be under-represented in caribou dung compared to more prolific, wind-pollinated trees (Bjune 2000).

The presence of insect-pollinated taxa in modern and ancient dung, however, does indicate that some plants were consumed as flower heads during bloom time. For instance, caribou are known to select flower heads of *Saxifraga* in the summer, and this pollen type is found in pellets from Granger ice patch (Figures 22, 23B; Appendix B; also see Staaland 1984; Thomas et al. 1996; White and Trudell 1980). The strong association between insect-pollinated plants such as *Pedicularis, Salix, Astragulus*, *Epilobioum*, and *Rannunculus* in the summer dung of the Ibex Herd suggests the direct consumption of flower heads. Several of the taxa identified in dung at Granger and Friday Creek ice patches are also insect-pollinated including *Polemonium, Pedicularis, Epilobium, Salix*, Caryophyllacaeae, and *Claytonia*, which suggests the direct ingestion of flower tops by caribou (Table 8).

Taxa (Genus)	**Mode of Pollination**	**Site**
Ericales	Insect	I, G, FC
Salix	Insect /Wind	I, G, FC
Polemonium	Insect	I, G, FC
Epilobium	Insect	I, G, FC
Pedicularis	Insect	I, G, FC
Caryophyllaceae	Insect	I, G, FC
Rannunculus	Insect	FC
Astragalus	Insect	I
cf. Frittilaria	Insect	I
Claytonia	Insect	G, FC
Saxifraga	Insect	G, F
Roseaceae	Insect	FC

Table 8. Mode of pollination for selected pollen taxa identified in modern and ancient dung. I = Ibex Herd; G = Granger Ice Patch; FC = Friday Creek Ice Patch.

Pollen aggregates, which can consist of hundreds of pollen grains of a single taxon clustered together, were likely from an anther and indicate that the flower heads were consumed directly. *Salix,* Cyperaceae, and *Betula* pollen clusters were found in samples from Friday Creek and Granger suggesting the presence of anthers.

11.5 Topography and Wind Direction

The topography and size of sampling location and its relation to pollen sources are important factors. In some cases pollen influx from different sites can reveal common background (regional) components, but different local and extralocal components (Bourgeois et al. 2001). This is especially the case when samples are from sampling locations within a similar region but come from different edaphic and topographic conditions (Gavin et al. 2005; Jacobson and Bradshaw 1981; Ritchie 1984:173-175). For instance, among high elevation sites, updrafts may bring pollen from lower altitudes to higher sites (Bourgeois 1990, 2001; Maher 1963 in Jacobson and Bradshaw 1981) (Figure 30).

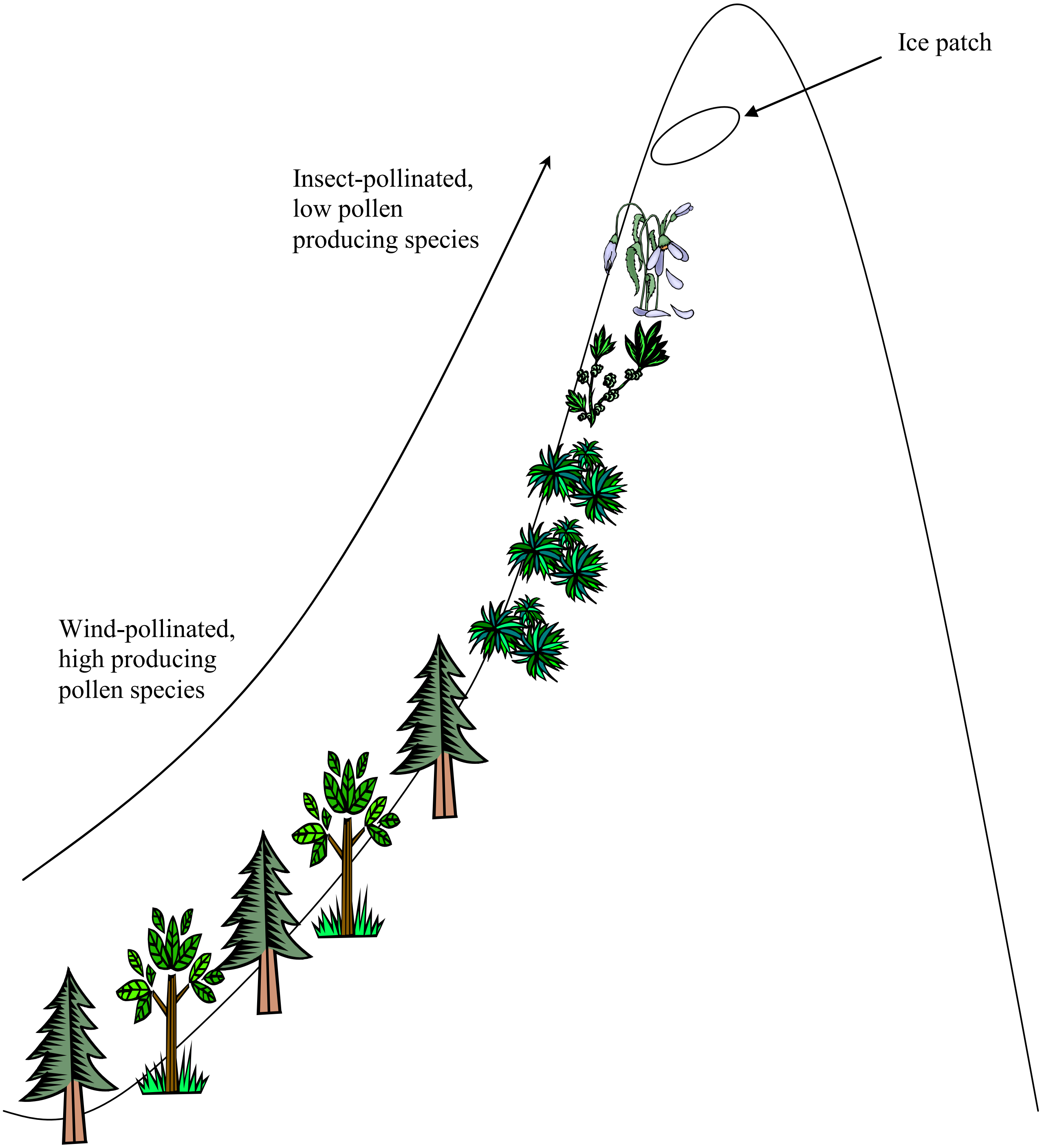


Figure 30. Pollen from lower forested elevations is transported up-slope to accumulate on tundra vegetation and ice patch. Pollen from lower vegetation zones may be deposited onto vegetation and water consumed at the ice patch and on to caribou dung.

Wind studies in the Whitehorse area of southwest Yukon show that predominant winds on mountaintops were from the southwest, south- and southeast (Pinard 2007). In the case of pollen assemblages from ice patches, pollen from lower elevations in the sub-alpine and valley bottoms may be inadvertently deposited on dung. Studies in the Swiss Alps (Markgraf 1980 in Jacobson and Bradshaw 1981) show that it is the gradient (prevailing winds) rather than updrafts that are responsible for regional character of the high altitude pollen spectra.

11.6 Vegetation at and Around Ice Patches

The pollen composition of caribou dung depends on the vegetation that caribou select as forage (Figure 31). Vegetation surveys conducted at the Friday Creek, Granger, and Thandlat ice patches document a mosaic of plant communities in the immediate area, which relate to local growing conditions (Rhodes 1999; B.A. Bennett 1997 personal communication). The influence of topography on snow depth and duration is the most important determinant for differences of tundra plant communities (Molau 1993). The complex topography of alpine areas with steep gradients and wide variations in aspect creates great variation in plant cover at alpine locations (Choler 2005; Loffler and Pape 2008; Oeggle et al. 2009; Skogland 1980).

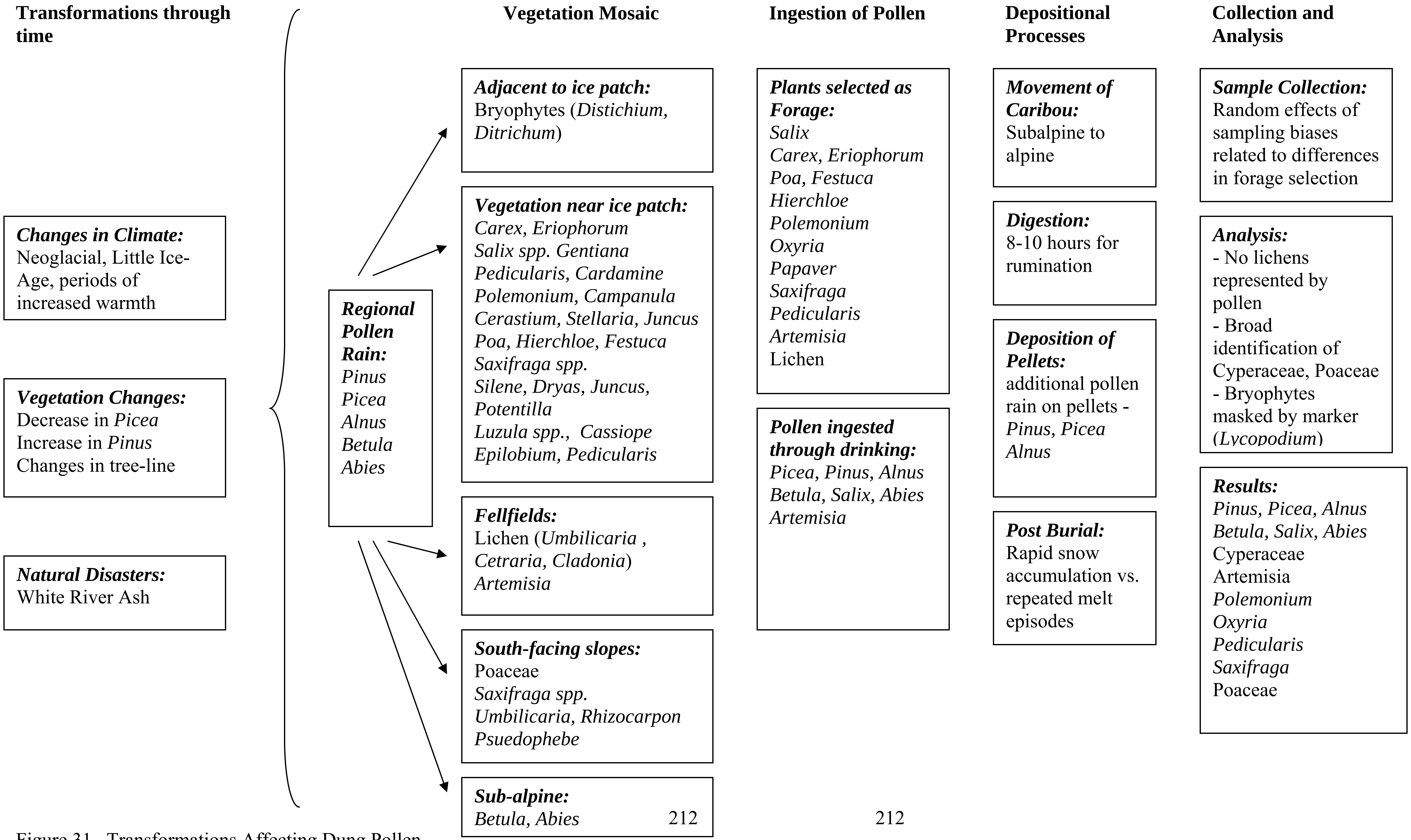


Figure 31. Transformations Affecting Dung Pollen.

Differences in radiation, water balance, soil instability, and winter conditions such as exposure to wind and protection from snow cover are also important in controlling the ecology of plant communities in regions of topographic diversity (Ritchie 1984:174). For instance, in a research study in the alpine tundra of the Kluane region, southwest Yukon,

Myers-Smith (2007:448) reports a complex series of interactions and feedbacks leading to an increase in shrubs, warmer winter soils, enhanced nutrient cycling and altered plant communities. Increases in tundra shrubs can trap snow in the winter causing an insulating effect, while in the spring dark-coloured shrubs alter albedo and accelerate local snow melt. In contrast, shading by shrubs in the summer decreases soil temperature under shrub canopy (Myers-Smith 2007).

Granger, Friday Creek and Thandlat ice patches, which are formed in topographic depressions, accumulate large amounts of snow during the winter months, and are covered with substantial depths of snow over much of the year. In general, ice patches are northeast-facing and vegetation immediately adjacent to ice patches is mesic to mesic-hydric with several meltwater streams at the sites. Bryophytes are the dominant vegetation with hydric mosses found directly associated with the streams. Further downslope meltwater has less influence and sedges and grasses become dominant.

Surrounding ice patches are snowbed meadows, or chionophillous communities, which are floristically distinctive patches of vegetation that occur in alpine regions where deep, persistent snow cover accumulates (Klanderud and Birks 2003; Kozlowski and Raczkowska 2006; Loffler and Pape 2008; Mourdant

1997; Ritchie 1984:59; Skogland 1980). Depending on local topoclimatic conditions, there are several factors that determine snowbed vegetation including insulation, a shortened growing season, meltwater, soil movement, a reduction in available photosynthetically active solar radiation, the mechanical effects of snow accumulation on steep slopes, reduction of the amplitude of temperature fluctuation, and protection against damage by frost, dessication, or wind (Harrison et al. 2001 in Kozlowska and Kaczkowska 2006; Helm 1982 in Kozlowska and Kaczkowska 2006). Throughout the Holocene various combinations of these factors contributed to differences in local vegetation patterns around Granger, Thandlat and Friday Creek ice patches. These factors in turn influenced the timing of forage availability, phenology, and forage selection.

Ice patches with surrounding snowbed meadows have the greatest plant species diversity in low to middle alpine zones. Many chionophyte species preferentially grow in snowbed habitats and are restricted to these habitats in the form of endemic species (Bjork and Molau 2007; MacKinnon et al. 1992; Trelawny 1988). Although there is considerable variation from site to site, species of *Salix* are often dominant with *Oxyria, Saxifraga, Carex, Rannunculus* and *Equisetum* as associates (Birks 1977; Ritchie 1984). In vegetation surveys conducted by Rhodes in the summer of 1999, *Salix polaris, Saxifraga spp. (S. foliosa, S. rivularis, S. tricuspidata)*, and sedges (*Carex* and *Eriophorum*) were noted growing near ice patches. In general, forbs are the dominant growth form at snowbed environments. A variety of forbs including *Campunala, Cardamine,* *Cerastium, Claytonia, Luzula spp., Oxytropis, Potentilla, Silene,* and *Stellaria* were recorded at the Granger and Thandlat ice patches (Rhodes 1999).

South-facing areas on upper slopes around ice patches are xeric, open fell field communities with vegetation ground cover in these areas being reduced. In these well drained areas and exposed surfaces lichens are the dominant growth form (Rhodes 1999). In addition, *Artemisia norvegica* (alpine artemisia), a plant that can indicate xerotrophic growing conditions, was noted growing in the immediate vicinity of the Granger ice patch. *Artemisia*, which grows in alpine locations with southwest exposure, is a taxon that often prefers open alpine habitat.

With a shorter snow-free period, the diversity of evergreen and deciduous shrubs around ice patches decreases, although a few dwarf shrubs are capable of growing in snowbed environments (Bjork and Molau 2007). For instance, dwarf willows (*Salix polaris*) were noted growing around all ice patches during modern vegetation surveys (Rhodes 1999). Graminoids have their largest diversity in moderate melting snowbeds and decrease in abundance towards both ends of a snow-free period gradient. At the Granger and Thandlat ice patches the grasses *Festuca, Hierchloe*, and *Poa spp.* were documented (Rhodes 1999).

Vegetation around the Friday Creek ice patch is limited to predominantly bryophytes in mesic locations and lichens in exposed, newly colonized areas. Rhodes (1999) noted that below the ice patch there is almost 100% bryophyte cover. Also present around the ice patch, at values less than 5% are *Festuca hyperborea, Papaver radicatum*, *Salix polaris, Saxifraga spp.*, and *Stellaria* *longipes* (Rhodes 1999). At Friday Creek ice patch, well drained areas and exposed surfaces have lichens (*Umbilicaria hyperborea*) as the dominant growth form at 70%. Adjacent south-facing areas on well-drained upper slopes are xeric and vegetation ground cover in these areas is approximately 5% and consists of members of Poaceae and species of *Saxifraga* (Rhodes 1999). Exposed rock surfaces are colonized by *Umbilicaria hyperoborea, Rhizocarpon geographicum*, and *Psuedophebe pubescens* at a cover of about 60% (Rhodes 1999).

Although it is unclear to what extent these various vegetation patterns existed in the past, it demonstrates that there is considerable variability in vegetation between different ice patches. Similar variation in vegetation cover over very short distances, such as that between the foraging area of the modern Ibex caribou herd, Granger and the Friday Creek ice patches, would have occurred in the past under different macro- and microclimatic regimes. Therefore, local differences between vegetation and grazing patterns have contributed to differences between ice patches and between modern and ancient pollen from dung.

11.7 Phenology

There are well-marked seasonal variations in pollen release. Some taxa, such as *Salix*, bloom in the early spring, while others, like, *Artemisia* bloom in the fall (Birks and Birks 1980; Kropf et al. 2007). Among tundra species, the length (and the stochasticity) of the vegetation growth period is the key determinant of their reproductive strategies. This period is regulated by climatic factors such as temperature, solar radiation, precipitation, and snow cover (Borner et al. 2008; Molau 1993). The timing of snow-melt and /or the beginning of autumn snow accumulation are key factors in the timing of flowering and dormancy of alpine plants (Bjork and Molau 2007; Borner et al. 2008; Cebrian et al. 2008). Much of the snow at ice patches persists long into the landscape's spring and summer thaw period and in many cases the final snowmelt does not occur until late in the growing season (Bjork and Molau 2007; Birks 1977; Ritchie 1984; Watson et al. 1994). Snowbed plants, or chionophytes, capable of surviving in a restricted growing period, require late-season soil moisture which is derived from melting ice patches (Bjork and Molau 2007).

Chionophytes must be able to complete their vegetation life cycle quickly (Bjork and Molau 2007). The phenological schedule of snowbed species is modified resulting in a diversity of flowering patterns that extends the regional flowering season. According to Kudo (1991), the phenology of alpine plants in snowbed habitats is controlled primarily by growth form. Most shrub species abandon flowering and consequently seed production when the growing season is extremely shortened. In contrast, forbs or graminoids may have flowers in any habitat, including short snow-free periods (Kudo 1991).

In the case of ice patches there can be an irregular build up of snow which affects the structure of the snow pack, including the density and occurrence of ice layers. This can in turn affect the melting process in spring and summer differently from year to year (Watson et al. 1994). Studies have shown the development of vegetative parts and the earliest formation of flower buds occur in some plants at a mean daily air temperature of 0ºC, and the first flowers appear when the temperature exceeds +2.5ºC. The most intense period of flowering occurs from mid-July to mid-August (Dubiel 1991). However, even within the same species, flowering season varies significantly between adjacent populations having different snowmelt conditions (Kudo Mountain Science Highlights www.ubc.ca/forestry highlights). Studies in alpine regions show that *Rannunculus* and *Saxifraga* are among some of the first bloomers after snowmelt (Dubiel 1991 in Bjune 2000). During my research, *Saxifraga, Artemisia, Claytonia, Potentilla* (Roseaceae), *Silene acaulis* (Caryophyllaceae), *Stellaria longipes* (Caryophyllaceae), *Antennaria* (Asteraceae) and several sedges were noted flowering near the ice patches in August (Rhodes 1999) (Table 9). The flowering schedule for certain alpine plants is important for caribou inhabiting the southwest Yukon that are looking for suitable forage.

Taxa (Genus or Family)	**May**	**June**	**July**	**August**
Abies	***********	***********		
Pinus	***********	***********	***********	
Picea	***********	***********	***********	
Betula		***********		
Alnus	**********	***********		
Tsuga	***********	***********		
Populus	***********			
Salix	**********	***********		
Ericales	**********	***********	**********	
Cyperaceae +	**********	***********	**********	*********
Polemonium	**********	***********	**********	*********
Epilobium	**********	***********	**********	*********
Saxifraga +	**********	***********	**********	*********
Pedicularis		***********	**********	
Caryophyllaceae		***********	**********	
Poaceae +		***********	**********	**********
Artemisia +		***********	**********	**********
Asteraceae		***********	**********	**********
Roseaceae		***********		
Claytonia +			**********	*********
Oxyria		***********	**********	*********
Rannunculus		***********	**********	**********
Chenopodium			**********	
Callitriche	***********	***********	**********	**********
Rumex			**********	**********
Astragalus			***********	******

Table 9. Bloom time for pollen taxa identified in modern and ancient dung. Based on Hoefs 1979; Johnson et al. 1995; Pratt 2002; Rhodes 1999. These (+) taxa were observed flowering the first week of August 2000 at the Thandlat ice patch.

11.8 Selection of Forage

Selection of forage is one of the most important filters between the available plants in the environment and the botanical material contained in animal dung (Anderson and Ertug-Yaras 1998; Oeggle et al. 2009). Pollen analysis of ungulate dung indicates a wide variation in the composition of the pollen assemblage, which depends on several factors (Figure 32). An understanding of the factors that might affect the selection of plants by ungulates assists in determining which pollen taxa might be present in dung (Anderson and Ertug-Yaras 1998; Oeggle et al. 2009). The time of year at which the animals were grazing, the forage available to them, digestibility of plants, chemical composition, palatability, and toxicity are among some of the factors that affect forage selection (Anderson and Ertug-Yaras 1998; Moe 1983).

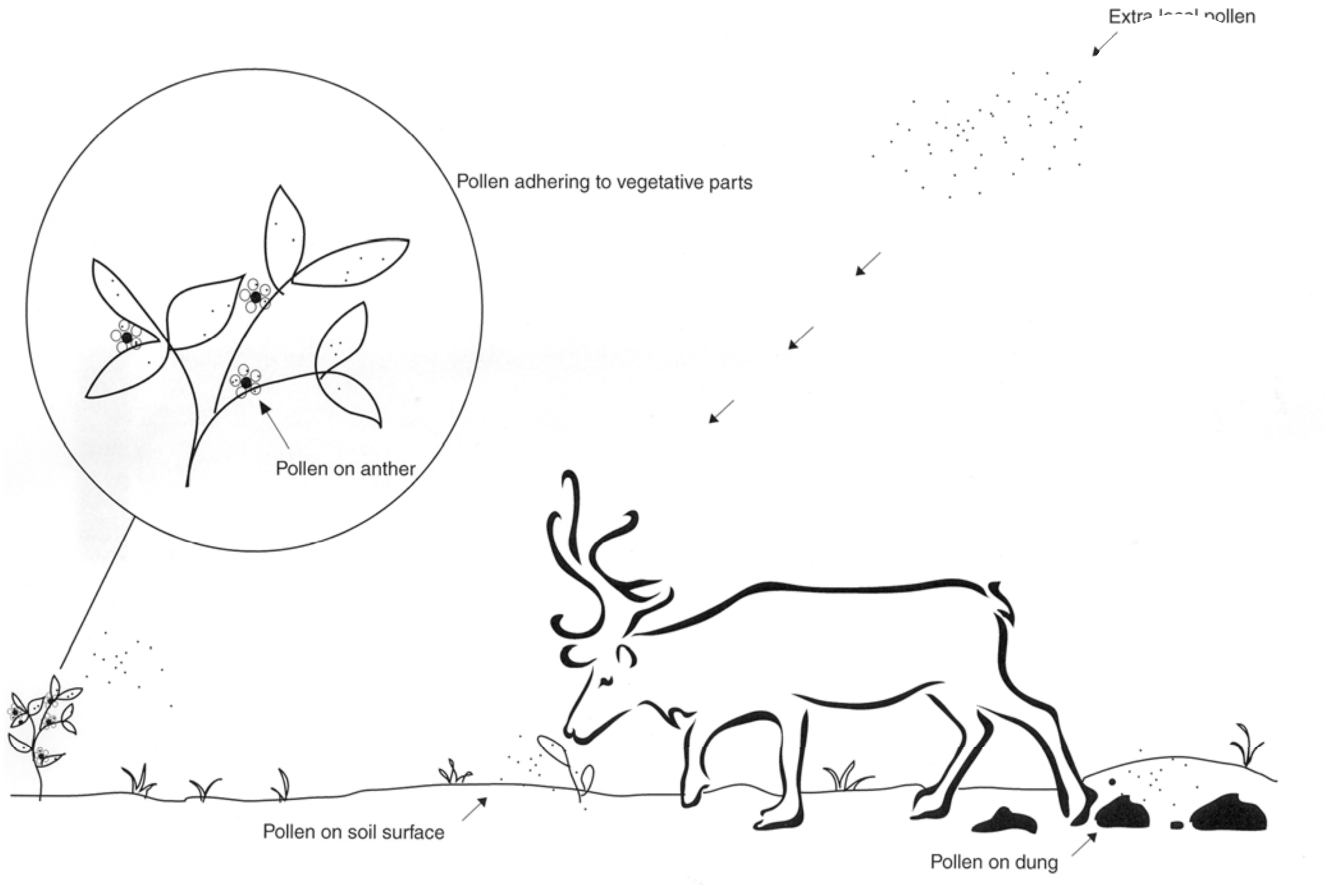


Figure 32. Taphonomy of pollen in dung illustrating multiple pathways of ingestion.

Forage patch selection by caribou is influenced by the timing of snowmelt (van der Wal et al. 2000). Modern diet studies show that during the summer caribou forage on vegetation in succession of first availability. The timing of snowmelt leads to a shift in the phenological availability of vegetation with a preference by caribou for emerging high quality young shoots (van der Wal et al. 2000). When the snowmelt starts in spring, caribou follow the altitudinal melt-off gradient by selecting habitats with the highest level of green phytomass at the most favourable stage (Figure 33). Caribou selective foraging leads them to graze on a local succession of green, protein rich, highly digestible young forbs. For instance, sedges, *Equisetum*, and *Oxyria* are important forage during the spring because they have high protein content and are rich in minerals (Bergerud 1972; Staaland 1984; Thomas et al. 1996).

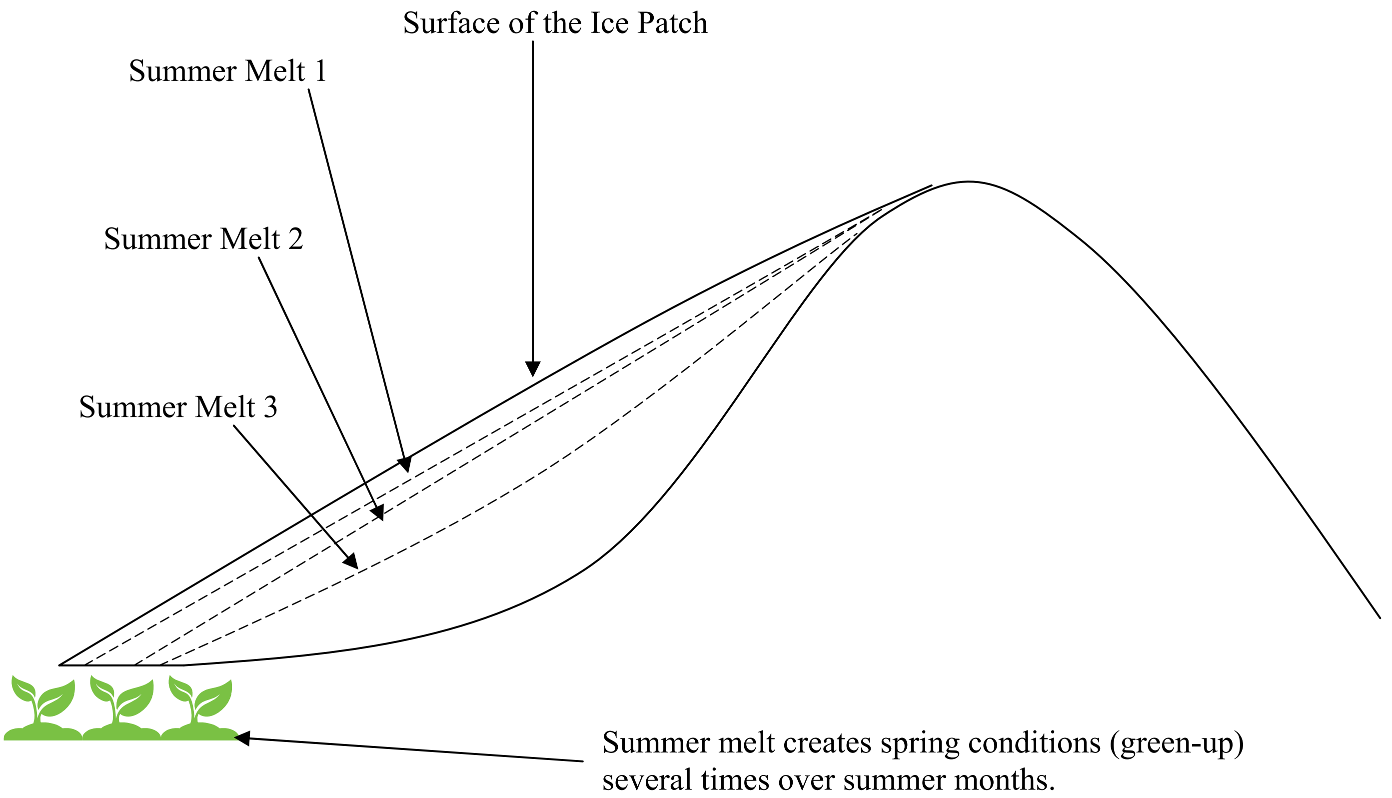


Figure 33. Schematic drawing showing spring-like conditions at alpine ice patches in summer months.

The shift in availability in high quality forage may be reproduced over summer months at snowbed meadows, as spring-like conditions are recreated with repeated melt episodes. As a general rule, moist areas include species with the highest nutritional quality and biomass, as well as the largest number of available forage species (see Bjune 2000). As one plant species is used up there is a switch to another species as it appears to green. As a result, caribou change to the new location where there is green vegetation (Bergerud 1972; Bergerud and Nolan 1970; Boertje 1984; Holleman et al. 1979; Skogland 1980). This forage switching would be reflected in the composition of pollen assemblages in dung pellets.

Caribou are known to switch during the summer season from grazing on south-facing slopes to grazing on slopes facing northwards, where snowmelt is delayed (Oosenbrug and Theberge 1980; Skogland 1980). The winter's build up of snow is likely to be consistently heaviest in a region where the overall regional summer climate would have the least effect, such as on east and north-east-facing slopes of Friday Creek and Granger ice patches (also see Watson et al. 1994). By creating conditions that result in repeated greening of vegetation over summer months, melting ice patches provide a diversity of plant taxa suitable for caribou forage, at different localities, potentially over an extended period of time. However, these conditions can change depending on various microclimatic factors around ice patches. During the summer field seasons of 1999 and 2000, several of the ice patches that were surveyed did not exhibit any melt. The lack of melt suggests that at least during some years, some ice patches did not provide the productive spring-like growth required of caribou during warm summer months.

During the summer months when caribou are seeking relief from heat and insects on ice patches feeding behaviour can vary. Some time is spent foraging around ice patches but other locations are also used during this time. In the southwest Yukon caribou are known to use ice patches from 1500 - 1800 m during mid-summer but are more restricted to elevations above 1800 m from mid-August to the rutting period. Caribou are known to move down from the alpine into the sub-alpine when the day time summer heat has subsided (Kuzyk and Farnell 1997). In contrast to the southwest Yukon pattern, Ion and Kershaw (1989) noted that daytime patterns of woodland caribou in the Northwest Territories, involved an ascent from slopes below 1700 m to ridges and snowpatches at above 2000 m in the late morning. Extended periods of time were spent on snow patches in the afternoon with a descent to land below 1700 m in the later afternoon and evening. This cycle was observed mostly under conditions when there were high air temperatures and low wind speeds which increased the need for relief habitat. Pollen taxa identified in dung from southwest Yukon ice patches may represent forage selected from a variety of feeding locations in the sub-alpine and alpine (Figure 31).

11.9 Digestion of Forage

Digestion, the other key factor influencing pollen assemblages from ungulate dung, is a process dependent on a number of variables, although there are general strategies that are specific to different kinds of herbivores (Guthrie 1984, 1990). The rate at which plant material passes through the digestive tract is highly variable, depending on the plant, animal species, and individual animal (Anderson and Ertug-Yaras 1998). In a series of digestion experiments carried out on cattle, it was found that most weed seeds were recovered from dung after two or three days, but in some cases they were recovered up to ten days after the source was removed (see Anderson and Ertug-Yaras 1998). The rumen turnover rate for caribou is approximately eight to ten hours (White and Trudell 1980; Farnell et al. 1991:34). Therefore, dung material is representative of food intake over a much broader area than the site of defecation and sample collection. As a consequence pollen from caribou dung may represent a "collection of feeding sites".

Quayle and Kershaw (1994) found that caribou cycle back and forth between habitat types where they forage, ruminate and defecate. The study concluded that animals feed and defecate in different habitats. In their study they found that in early July and early August the largest number of caribou pellet groups was recorded on the summit of mountains while there was an absence of pellets at the lower elevations surveyed. The implication for this study is that caribou spend more time defecating on ice patches when they are seeking relief from heat and insects but the composition of pellets on ice patches is not limited to vegetation found in the immediate vicinity.

11.10 Use of Modern Analogue Samples

The use of modern dung samples to assist in interpreting data sets from ancient dung assumes that the modern caribou adequately represent the local vegetation and foraging patterns of ancient caribou (see Figure 31). The modern analogue technique assumes that a fossil pollen assemblage of similar composition to a modern counterpart has been produced by similar vegetation and reflects a similar climate (Frechette et al. 2008; King and Graham 1981). However, modern dung samples are collected from potentially a different population of caribou with variations in foraging patterns that are superimposed on broadscale changes in vegetation, climate and seasonality patterns over time. To improve the modern analogue method multiple dung samples, from various herds over yearly seasons on a mult-year basis would be needed.

Analysis of pollen from modern dung of different seasons produces a pollen spectrum or "signature" that includes the flora of current local and regional vegetation and current climatic conditions. The further back in time one goes, the more complex interpretations for seasonality become as changes in vegetation and climate have occurred in the region throughout the Holocene (Anderson and Brubaker 1996; Cwynar 1988; Cwynar and Spear 1991; Denton and Karlen 1977; Keenan and Cwynar 1992; Lacourse and Gajewski

2000; Wang and Guerts 1991a, 1991b; Rampton 1971). It is recommended that future research examine the relationship between pollen spectra from dung samples and vegetation and climate changes in alpine locations.

The Holocene climate records for the southwest Yukon are complex and variable (Anderson et al. 2007; Anderson et al. 2005a and 2005b; Chakraborty et al. 2010; Clague et al. 2010; Kaufman et al. 2005; Lamoureux and Cockburn 2005; Pienitz et al. 2000; Spooner et al. 2003). Regional studies in northern North American Cordillera indicate that there were at least three Neoglacial ice advances for the St. Elias Range. Mid- to late Holocene glacial advances in the southwest Yukon coincide with increasingly wet climatic conditions and decreases in summer insolation. This cold period culminated in the Little Ice Age between AD 1500-1900 (Figure 30; Anderson et al. 2005a and 2005b; Anderson et al. 2007; Calkin 1988; also see Clague et al. 2010 for discussion on the utility of the term Little Ice Age; Lamoreux and Cockburn 2005).

The effects of White River Ash on caribou and other ungulate populations in the southwest Yukon is poorly understood (Figure 30). The immediate effects of the ash would have had devastating effects on the vegetation and wildlife in the area (see Anderson et al. 2005; Kuhn et al. 2010; Workman 1973, 1979). It is very likely that the impoverished environment would pose significant difficulties for herbivorous mammals (cf. Hare 1992; Kuhn et al. 2010). In high elevation areas where ashfall may have been heavy, considerable pasture may have been ruined for years and may have caused herds to abandon their calving locations or areas in the alpine used as summer forage (Workman 1973, 1979).

11.11 Summary

The main implications for the present study are that: (1) dung collected at a static point, such as an ice patch, contain plant material from the sub-alpine and alpine vegetation; (2) plant material from different grazing environments are contained in the gut at the same time and are potentially passed togther into the same dung pellet; (3) caribou select plants and plant parts that do not yield pollen (lichen; leaves and young stalks); (4) some arboreal pollen types, not related to forage, or which only represent a small portion of caribou diet, are greatly overrepresented in dung; (5) pollen of insect-pollinated plants such as forbs, that make up a significant proportion of summer diet, are underrepresented in dung; (6) changes in Holocene macro- and microclimate affects past vegetation, plant phenology and availability.

In Table 10 I have summarized some of the key signatures that are expected to characterize pollen samples from particular seasons. This table is based on a synthesis of several studies that look specifically at interpretations of seasonality based on pollen in dung (Bjune 2000; Bjune et al. 2005; Bryant 1974; Mead et al. 1986; Moe 1983; Thompson et al. 1980; van der Knapp 1989; Posse et al. 1996; Kropf et al. 2007).

Season	Pollen Signatures in Dung
Summer	High diversity of pollen types Presence of insect-pollinated taxa High pollen concentrations High inter-sample variability Presence of taxa that bloom in the spring and summer Presence of pollen aggregates Over-representation of wind-blown arboreal taxa
Fall	Decrease in the diversity of pollen types Decrease in pollen concentrations Absence of insect-pollinated taxa Absence of pollen aggregates Decrease in inter-sample variability Over-representation of wind-pollinated arboreal taxa with higher proportions of regional pollen types
Winter	Low diversity of pollen types Low pollen concentration Low inter-sample variability Absence of insect-pollinated taxa Over-representation of wind-pollinated arboreal taxa with higher proportions of regional pollen types Absence of pollen aggregates
Spring	Low diversity of pollen types Low pollen concentrations Presence of some insect-pollinated taxa (e.g. *Salix* and other early blooming taxa) Presence of pollen aggregates (but not as high as in summer) Over-representation of wind-pollinated arboreal taxa

Table 10. Pollen signatures indicating seasonality from caribou dung on ice patches. Based on studies by Bjune 2000; Bjune et al. 2005; Bryant 1974; Mead et al. 1986; Moe 1983; Thompson et al. 1980; van der Knapp 1989; Posse et al. 1996; Kropf et al. 2007.

I have used the seasonality signatures outlined in Table 10 as a way to qualitatively assess the pollen assemblages of dung from the Granger and Friday Creek ice patches. I have also included the modern Ibex caribou herd for comparison (Table 11). Examining these assemblages for various seasonality signatures assists in determining whether ancient caribou dung pellets were deposited in the summer.

The most informative pollen signatures for assessing seasonality of caribou dung in this study are: (i) the presence of a diversity of pollen types; (ii) the presence of insect-pollinated taxa and (iii) high inter-sample variability (Table 11). In addition, the presence of taxa such as Cypearceae, *Polemonium, Saxifraga*, and *Oxyria,* which are are preferred caribou forage in bloom during the summer, are strong seasonal pollen signatures in ancient dung.

Another seasonal indicator of summer is the overrepresentation of arboreal taxa such as *Alnus, Betula*, and to a lesser extent *Picea* and *Pinus*. None of these taxa are currently found growing in the alpine.

Signatures - Summer	**Modern Ibex Herd (n=12)**	**Granger Ice Patch (n=15)**	**Friday Creek Ice Patch (n=36)**
High diversity of pollen types	28 types	26 types	32 types
Insect-pollinated taxa	All samples (100%)	12/15 samples (80%)	All samples (100%)
High inter-sample variability	Yes – see NMS	Yes – see NMS	Yes – see NMS
Pollen aggregates	0/12 samples (0%)	3/15 samples (20%)	5/36 samples (14%)
Overrepresentation of arboreal taxa	Yes	Yes	Yes
Presence of taxa that bloom in the spring and summer	All samples	All samples	All samples

Table 11. Comparison of pollen signatures indicating summer season to the pollen signatures from dung of the modern Ibex herd, Granger ice patch and Friday Creek ice patch.

The overrepresentation of arboreal taxa may partly reflect spring and summer atmospheric pollen rain, although it might also reflect the over-abundance of these taxa at high elevation locations in general. The presence of pollen aggregates in ancient dung samples is not a strong signature of summer dung. Pollen aggregates were present, but not common in the Granger and Friday Creek ice patch samples and interestingly, they were absent from the dung samples examined from the modern Ibex caribou herd

What is important is that the analyst needs to evaluate the composition and characterisitics of pollen spectra from dung samples, or the seasonal signatures, in addition to looking for specific taxa when determining seasonality. Taken together these various lines of evidence allow us to evaluate seasonality of dung pollen in a more productive way, rather than relying on pattern matching between ancient and modern analogues. This approach is especially useful when there is no modern analogue for ancient samples.

12.0 HUNTING AT ICE PATCHES

12.1 Hunting at Ice Patches - Overview

With the knowledge of caribou habits combined with years of experience, precontact inhabitants of the southern Yukon were able to decide on the most effective ways to hunt these animals (McClellan 1975; also see Brink 2005:21). Ethnographic descriptions of caribou hunting provide insights into what must have been part of a dynamic situation involving the consideration of a variety of factors. Hunting strategies at each site took into consideration weather patterns, topography, forage availability, caribou migration patterns, and how caribou flee when panicked. All of these conditions contributed to an effective land-use pattern (following Benedict 2005; Brink 2005).

12.2 An Altitudinal Model of Caribou Hunting

What is emphasized in this research is that the topogeographic diversity of the southwestern Yukon had important consequences for precontact hunter-gatherer land-use in the region. In the southwest Yukon valley bottoms along rivers and lakeshores, and the alpine, are found at an altitudinal difference of 1000 m, and are separated from each other by as little as 10-15 km. Inhabitants of the southwest Yukon were able to take advantage of a variety of resources in both lowland and alpine zones (following Lieberman 1993; Lovis et al. 2005). Precontact occupants of the region selected different habitat types suitable for locating animals and certain localities were used repeatedly, even if intermittently, over several years.

Typically, models of caribou hunting focus on large-scale latitudinal strategies, which involve drive-lane systems and communal hunting tactics (Benedict 1996, 2005; Brink 2005; MacDonald 1985; Sturdy 1975). Ethnographic references from the southwest Yukon suggest that similar systems, using caribou fences, were used historically by the ancestors of First Nations in the region (McClellan 1975; Greer 1984; CAFN et al. 1999 as cited in Hare et al. 2004; Hare et al. 2004; Sidney as cited in Hare et al. 2004). The importance of the drive lane and corral hunting strategy cannot be underestimated for the southwest Yukon, although it is unclear how long this system has been in place (although see Legros 2007). The drive lane hunting tactic does not appear to have been part of the ice patch hunting strategy, as it is currently understood. Currently, there is no evidence of domestic artifacts, habitation structures, or shelters to suggest that hunters or their families stayed overnight for extended periods in the high alpine (Hare et al. 2004). Rather, exisiting data suggest that ice patches were hunting sites where caribou and potentially other game were killed by task groups of two or three individuals and small work parties, although this requires further investigation (also see Hare et al. 2004).

What is proposed in this research is that archaeological explanations of caribou hunting in the southwest Yukon need not be limited to models that focus on large-scale latitudinal barren ground caribou migrations and their associated corral and drive lane hunting systems. Instead, the success of hunting at ice patches depended on the thorough knowledge of caribou, including the altitudinal movements and biological requirements of these animals (also see Blehr 1990; Burch 1991, 2007; Gordon 1990; Jordhoy 2008; Ryd 2101; Thacker 1997). By understanding the altitudinal migrations of caribou, that is, their movements from core residential winter range in valley bottoms to high quality forage in the alpine during summer months, a more comprehensive picture of caribou hunting and land-use patterns is presented for the southwest Yukon (Figure 34). The altitudinal hunting strategy may have been employed in varying degrees depending on various factors associated with seasonal and cyclical variations and broader scale environmental instability in the southwest Yukon (i.e. the onset of the Little Ice Age, White River ashfall) (see Anderson et al. 2007; Chatters and Prentiss 2005; Lamoureux et al. 2005: Morgan 2009). It is important to note that the pattern presented here represents one variation in a range of caribou movement and associated hunting strategies. The model presented in this research (Figure 34) is provided as a heuristic device for further investigation into caribou hunting.This model is not intended to represent a single static model that can be applied throughout the Holocene.

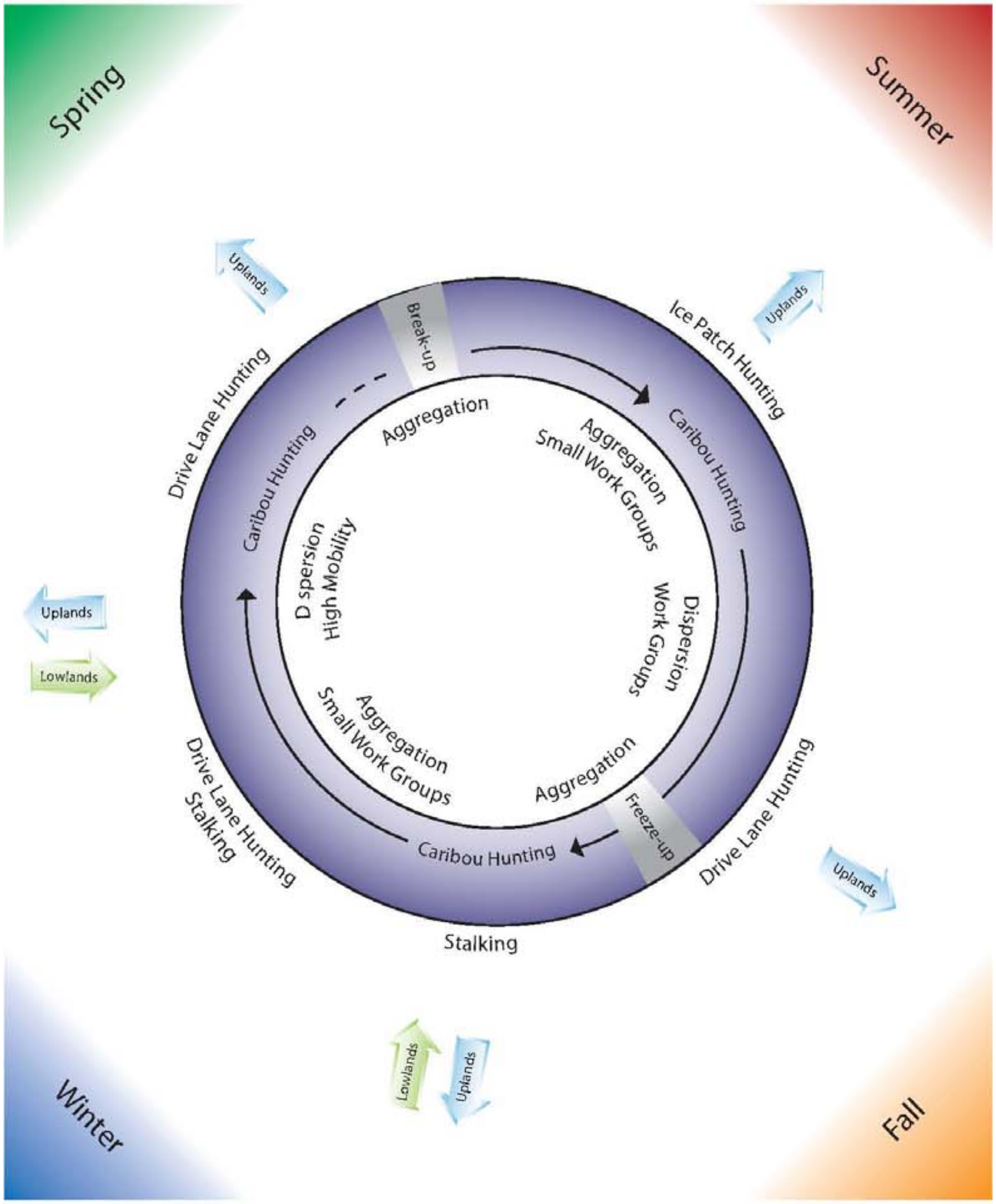


Figure 34. Caribou Hunting in Southwest Yukon. Based on a summary of McClellan 1975 and others and research outlined in this study.

12.3 Caribou on Ice Patches

Topographic features influenced the movements of caribou in predictable ways and were incorporated into the ice patch hunting strategy. Woodland caribou are resident populations that make relatively small seasonal migrations throughout the year. In the fall, cows, calves and bulls are in larger aggregates during the rut in the alpine. From January to April caribou reside on the winter range in the forested areas where they forage on high quality lichen. During the spring, cows move to isolated, rugged terrain to avoid predators while calving. After calving in the spring from May to June cows and calves move from isolated mountain tops (Kuzyk and Farnell 1997).

Females and young form small nursery bands and remain on ridges and in alpine meadows throughout the summer. In the summer caribou move upslope altitudinally between sub-alpine and alpine as snow melts and vegetation greens-up. As the snow melts caribou move up into the alpine zone following the green up of flowering plants, leaves of dwarf willow sedges, grasses and lichens. This forage is especially necessary to females who need nutrient rich foods for milk production. During the mid-summer caribou are at elevations primarily between 1500 and 1800 m and above 1800 m from mid-August to the rutting period (Kuzyk and Farnell 1997) .

Pollen analysis of ancient caribou dung from Granger and Friday Creek ice patches suggests that at least some of the pellets were deposited on ice patches in the summer. Caribou congregate primarily on ice patches to seek relief from heat and insects. Snow patches can be up to 3° C cooler on snow patches than on adjacent areas (Ion and Kershaw 1989; Toupin et al. 1996). Caribou, particulary calves, are susceptible to heat stress when the ambient temperature exceeds 20° C (Anderson and Nilssen 1998; Wedadji et al. 2003). Ion and Kershaw (1989) found that caribou were unlikely to suffer unduly from heat stress and caribou have a good capacity for heat resistance when water is available. However, studies in Norway indicate that in the summer caribou rarely stay at altitudes lower than 1000 m, given that above this altitude temperatures rarely exceed 20º C, with temperatures of 25º C rarely occurring (Hagemoen and Reimers 2002). Regardless, caribou generally use snow patches primarily during the heat of warm sunny days.

Even though caribou receive a thermoregulatory benefit from using snow patches, snowpatch selection is a primary way of reducing insect harassment, especially skin warble flies (*Hypoderma tarandi*) and nasal bot flies (*Cephenemyia trompe*) (Hagemoen and Reimers 2002; Ion and Keshaw 1989; Nilssen and Haugerud 1994; Ryd 2010; Toupin et al. 1996; Weladji et al. 2003). Caribou behaviour associated with insect harassment has been asessed using a temperature/wind speed index to estimate severity of the harassment (Russell et al. 1993; also see Hagemoen and Reimers 2002; Weldaji et al. 2003). Indices developed for the Porcupine Caribou herd used an ambient temperature of ≥ 13º C and winds of < 6 m/s to predict insect harassment. In addition, Weldaji et al. (2003) found that the intensity of insect harassment increases when cloud cover is < 40%. It is concluded that insect harassment is a key weather-related factor in the summer ecology of caribou.

By understanding the different insect harassment levels between caribou summer ranges it is possible to map a distribution of the insect harassment levels according to various caribou summer grazing areas, taking into account the potential affect of topography. In this regard, it has been suggested that key habitats that are important insect relief sites can be identified (Weldaji et al. 2003).

Significant variations in caribou group size and composition occur on ice patches during summer. Group size can vary from ten to several hundred (Anderson and Nilssen 1998; Ion and Kershaw 1989). Due to the gregarious nature of of caribou it is rare to see only a few animals on snow patches. Herds are known to form spiral-shaped aggregations with the outermost animals seeking their way to the middle (Anderson and Nilssen 1998). Many of these animals are tightly clumped or aggregated on ice patches during this time as a response to the availability of snow patches as relief habitat (Ion and Kershaw 1989). For instance, some snow patches are too small to create a significant microclimate different from snow-free areas or are too steep for caribou to negotiate. Therefore, animals are forced to congregate in larger groups on those snow patches which offer relief habitat (Anderson and Nilssen 1998; Ion and Keshaw 1989). In addition, given the caribou's gregarious nature, aggregates of caribou may focus on just three or four snow patches out of the ten or twelve available in a particular area (Anderson and Nilssen 1998). It is also possible that the use of certain ice patches by caribou is learned behaviour, similar to the use of certain mineral licks. For instance, the Klaza herd of west-central Yukon is known to congregate around a single large ice patch in its range (Farnell et al. 2004:249).

Observations indicate that the sex composition of caribou herds varies on and off snow patches. In summer, caribou are separated into cow-dominated groups (cow/calf/yearling groups) and bull-dominated groups (bull groups and bulls with yearlings). However, mixed groups are disproportionately observed together on snow patches (Anderson and Nilssen 1998; Ion and Kershaw 1989). These groups, which normally remain separate at this time of year, are drawn together on snowpatches where they utilize them as relief habitat. Since the relief is restricted, they must share the snow patch resources (Ion and Kershaw 1989). Overall, caribou can gather in relatively large groups of mixed sex congregations on snow under conditions of increased insect activity (Ion and Kershaw 1989).

During insect harassment caribou stay on snow patches for hours and can be greatly distracted at this time with animals showing nervous and very agitated behaviour (Hagemoen and Reimers 2002). Among various defensive, anti-fly behaviours, caribou shake their heads, rumps, and bodies, flap their ears and kick their legs (Anderson and Nilssen 1998: Table 6). During intense insect harassment period caribou are known to run around in circles at high speeds in spiral shaped aggregations (Hagemoen and Reimers 2002). In addition, the presence of osterid flies affects the whole herd rather than only the attacked individual, as alertness and notice of the presence of the flies is spread with the herd (Hagemoen and Reimers 2002).

The cultural significance of ice patches for human hunters is related to the presence of snow and ice for insect relief and heat, and the availability of high quality forage in the alpine, which results in the summer aggregations of caribou at these locations. It was the presence of caribou on the alpine landscape that attracted hunters to these areas through the millennia (also see Hare 2007). The presence of caribou on ice patches in the summer months in the alpine made them an easy target for hunters. In any particular area caribou are found in mixed herds of bulls, cows, and calves, in potentially large numbers, on a select few ice patches. If the weather is especially warm and insect harassment is severe, they are distracted and less acutely aware of human hunters. Among Saami hunters in Norway, ice patch hunting works best on small patches, generally under a 100 m in diameter. Caribou are able to hear the humming of the insects between the borders of the snow and as a result are unwilling to leave the ice patch (Ryd 2010). According to one Saami hunter, it is possible to approach a herd within shooting range for the bow, openly and clearly visible, but very slowly. In contrast, on large ice patches this approach is more difficult as caribou can more easily flee from hunters (Ryd 2010).

12.4 Ice Patches as Hunting Localities

Hunters would have used a variety of methods that took advantage of local topography as part of the caribou hunting strategy on ice patches (following Benedict 2005; Brink 2005; Gubser 1965; Jordhoy 2008;

Stefansson 1922, 1944). For instance, when frightened or alarmed, caribou tend to move upslope. A caribou herd, or part of a herd, does not hesitate to ascend a mountain rising 600 or 700 metres from the valley floor, and then after a few kilometres of travelling along ridge tops, descend (Burch 1972; Gubser 1965:308). A good hunter will take great care to work his way around and above a feeding herd or to situate himself just above the probable line of travel. If possible, the best marksman tries to place himself above the herd and lets the other hunters drive the herd toward him (Gubser 1965). Likewise, hunters may have taken advantage of the animal's reduced ability to turn or stop when running downhill, especially with their front-heavy antlers (Brink 2005). Kelsall (1968) also notes that caribou have difficulty changing direction once in full gallop and will run past an observer rather than move away.

Hunters may have taken advantage of certain panic responses by caribou when hunting at ice patches. For instance, caribou are known to run towards ice when panicked (Gubser 1965; Brink 2005). Caribou are able to move onto ice because their hooves show a seasonal adaptation to winter conditions. The caribou's splayed, sharp-edged hooves provide greater traction and "non-skid" support on icy surfaces (Banfield 1974). Caribou are also known to clump together when threatened by predators (see Brink 2005:20). If caribou were not already on ice patches, then these two panic responses by caribou would have assisted hunters in moving the animals towards ice patches for dispatch (Kelsall 1968:34). Once caribou were on ice patches, or if the animals were already there, hunters may have waited on the ridgetops above the ice patches while other hunters, at the base, scared the animals promoting a flee response in which caribou moved up the ice patch.

When hunting at ice patches wind direction was extremely important. Smell is the sharpest sense for caribou and they rely almost entirely on this sense to detect danger (Banfield 1974; Gubser 1965). Caribou are very sensitive to human scent which they can detect at a distance of over one kilometer (Kelsall 1968). In caribou populations that are accustomed to being hunted, the human scent from upwind will cause caribou to move away in a downward direction with the rapidity of the movement depending on the strength of the scent. Nunamiut hunters reported that when perspiring and wearing old, dirty clothes they were more likely to be smelled by caribou, whereas experienced hunters used smoke to conceal their human scent (Gubser 1965). It is reported that Inland Tlingit men would light spruce burls to eliminate their human scent and then advance on a caribou herd, since the animals will walk towards smoke (McClellan 1975:111). Caribou may have been hunted in the direction of the prevailing wind, or across the wind at a low angle (Benedict 1992:4).

Using ice patches only intermittently may have been part of the ice patch hunting strategy. Caribou can communicate chemically over long periods of time or when not in direct eye contact with each other. Various glands spaced about their bodies secrete pheromones, chemical substances that influence the behaviour of other members of the species (Spiess 1979).

Caribou are highly sensitive to these pheromones and other odours in the environment. If caribou are alarmed, pheromones are released and other caribou will become spooked if passing near the marked spot (Lewin and Stelfox in Spiess 1979:37). For instance, Alaskan Brooks Range Inuit (Gubser 1965; Spiess 1979) recognized that repeated ambushes at one spot of many migrating caribou will not be successful unless the first several groups of caribou are allowed to pass through the area. If caribou are alarmed, trailing caribou – even several days later – will also become scared and avoid the location.

Caribou are naturally curious animals and this can be advantageous to hunters because given certain circumstances, they will regard a person as an object of curiosity rather than a source of danger (Kelsall 1968; Symington 1965). Caribou tend to be less aware of motionless objects, especially if they are walking downwind toward the object. Caribou may investigate, either by circling downwind for a scent, or by making an approach (Spiess 1979; Gubser 1965:322, 323). Ethnographic accounts indicate that hunters deliberately showed themselves to caribou and then slowly walked away. In some cases the animals were sufficiently curious to follow, so one hunter would drop behind for cover while the second hunter continued to retreat. The concealed hunter dispatched the animal when it was within shooting range (Kelsall 1968). Hunters may have also taken advantage of the curiosity of caribou by imitating caribou foraging. There are accounts in the subarctic region where humans imitated grazing caribou, revealing themselves in select locations and drawing in the curious animals (Brink 2005:21; Spiess 1979). Given that areas around the ice patches provided high quality forage, hunters may have positioned themselves in surrounding snowbed meadows, provoking a curious response in caribou.

12.5 Hunting Blinds

Hunters likely used loose rocks from blockfields and areas of frost-sorted patterned ground to construct blinds (also see Benedict 2005). At locales where constructed blinds are absent, hunters may have used elements of local topography and existing lines of boulders to conceal themselves (Hare et al. 2004). Currently it is unclear what role hunting blinds may have played in the caribou harvest (Greer 1986; Hare 2007; Hare et al. 2004: Hare 2007). Many of these hunting blinds are located near resident populations of Dall sheep so in some, or in all cases, they may have been employed in sheep hunting rather than caribou, or they were used to hunt both animals, or were used differently over time (also see Greer 1986; Hare et al. 2004; Hare et al. 2007). Hunting blinds constructed of boulders are documented in the precontact record in the mountains near Kusawa Lake, near Thandlat and at a similar elevation (ca. 1900 m) (Greer 1986). Hunting blinds are also reported on Caribou Mountain and Mount Skukum within the Wheaton-Watson basins and these are discussed in more detail below (Greer 1984, 1987). The relationship between hunting blind, sheep and caribou hunting requires further study, but until this relationship is further clarified, it is important to consider what role these features may have played in caribou hunting strategies at ice patches. It should be noted that some of these features may have also served as caches (Hare, personal communication 2010).

The association of hunting blinds with the Granger and Friday Creek ice patches suggests that visual cover was likely important. The eyesight of caribou can be poor as an initial warning agent but they can be remarkably sensitive to movement (Kelsall 1968; Stefansson 1944; Symington 1965). Caribou can recognize movement at great distances, and if the animals recognize the movement as a predator they will flee. Individual bulls from barren ground herds are known to flee from an inconspicuously dressed, but moving observer, at distances of over one kilometer (Gubser 1965:322, 323).

Hunting blinds may have been used to make observations on game and gather information even when caribou were not dispatched (Binford 1978, 1980). Hunting blinds, which are generally integral to co-ordinated hunting, can be locations where hunting strategies are planned once game is sighted (Binford 1980). At hunting stations or blinds the hunter can position himself to monitor the area where game is anticipated (Binford 1978). Locating hunting blinds on ridgetop locations or on plateaux, not visible to caribou, was advantageous, especially if hunting in winter when human silouettes on snow backgrounds may alarm caribou.

12.6 Overview of Cultural Historical Context

At the close of the 2010 field season, 217 well-preserved, principally organic artifacts had been recovered at 24 ice patches in southwest Yukon (Hare et al. 2004; Hare personal communication 2011). The collection of artifacts from alpine ice patches can be grouped into throwing dart (atlatl) technology, bow-and-arrow technology and a small number of miscellaneous artifacts, which includes a carved wooden knife handle, a leather mocassion, various unmodified sticks, several stone flakes and cut antler tines of unknown function (Hare et al. 2004). One other artifact is a small carved wooden stick with the shape of a blunt arrow at one end. One interpretation is that this may be an Athapaskan hunting tool known as a “Little Owl’ which was used to hunt rabbits (Hare et al. 2004). Another interpretation is that the object is an unusually small throwing board. The artifact is dated to 1210 +/- 40 BP (Hare et al. 2004). Artifacts are constructed of bone, antler, wood, and stone and many are in an excellent state of preservation (Hare et al. 2004). AMS radiocarbon dates have been obtained from 55 artifacts in the Ice Patch collection (Hare et al. 2004; Table 2, Table 3).

Although some artifacts are dated to between 9000 and 8000 years ago, the majority of items date to between 6000 and 100 years ago falling within the middle to late Holocene. There is an absence of cultural material between 3000 and 2000 years ago, which may be related to the onset of the Neoglacial, although this relationship needs to be evaluated further (Anderson et al 2001, Anderson et al. 2005; Denton and Stuiver 1967; Lamoreux et al.

2005). Various styles of projectile points have been found at ice patch locations, suggesting that hunting occurred during various cultural phases of the southwest Yukon. Ice patches located in productive locations may have been used over generations, potentially by a succession of different cultures (also see Brink 2005; Hockett 2005). It appears that ice patches were used as part of a land-use pattern where people returned repeatedly throughout the Holocene, even if intermittently.

Currently, the cultural chronology of the interior western subarctic is being debated (Potter et al. 2011). There are two broad interpretations for the late Pleistocene-early Holocene which includes: (i) a single broad technological tradition with variations based on habitat use, seasonality, and mobility patterns; and (ii) multiple technological traditions representing different populations (Potter et al. 2011:1061). Evidence from the Yukon is limited, but there does appear to be a Paleoindian presence which appears to pre-date microlithic technology (Hare 1995; Heffner 2000). However, in many places this technological tradition existed contemporaneously with users of the microblade tradition of the Little Arm Phase, as is the case in southern Yukon (Hare 1995).

Clark and Clark (1993) classify interior sites older than 7000 to 8000 years BP and lacking microblades, as the Northern Cordilleran (Clark and Gotthardt 1999). The Northern Cordilleran lithic tool assemblage is characterized by large core and flake tools, bifaces, bifacial projectile points (including lanceolate and fluted ponts), burins, and occasional large blades (which may be linked to late Pleistocene tool assmblages) (Clark 1981, 1983, 1992; Gotthardt 1990; Hare 1995; MacNeish 1964; Morlan and Cinq-Mars 1982). Elongate stone knives and bipoints can also be added to the list. The basal occupation of the Canyon site, which is dated to 7195 +/- BP and Moose Lake, which is dated between 10670 +/-80 BP and 10130 +/-50 BP, have been identified as Northern Cordilleran occupations (Hare 1990; Heffner 2000; MacKay 2008).

After 8000 years BP, a distinctive microblade technology known as the Little Arm Phase spread over many areas of the Yukon (Workman 1978). The presence of a microblade technology is more characteristic of the Paleoarctic or Denali complexes (Clark and Gotthardt 1999; Hare 1995; Heffner 2000). The earliest appearance of microblades for the region remains unclear and may in fact predate Paleoindian sites (Hare 1995). Originally it was thought that microblade technology became obsolete after 5000 years BP, but reevaluations suggest that it was present much later (Hare 1995; MacKay 2008). This phase is characterized by microblades, tabular wedged shaped microcores, burins, and geometric round-based points. There are no notched points and large bifaces and other heavy implements are very rare or absent. It is suggested that sites dating to this period probably represented short stays by small groups and resources included bison, caribou, moose and birds (Workman 1978).

The earliest evidence for the use of ice patches in the southwest Yukon comes from the Gladstone site (JhV-1) which is located in the western edge of the study region north of Haines Junction. Various dart shaft fragments have been recovered from Gladstone with one dating to 8360 ± 60 years BP. In addition, a slotted antler point was found at the Gladstone ice patch suggesting that the site was used by people of the Little Arm Phase. This slotted antler point is dated to 7310 ± 40 year BP and was found in association with a dart shaft dating to approximately the same age at 7290 ± 50 years BP (Helwig et al. 2008; Hare et al. 2004:Table 2). The slotted antler point has an incised design of intersecting lines, which are possible ownership marks (Hare et al. 2004; Helwig et al. 2008).

The antler point has slots along both lateral edges for the insertion of microblades. The presence of the adhesive pine resin identified in the slots of the antler point is thought to have held the microblades in place (Helwig et al. 2008). The microblades may have been inserted to provide sharp cutting tools that could be removed and replaced when dulled or they may have been used to make composite cutting tools (Clark 1991; Helwig 2008). Discussion continues about how microblades were used in prehistoric North America (Helwig et al. 2008; also see Clark and Gotthardt 1999).

Workman (1973, 1978) notes a marked technological discontinuity in the southwest Yukon at approximately 5000 years ago, which he called the Taye Lake Phase (5000-1250 years BP). Over most of the region microlithic technology disappeared and side notched points became common. The Taye Lake Phase is part of the widespread Northern Archaic Tradition, which Clark (1993; Esdale 2008) believes developed out of the Northern Cordilleran

Tradition. This phase consists of all archaeological materials that are younger than 5000 years BP but pre-date the White River Ash and is characterized by notched or lanceolate points with straight or slightly concave bases, an abundance of large bifaces, unifaces, a variety of endscrapers, hide-processing stones, cobble net sinkers, a developed bone industry, and a lack of microblades or microcores (Greer 1993; Hare 1995). Ground stone was present but native copper was not in use. Large rich sites were suggestive of seasonal returns to favourable locations over a long period of time. Big game hunting was supplemented by trapping, fishing, and bird hunting (Workman 1978).

The majority of artifacts from Yukon ice patches date to the Northern Archaic and fall within Workman's Taye Lake Phase. Twenty-eight dart-related artifacts were AMS radiocarbon dated from the Ice Patch collection. Resultant dates range from 8360 +/- 60 BP to 1250 +/- 40 BP with the majority of dates falling between 4700 and 3200 BP (see Hare et al. 2004: Tables 2 and 3). Within the Yukon Ice Patch collection, approximately 64 artifacts are associated with throwing-dart technology: which includes 43 complete or fragmentary wood shafts or foreshafts, 17 stone projectile points (which all appear to be dart points), two antler points and two bone/antler foreshafts. Dart projectiles include seventeen projectile points and two antler points recovered from ice patches associated with dart-throwing systems. Two stone points, one being from Friday Creek (JcUu-1:15), were still hafted to the dart shaft (Hare et al. 2004: Figure 7). This hafted foreshaft from Friday Creek dates to 4480 +/-60 years BP (Beta 37722; see Hare et al. 2004:Table 2).

Within the ice patch collection, only five examples of throwing-dart technology appear to incorporate bone or antler components. From Friday Creek, this includes an unbarbed antler point (JcUu-1:21) dated at 3870 +/-40 BP and a complete dart shaft (JcUu-1:17) with an open socket and well-preserved lashing designed to accommodate an antler projectile point is dated to 1260 +/- BP. This represents the latest appearance of throwing-dart technology (Hare et al. 2004).

In southern Yukon, the beginning of the Late Prehistoric Tradition (1250-50 years BP) is arbitrarily defined by the presence of the White River ash at 1250 years BP (Clague et al. 1998; Lerbekmo et al. 1975; Robinson et al. 2001; Workman 1978). Although there is no evidence that the volcanic ash event contributed directly to changes in technology, it may have affected the population base of the area resulting in a sparser population after the ashfall (Workman 1978; Hare 1995; Ives 1990). Characteristic elements of the Late Prehistoric period include increased emphasis on bone and antler tools, including multi-barbed points, known as Klo-Kut points, and copper tools (Clark 1981; Hare 1995; Greer and Le Blanc 1984). Small sites are the predominant pattern of land-use during this time.

Thirty-two artifacts are associated wth bow-and-arrow technology, including wood arrow shafts, antler projectile points and fragments of a wood bow. A total of 19 AMS radiocarbon dates were run on elements of bow-and-arrow technology, with the majority of these dates clustering between 1300 and 90 BP (Hare et al. 2004: Table 3). When these dates are contrasted with the radiocarbon dates for dart shafts, there is very little temporal overlap between dart-throwing and bow-and-arrow technology in the southern Yukon (Hare et al. 2004).

12.7 Weaponry Used at Ice Patches

As mentioned above, precontact hunters at ice patches employed a variety of technologies including atlatls, bows and arrows, barbed antler and stone projectile points, suggesting hunting activities (Hare et al. 2004). Almost all of these artifacts are related to hunting big game in the alpine, and most represent elements of throwing dart (atlatl) or bow-and-arrow technology (Dove et al. 2005; Hare et al. 2004; Helwig et al. 2008; Kuzyk et al. 1999). A key factor in the hunting strategy at ice patches is the weaponry used. The effective distance, accuracy, and impact were also important considerations (Hare et al. 2004). The range of form and use of implements relates to the obvious connection between the task to be accomplished, that of hunting, and the implement that can accomplish that task. Yet the same task can be accomplished with implements differing in design and complexity (Ellis 2008; Read 2008).

Dart shafts associated with throwing dart technology exhibit considerable variability in the Ice Patch Research collection with variation in size, robustness of shafts and craftsmanship (Hare et al. 2008). Some of the shafts exhibit traces of ochre staining, while nine possess sinew ties and several of these retained fletching feathers (Dove et al. 2005; Hare et al. 2004). The hafted foreshaft from Friday Creek (4480 ± 60 years BP) contains remnant caribou hair wedged between the stone point and the wooden shaft (Hare, personal communication 2010). Most stone projectiles are complete or nearly so and the Ice Patch collection is noteworthy in terms of its variability including stemmed, unstemmed and side-notched types, ranging from lanceolate to leaf-shaped in outline (Hare et al. 2004; Hare et al. 2008). All of the points would have been mounted in a slotted haft element at the distal end of a shaft. Some of the points exhibit traces of ochre and have traces of pitch (Helwig et al. 2008).

Bow-and-arrow technology is well represented in the Ice Patch Research collection with several arrows being recovered intact (Hare et al. 2004). Four of these arrows had projectile points still attached or in direct association. In addition, 13 barbed antler projectile points and one barbed point were recovered with associated shafts. Three bow shafts were also recovered. Several of the arrows retained sinew ties in association with fletching or hafting of the antler arrow points, or both. Ochre was also present on a number of shafts, often associated with sinew ties. All of the points associated with bow-and-arrow technology are made from antler or bone but with considerable stylistic variation (Hare et al. 2004; Hare et al. 2008).

Using either a throwing dart or a bow and arrow, hunters would have situated themselves where they could dispatch caribou and possibly other game with some certainty. Nelson (1899:152 in Benedict 2005) reports that Inuit hunters armed with throwing sticks could hurl spears for distance of up to 46 m with considerable accuracy and force. Stefansson (1919:96 in Benedict 2005) considered the maximum effective range of an Inuit bow against caribou to be 67 – 82 m, depending on the archer but other observers reported much shorter distances (Lyon 1824:244; Jenness 1922:146 in Benedict 2005). For instance, Netsilik hunters had to shoot caribou within 20 m to be successful (see Rasmussen 1931 in Benedict 2005).

12.8 Faunal Material Found at Ice Patches

Approximately 600 large mammal remains, including postcranial and cranial skeletal elements, antler, antler velvet and horn sheaths have been recovered from southwest Yukon ice patches (Farnell et al. 2004; Hare 2007). Caribou elements and isolated finds of wood bison, Dall sheep, elk, and goat have been identified at ice patches (Farnell et al. 2004). In addition, the preserved remains of over 100 small mammals and birds have been collected (Hare 2007). The faunal material recovered at ice patches represent a combination of animals killed on the snow or the remains of other species that died at the location and then became part of the ice patch assemblage (Hare 2007). Caribou remains dominate the faunal assemblages from ice patches, with over 1000 faunal elements documented (Hare et al. 2004; Hare personal communication, 2010). Eighteen non-artifactual caribou elements were dated from the ice patches including a scapula dating to 3650 +/- 50 BP and seventeen mandibles dating to between 6320 and 360 BP (Hare et al. 2004).

From the ice patch sites, ten caribou antler tines appear to have been intentionally selected by hunters. These tines have been snapped or cut off at a transverse angle. Le Blanc (1984) interpreted similar objects from the Rat Indian Creek site in northern Yukon as by products of antler core preparation (Hare et al. 2004). The majority of these antler derived artifacts have been dated to the last 1200 years. However, three of the transverse-cut antler tines were also dated to 3720 +/-40 BP, 3810 +/- 40 BP and 5000 +/- 40 BP (Hare et al. 2004; Table 5). It has also been suggested that these antler tines were used as pressure flakers on stone projectile points, although their function is currently unknown (Hare et al. 2004).

The presence of elk at the Ibex ice patch, at 2690 +/- 40 years BP (Beta-164992) is important for reconstructing the past large mammal community in southwest Yukon (Farnell et al. 2004). The only other reliably dated occurrence in the study area (from an antler found near Whitehorse) is more recent, dated at 1540 +/-40 years BP. The presence of mountain goat from the Sandpiper ice patch dating to 2510 +/-40 years BP, provides the only date on goat from the southern Yukon (Farnell et al. 2004). The presence of sheep and mountain goat at nearby ice patches suggests that these animals may have been distributed sympatrically for the last 2500 years (Farnell et al. 2004; also see Shafer et al. 2010).

Bison remains including bones and dung, have been identified at ice patches (Farnell et al. 2004). Radiocarbon dates on bison indicate that they were present at ice patches from at least 7500 years ago. Radiocarbon dates from bone at the Granger ice patch provided a date of 7510 +/-90 BP (Beta-135361) and two bison dung samples from Friday Creek dated to 2840 +/-60 (Beta-165096) and 3500 +/- 60 years BP (Beta-162359). According to ethnographic accounts, wood bison were known to have been run down and shot with a bow and arrow (McClellan 2001).

The bison remains from ice patches combined with those from other Yukon sites support the widespread occurrence of the species in the territory through the Holocene to as late as 370 years BP (Farnell et al. 2004; Stephenson et al. 2001; Table 1; Harington 2003). Diet analysis on dung provided a composition typical to that of the modern dung collected from the modern Yukon herd (Farnell et al. 2004). The occurrence of bison remains in ice patches extends the species' summer habitat use to high elevations. Wood bison have been successfully reintroduced to the southwest Yukon. The extant herd is known to use the alpine from June through August, to aggregate in the immediate vicinity of ice patches and to wallow in ancient dung around ice patches (Farnell et al 2004). These findings illustrate the adaptable nature of the species, with its ability to exist in alpine as well as low-elevation meadow habitats in the north (Farnell et al. 2004).

Sheep (*Ovis sp.*) make up approximately 24% of the faunal remains at ice patches (Hare and Thomas 2010). Most sheep elements in the ice patch collection show no indication of cultural activity with only four sheep elements showing signs of possible butchering (Hare and Thomas 2010). Sheep remains from the Granger ice patch date to 670+/-40 years BP (Farnell et al. 2004:Table 4). Sheep remains recovered from the Sandpiper 3 ice patch site dates to 3570 +/-40 years BP. The majority of faunal sheep remains come from the Sandpiper and Texas Gulch sites, which are dominated by *Ovis sp*. material (Hare and Thomas 2010). Almost all of the sheep elements show signs of carnivore gnawing and are poorly preserved. Regardless, the dominance of sheep at the Sandpiper 3 and Texas Gulch sites suggest that ice patch hunting was not limited to caribou and that at least some of the ice patches within the southwest Yukon were used for sheep hunting. Dall sheep (*Ovis daali*) is reported for ice patches in Alaska (Dixon and Jarman 2010) and bighorn sheep (*Ovis canadensis*) has been identified at ice patches in the Rocky Mountains of the United States (Lee 2010).

Sheep is known as a precontact game animal of the North American alpine and is commonly reported as an important animal in ethnographic records of the western subarctic (Arnold 2010; Lee 2010; Benedict 1999; Legros 2007; Loerh et al. 2005; Lyman 2009; McClellan 1975; 1981b, 1981c, 1981d). For those who did not have good access to good salmon runs, sheep were especially important (McClellan 1975). The summer sheep hunt was important as the meat and fat is considered to be delicate and excellent eating (Emmons 1911; Legros 2007; McClellan 1975).

Tutchone, Tagish and Inland Tlingit hunters agree that in the old days snaring was a common method of catching sheep in the high country (McClellan 1975). According to Mrs. Annie Ned "it's easy to catch sheep in the mountains" (as reported to Julie Cruikshank 1985). Sheep were hunted using snares, corralling, and stalking and dispatching with a bow and arrow (Cruikshank 1985; Emmons 1911; Legros 2007:291; McClellan 1975).

According to Legros (2007), one method to hunt Dall sheep was to build a miniature rock shelter with narrow openings. A hunter would lie down inside and wait for a Dall sheep to approach. This could last for several hours but once an animal was close enough, the hunter dispatched the animal with a bow and arrow. When Dall sheep were plentiful, several hunters would spread out in all directions at the foot of a mountain, and then each one would choose a flank to climb. When the sheep noticed the hunters the animals would seek refuge by climbing the steepest peak. The hunters, in groups of four or five, would climb the peak and then club the animals (Legros 2007:291). Legros (2007) also describes Dall sheep camps near Kluane in which hunters of at least five adults were camped above tree line, in the cirques of very high mountains.

Mountain goat (*Oreamanos americanus*) from the Sandpiper ice patch (JbVa-2) dated at 2510 +/-40 years BP (Beta 164993; Farnell et al. 2004) provides the only date on goat from the Yukon. The Sandpiper ice patch is just outside the present range of the species, which is approximately 30 km south of Kusawa Lake (Farnell et al. 2004). The presence of sheep and goat at nearby ice patches indicates that they may have been distributed sympatrically over the last 2500 years in this coastal ecotone (Farnell et al. 2004).

Goats were hunted in similar ways to sheep. Hunting methods included the use of snares set along trails or the animals were stalked with bows and arrows (Albright 1984; Emmons 1911; McClellan 1975). McClellan (1975) reports that hunters chased goats out onto rock formations near the top of mountain peaks, such as “Three Aces” near Teslin Lake. At these locations hunters could easily shoot them with a bow and arrow (McClellan 1975). In the areas where goats are found, the meat of the young animal is also eaten and especially desirable (McClellan 1975).

12.9 Evidence for Faunal Processing at Ice Patches

As mentioned above, evidence for butchering caribou and sheep is tenuous with only a few bones showing evidence for cut marks (Hare and Thomas 2010). This may be due to the prevelance of off-site butchering and to factors that discourage bone preservation in the alpine (off ice patches), such as long exposure, animal gnawing, and low soil pH. In fact, many of the bones show evidence for carnivore gnawing and several wolves were noted around ice patches during summer surveys (Hare, personal communication 2010). Future research on faunal material might include more detailed studies that assess assemblages for signatures of carnivore and human hunting activity (Kooyman et al. 2006).

Spiritual practices of precontact hunters may have influenced the assemblage of caribou remains at ice patches. Although speculative, such spiritual influences are important. It is known that among some northern caribou hunters the proper ritual treatment of caribou dictacted that the head of the animal was completely severed from the body to release the animal's spirit (Gubser 1965; Minc 1986). Once the head was removed, the rest of the animal may have been taken away to a secondary location for butchering (also see Patterson 2008).

Butchering tools and wasteflakes from tool resharpening are underrepresented in the kill areas of the ice patches, suggesting that the carcasses were transported to lower altitudes after only minimal butchering. This may have been especially feasible for bighorn sheep due to their small size. However, if bison, which are several times larger than sheep and caribou, were routinely hunted at ice patches, more evidence of on-site butchering might be expected in the form of larger tools and greater numbers of resharpening flakes. After successful hunts at ice patches, minimally butchered carcasses may have been carried downslope to a butchering station. Butchering stations in the region may have been more sheltered and located near a dependable water supply (see Patterson 2008). An abundant water source may have been important for keeping hunting sites clean and free of the scent of blood. According to Gwich'in native Darius Elias from Old Crow, Yukon it is important to clean up every bit of blood as it is disrespectful of the next caribou to smell their own blood (D. Elias; http://arctic voices.org./interview_darius.htm). A similar situation is reported for the Northwest Territories where faunal assemblages are composed primarily of caribou but there are no cut or butchering marks. It is reported by Andrews et al. (2010) that First Nations beliefs dictate that the dispatched animals need to be taken to a butchering location because blood will spoil the hunting site.

12.10 Ice Patches and Altitudinal Hunting

The focus in this study is on caribou but it is possible that other game animals such as sheep and potentially bison and goat were a primary attraction of the alpine region of the southwest Yukon. Caribou, sheep and goat are gregarious animals that congregate into herds in the alpine that are large enough to justify making hunting forays to these locations during summer months. Evidence for bison at ice patches is more limited and an animal as large and difficult to control as bison may have been hunted only occasionally (see Brink 2005). Small mammals such as marmot may have been hunted in the alpine, although evidence for southern Yukon ice patches is currently limited. Ground squirrel snares are reported near ice patches in the Northwest Territories and Alaska (Andrews et al. 2010; VanderHoek 2010).

With favourable macro- and microclimatic factors, the southwest Yukon can provide bountiful resources in the alpine during the summer. There may have been times throughout the Holocene when ungulates, such as caribou and sheep were more abundant and potentially more predictable in the alpine of the southern Yukon. As outlined previously, caribou are known to use alpine ice patches with some predictability during summer months when they are seeking insect relief and high quality forage. In addition, sheep and goats are animals of the alpine that show strong fidelity to their ranges (Loerh et al. 2005; Shafer et al. 2010). These animals are generally not far from suitable escape terrain, such as rocky slopes and cliffs, for predator avoidance (Loerh et al. 2005; Jean Carey, personal communication 2010; Shafer et al. 2010). These predictable habits in behaviour suggest that these animals can be located with some anticipation by hunters. These factors may have provided incentives for humans to make regular trips to the high country. In other words, the alpine and ice patches specifically, had an economic attraction – caribou - and other large game such as sheep, possibly bison and goat. As a consequence, it is possible that a more complex subsistence mosaic existed in southwest Yukon during the mid-to Late Holocene (Hare et al. 2004). The ice patches themselves, along with hunting facilities, may have provided focal points where hunters stopped to monitor game, made observations on snow melt and plant phenology, and gathered information about the area.

13.0 SEASONAL PATTERNS OF MOBILITY

13.1 Ice Patch Hunting

Granger and Friday Creek ice patch sites are located within a few hours' hike (10-15 km or less) of known archaeological sites in the adjacent valley bottoms (CHIN 2002 as cited in Hare et al. 2004). Archaeological evidence indicates that many camps in the lowlands were used repeatedly over hundreds and thousands of years. These nearby camps, often in lakeside settings, were used in precontact as well as historic times (Hare et al. 2004). For instance, the Thandlat ice patch can be easily reached from camps along the shore of Kusawa Lake. One of the camps along the shore of Kusawa Lake was used in the 19th and 20th centuries as a base camp for caribou and sheep hunting in the mountains surrounding the lake (CAFN n.d.; Hare et al. 2004).

In rich environments, such as that of the southwest Yukon, hunter-gatherers tend to select locales near ecotones, where resources from several habitats can be gathered or hunted from the same site (Kelly 1983). Ethnographic accounts from Inland Tlingit emphasize that it is important to "stay in a place where it's going to be good to get game of different kinds" (McClellan 1975:104). When hunters were seeking caribou on ice patches they were also in the vicinity of sheep, possibly bison habitat and potentially small mammals like marmot. According to one Teslin woman, when searching for caribou, it is important to camp at the same place where marmot is hunted. This camp becomes the location where meat and berries are dried for caching (McClellan 1975:108).

13.2 Granger Ice Patch – Archaeological Context

The Granger ice patch is located within a few kilometers of archaeological sites in the adjacent valley bottom of Fish Lake (Lu Zil Man) (Gotthardt 1994; Gotthardt and Hare 1994). Archaeological investigations in the Fish Lake area suggest a long history of occupation of the region with various camps, quarries, and trails in the vicinity (Gotthardt 1994). Thousands of flakes and numerous stone tools found at large archaeological sites buried along the shoreline of the north end of the Fish Lake suggest a long history of habitation (Gotthardt and Hare 1994). Various artifacts were identified at these ancient camps including side-notched and leaf-shaped spear points, scrapers, stone knives, wedges, and large scrapers. Artifacts and features indicate that many of these sites represent base camps that were re-used repeatedly over several thousand years. Key artifacts include microblades and spear points of various ages, beginning at least 7000 years ago (Gotthardt 1994; Workman 1978).

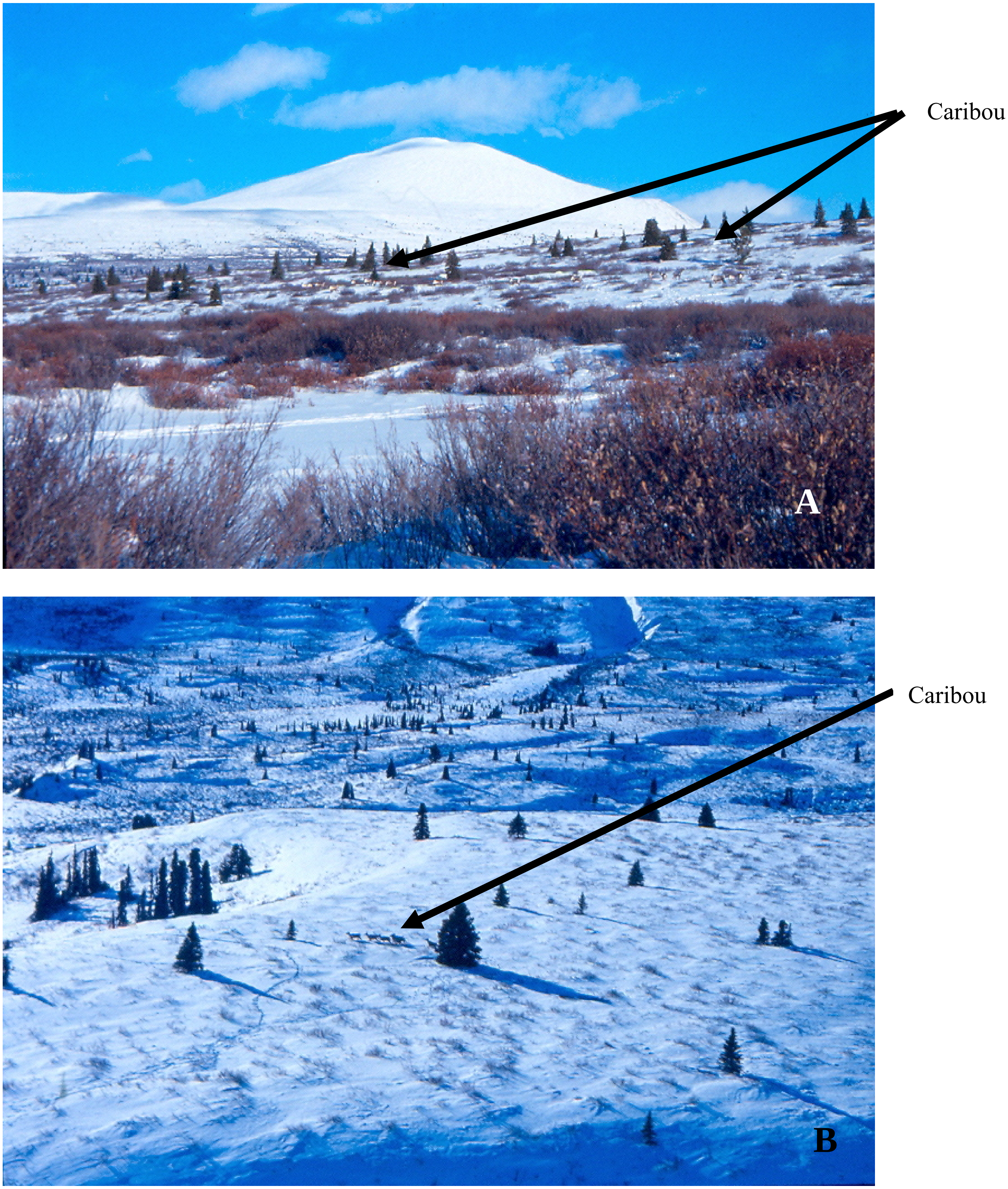
13.3 Hunting at Granger Ice Patch

The sites around Fish Lake, including the Granger ice patch, fall within the traditional territory of Kwanlin Dun First Nation. According to published sources on the traditional land-use of Fish Lake, the area is remembered as a summer gathering place where people fished, hunted and held potlatches. Over the years many different families have gathered there and people continue to fish and hunt around the lake (Gotthardt and Hare

1994). According to Kwanlin Dun elders the north end of Fish Lake was a principal whitefish camp, where whitefish spawn in the fall. Moose, sheep, and caribou were hunted in the area in the fall, before and after the whitefish run (Gotthardt and Hare 1994).

According to elders, during the winter and spring, many people stayed at the lake to fish through the ice and hunt for caribou and moose. Old foot trails used to run all around Fish Lake to hunting areas at Bonneville Lake, the Ibex Valley, and Primrose and Rose (Mud) Lake, where caribou and sheep were plentiful in the high country (Gotthardt and Hare 1994). By late January, hunters around Fish Lake travelled to the mountains to hunt caribou, while others stayed on the lake to fish and hunt small game (Gotthardt and Hare 1994). Hunting caribou in the mountains in the winter was possible, and even advantageous in some years, depending on snow conditions. Therefore, a brief discussion of caribou use of the alpine in the winter and their winter habitat is discussed.

During winter, lichen makes up 70% of the caribou's diet, so during this season the animals are located where there is the greatest relative availability of food including sufficient lichen and shallow snow cover allowing caribou to crater for food (Figures 35A and 35B, Figure 36). The caribou's broad expanse of hoof and dewclaw is ideally suited for walking on snow and also allows them to dig down to lichen (Guthrie 1990:262). However, deep snow in excess of 60 cm and hard packed crusts of icy snow can impede locomotion and digging feeding craters, thus decreasing forage intake and increasing energy costs (Boertje et al. 1996; Farnell et al. 1991; Holleman et al. 1979; Larter and Nagy 2001; Thomas and Edmonds 1983; Woodland Caribou Management 1996). When there are years with deep snow conditions in valley bottoms, cold wind chills, extreme temperatures, and inversions at



Figures 35A and 35B. Woodland Caribou in the sub-alpine near Whitehorse. February 2002.

Figure 36. Caribou cratering location in the sub-alpine near Whitehorse. February 2002

higher elevations, caribou will move upland to save energy expenditure. In the southern Yukon today some caribou herds are known to move into the alpine in light snow years (Kuzyk and Farnell 1997).

Given that snow conditions are the most important factor influencing caribou movement during the winter, caribou may be limited to a fairly restricted region. To precontact hunters, knowledgeable about the various types of snow zones and their implications for caribou movements, the boundaries of these zones may be very apparent. Once a hunter finds an area with a wintering caribou herd, he will travel to the location to hunt. If similar snow conditions occur with some regularity from one year to the next, the element of chance of finding wintering caribou populations is enhanced for hunters familiar with the territory.

13.4 Friday Creek Ice Patch – Archaeological Context

The Friday Creek ice patch is located within the Wheaton-Watson basins, part of the Carcross/Tagish First Nations traditional territory, which covered over 10,000 square kilometres in the protohistoric period (Greer 1987; McClellan 1975). The First Nations inhabitants of this territory used all parts of the landscape from the alpine meadows of the Coast Mountains to the lakes and forested valleys of the plateau country (Greer 1987). The entire upper Watson River valley may be archaeologically important (Greer 1981).

Traditionally, the Wheaton-Watson area is known best for its hunting with forays known to have been made in many places in the Coast Mountains (Greer 1987). Sections of the Coast Mountain within the Wheaton and Watson basins are known to be some of the best sheep hunting country in the Yukon (according to Mr. Johnny Johns in Greer 1987). The late Mr. Johnny Johns made the region well known internationally when he pioneered big-game hunting in the Yukon (Greer 1981).

The Friday Creek ice patch is located within a few kilometers of the Alligator Lake archaeological site. Very little is known about the archaeological history of the Alligator Lake site, although it is known to have been a gathering place as a fish camp and for hunting in the surrounding area (McClellan 1975). It is possible that the name for Alligator Lake is really "All together lake" as people are supposed to have gathered there for fishing and hunting (Greer 1987; McClellan 1975). A large precontact site (JcUt-3) is located at the north end of Alligator Lake where artifacts are scattered over the surface and eroding out of wind carved gullies (Greer 1981).

Hunting blinds are reported on Caribou Mountain and Mount Skukum within the Wheaton-Watson basins (Greer 1984, 1987). These archaeological features are above-ground structures consisting of semi-circular piles of rocks, built in high elevation settings beside game trails and were likely in widespread use in precontact times, given the well-established lichen growth (Greer 1984, 1987). These hunting blinds are located at about 1800 metres a.s.l., almost on top of the mountain. According to Greer (1984, 1987) one locale consists of at least ten hunting blinds constructed of angular boulders built into a hillside along a trail leading uphill to escape terrain. Looking up from below, the blinds are barely detectable, and would have functioned effectively to hide waiting hunters while others sent the frightened animals their way (Greer 1984). Greer (1986) suggests that hunting blinds in the area were used for sheep hunting given their general location near Dall sheep trails and habitat. The hunting blinds described by Greer are similar to those located between the Friday Creek and Alligator ice patches on the Friday Creek Lake Plateau (see Figure 26). Below the hunting blinds on the Friday Creek Lake Plateau are sheep caves where animals were observed during the author's summer fieldwork in 1999. It may be that hunting blinds situated near ice patches were multi-purpose; being used for sheep and caribou hunting (also see Hare et al. 2004, Hare 2007). The purpose and overall function of hunting blinds in the region and their relation to caribou and sheep hunting requires further study.

The importance of caribou hunting in the area is supported by the archaeological record. In an archaeological survey, Greer (1981) noted caribou bones in faunal samples from all sites clustered along the shores of Tagish Lake. Greer (1981) suggests that these sites were used to intercept caribou crossing Tagish Lake and to process the carcasses. The Nustsehe site (JaUk-23), situated near Tarfu Lake, yielded bones of only caribou. Greer (1984) interprets the Nustsehe site as a short-term, special purpose site, where caribou were butchered. Economic information and chronology on these sites remains limited, although Greer suggests they probably date to the late prehistoric or "post White River Ash Fall".

The Annie Lake site (JcUr-3), located not far from the Friday Creek ice patch, is a well investigated archaeological site, which dates from ca. 1500 to 5000 years BP (Greer 1993; Hare 1995). According to elders, as reported in published sources, people came to Annie Lake (Desdele Mene) in the spring to catch muskrat, hunt beaver, and fish for grayling in the creeks around the lake (Hare and Greer 1994). Fur-bearers such as lynx, fox, mink, and otter were trapped. Goats and sheep were hunted in the high country, while moose and grouse were hunted at lower elevations. Elders recall hunting caribou in the valley (Hare and Greer 1994). Archaeological investigations at the Annie

Lake site indicate that it was possibly a specialized hunting/kill processing camp for sheep, goats and caribou (Greer 1993; Hare 1995).

In light of what is now known about caribou hunting and associated hunting tactics at ice patches, it may be necessary to review some of the earlier interpretations of lowland sites, especially where there is an abundance of caribou remains or other animals. It may be that animals were transported from ice patch hunting locations to secondary base camps or butchering stations in the sub-alpine or to lowland sites around lakes. A careful examination of the relationships between lowland, sub-alpine, and ice patch sites in the alpine will provide a better understanding of regional land-use patterns in the area.

13.5 Hunting at Friday Creek Ice Patch

Traditional First Nations' camps were frequently made around what is now Carcross, and camps are known to have been made at Alligator and Annie Lakes (according to Mrs. A. Sidney 1980 in Greer 1987). None of the traditional Tagish camps are known to have been permanently occupied although their main camp on the Tagish River was reoccupied each summer for fishing and trading activities (Greer 1987; Hare and Greer 1994; McClellan 1975).

Elders recount that in the spring and early summer families gathered where fish were running. They would fish and hunt small game and waterfowl. By late summer, some people would travel where the salmon ran, such as at McClintock River. Other places, such as Tagish, where people often gathered, had fish all year round (Hare and Greer 1994). Caribou hunting on ice patches during summer months was possible (Anderson and Nilssen 1998:15; Hagemoen and Reimers 2002:888; Ion and Kershaw 1989; Toupin et al. 1996; Weladji et al. 2003). Also, because caribou are gregarious, large groups of caribou congregate on only two or three ice patches, while there are 10 or 20 neighbouring ice patches with no caribou (Anderson and Nilssen 1998). During this time, caribou are known to be less alert to predators given that they are distracted during the insect harassment season, resulting in their sense of smell and hearing being less acute (Gubser 1965:321, 324).

When caribou are not on snow patches, foraging is the predominant activity (Hagemoen and Reimers 2002; Ion and Kershaw 1989). However, caribou are known to strongly modify their summer foraging behaviour around ice patches when insect harassment is heightened (Toupin et al. 1996). Under severe insect harassment caribou foraging is reduced as they are distracted from feeding activity; during severe or long-lasting “fly” seasons caribou have few opportunities to feed and rest (Hagemoen and Reimers 2002:890). Studies have shown that caribou weights can be significantly lower in very hot summers.

In areas which have few biting insects, caribou may develop heavy fat deposits during the summer and fatten early (Bouchard 2004; Kelsall 1968:40, 41; Gubser 1965; Stefansson 1956). As the fatness cycle advances, the fat on the back of caribou can be over 7 cm thick and weigh up between 20 and 25 kilograms (Kelsall 1968). At the end of the fly season, usually at the end of August, fat builds up rapidly. Toward the end of summer, fish camps broke up and small groups of two or three families moved to the alpine to hunt marmots, caribou, moose and sheep during the large scale meat hunts (Hare and Greer 1994). Ethnographic accounts documented by McClellan (1975:99) indicate that hunting was carried out around Carcross and Tagish just before the snow came in August and September. Cow and bull conditions are optimal for hunting, after the animals have been feeding on high quality forage. By September and October, guard hairs are present, but not too thick, and warble-fly holes have healed and hides are in prime condition for winter clothing and shelter (Kelsall 1968; Osgood 1971:85, 86; Spiess 1979:29).

According to one Teslin woman caribou (and moose) became the main focus during the fall, after marmot season. Throughout the fall, meat was dried and cached for the winter months. The importance of hunting caribou in the alpine during fall months is emphasized in stories from the Inland Tlingit, who in the “old days”, never thought about staying in the village around Teslin after the game began to get fat (McClellan 1975:104; also see Bouchard 2004).

In early December, most families returned to Tagish. Fishing was important during winter months when whitefish, trout and burbot were netted, freezing some for later consumption (McClellan 1975). During winter, food can be scarce so caribou and moose were hunted all winter by some, while others stayed on the lakes to fish and hunt small game near the lakes. By late

January people dispersed over the landscape to trap, hunt and fish. Over winter months, once the snow came, people hunted beaver, set snares for rabbits, and trapped animals such as lynx, mink and coyote until March. Around February and March muskrat traps were set, this continuing until May (McClellan 1975). During the spring, nets are set out for fishing on lakes around Tagish and hunting waterfowl (Hare and Greer 1994).

13.6 Altitudinal Hunting, Seasonal Mobility, and Secondary Resources

Land-use patterns in the summer may have included hunting forays to ice patches from base camps such as at Fish Lake and Alligator Lake in the valley bottoms, or from secondary base camps in the sub-alpine. However, there is a general discrepancy regarding the optimal time to hunt caribou and other ungulates such as sheep and goat. According to ethnographic accounts, summer animals such as caribou are too thin to be worth stalking (McClellan 1975:111). It has been noted that caribou meat is generally at its best at the end of the summer. In addition, the meat of Dall sheep is in prime condition around the end of August and throughout September when they develop a 6-8 cm layer of fat (Legros 2007). Mountain goat is also hunted in the fall when the animals have a thick fat layer (Emmons 1911). However, the primary objective of summer hunting trips to the alpine was not necessarily limited to obtaining meat and hides in their optimal condition. Obtaining high quality meat and hides may have been the primary focus of late summer and fall hunting activities, whereas the objective of summer hunts may have involved the acquisition of a variety of primary and secondary resources from alpine ungulates.

Besides their desirability as food, caribou, sheep and goat provide various secondary resources including hides, bone, antler, babiche and sinew for the manufacture of tools, hunting paraphernalia, clothing and a variety of other items (Albright 1984; Legros 2007; McClellan 1975; McClellan 1981b, 1981c, 1981d; Osgood 1971). There is confliciting evidence regarding the best time to obtain caribou hides. During the height of the summer fly season, hides are full of holes from emerging larvae of the warble fly, and are thought to be useless to humans. However, according to Ms. Annie Ned, caribou skins to make "parkey" are best in the summer month of July, when the hair is short (Cruikshank 1985:11). For the Inland Tlingit, late summer skins of caribou were best for traditional clothing and footwear (McClellan 1981b). Caribou skins however were not only particularly important in making articles of clothing, but they were also used to make a variety of bags, and containers for storage (Albright 1984; MacLachlan 1981; McClellan 1975; McClellan 1981b, 1981c; 1981d; Osgood 1974). The best types of skin toboggans were made from sewing together the split skins from the forelegs of caribou, so that the hairs all ran in the same direction (McClellan 1975).

Caribou babiche and sinew were used in lashing, netting and sewing. Babiche is cut from a dampened piece of caribou hide, cleaned and soaked in brain water. Babiche is not smoked, but was cut into long, parallel lines and used to make items such as snowshoes and beaver nets (MClellan 1975;

Albright 1984). Some of the longest and finest sinew, important in sewing, comes from caribou (McClellan 1975:266). In addition, sinew from the the back of the caribou was used in the manufacture of bow strings (Albright 1984). When skinning hides, the large upper leg of caribou was fashioned into an implement used to remove the flesh (Albright 1984; McClellan 1975). Traditional skinning knives among the Tahltan were made of caribou antler and the rib of a caribou, or the longtitudinal, flat section of the lower leg bone.

Caribou bone and antler were used to make hunting equipment such as arrowheads and clubs (Albright 1984; McClellan 1975; McClellan 1981b, 1981d). Bow points made of antler and bone were sometimes attached to the upper end of the bow with sinew lashing and was used as a spear for dispatching an animal (Albright 1984:46). Caribou antler, like those found at southwest Yukon ice patches, was used to make detachable barbed projectile points.

The non-food materials that sheep provided made them highly desirable resources (Albright 1984; Legros 2007, Table IX: 271). Dall sheep was given great value by the Tutchone for the desirability of their skins, horns, and other resources, rather than for the actual quantities of meat they might acquire (Legros 2007:283). Sheep do not experience the same fly infestation as caribou so their skins are valuable at any time of year (Jean Carey, personal communication 2010). Sheep skins were important as they were also used to make “parkeys”, blankets, and mattresses (Cruikshank 1985; Emmons 1911). Mattresses were made of layers of moose skin and caribou skin, with a sheep skin placed on top. These mattresses, according to Mrs. Annie Ned, were put on the snow when trapping (Cruikshank 1985: Legros 2007).

The curved horns of sheep were softened by boiling, then cut, shaped, and pressed into dishes, spoons, knife handles, tools, and bow points (Albright 1984:46; Emmons 1911; Legros 2007; McClellan 1975; McClellan 1981b, 1981c, 1981d; Osgood 1971). According to McClellan (1975:281) most families had several sheep horn ladels. The horns of goat were boiled and made into several implements such as spoons, knives, awls, tool handles, and spear points (Albright 1984; Emmons 1911). Goat skins were used as mats and rugs and the wool was rolled and twisted into cord that was used in making carrying bags. In areas where goats are found the skins were just as important as the meat (McClellan 1975). Although the skins are difficult to tan, the long-haired silky fleece was used for long winter trousers which were worn with the hair on the inside. In addition, the skin does not get damp and dries quickly (McClellan 1975).

Obtaining some of these secondary items may have been necessary to fulfill social obligations, were used as trade goods, or fashioned into feasting utensils. Of course it is impossible to determine to what extent these items were required the further one goes back in time, but certainly some of these items were in demand during the Late Prehistoric and historic period (de Laguana 1972; McClellan 1981a, McClellan 1981b, 1981c; McClellan and Denniston 1981; Richardson et al. 2007). For instance, implements, such as sheep spoons were in great demand by Coastal groups (Emmons 1911). Some of the larger and more elaborately decorated examples were used as "potlatch spoons" in ceremonial grease drinking (McClellan 1975; Legros 2007).

14.0 SUMMARY AND CONCLUSIONS

The central focus of this dissertation has been an examination of caribou hunting in the southwest Yukon within the broader context of hunter-gatherer land-use patterns. This thesis set out to meet three key objectives. The first objective was to develop a seasonal model of caribou hunting based on caribou biology. The second objective was to test this model against independently collected palynological data sets from the modern Ibex caribou herd and the Granger and Friday Creek ice patches. These pollen records, along with previously reported microhistological data from dung of local herds were combined to provide an interpretation of the seasonal use of ice patches by caribou. Accordingly, these data sets were presented and compared to published ethnographic and archaeological data for the region. The third objective was to examine the implications these results had for understanding hunter-gatherer land-use strategies in the southwest Yukon.

Biological literature indicates that caribou use ice patches during the summer months for insect relief, thermal regulation, and to seek high quality forage in the alpine. A multivariate ordination analysis, Nonmetric Multidimensional Scaling (NMS) shows that generally, ancient pollen assemblages are distinct from the modern Ibex caribou herd. The differences between the modern and ancient assemblages is due to several taphonomic factors and temporal transformations including the changes in prevailing macro- and microclimate and its effects on paleovegetation and phenology of each study site, the unique nature of caribou forage selection from a variety of plant mosaics in the alpine and sub-alpine, and the difficulties in distinguishing arboreal taxa that is caribou forage and that which is not.

Qualitiative indicators lend some support to the interpretation that caribou were on ice patches in summer months. The strongest indicators of summer use by caribou at Granger and Friday Creek ice patches are a high diversity of forbs, the presence of insect-pollinated taxa, and the dominance of Cyperaceae and *Salix* pollen in the dung. The strong occurrence of *Polemonium* and *Epilobium* pollen in Friday Creek dung provides additional evidence that this ice patch was used by caribou over warm summer months. Microhistological studies from ancient dung agree with modern seasonality studies of caribou in the area suggesting summer use of ice patches.

Hunting at ice patches formed part of a broader strategy of caribou hunting that has considerable time depth in the region. This hunting strategy is previously unreported in the published ethnographic and archaeological record for the area. Radiocarbon dates from the Granger and Friday Creek ice patches indicate that caribou and humans have been using these locales repeatedly for at least 8000 years. To successfully hunt caribou, precontact inhabitants of the southern Yukon had an intimate knowledge of this game animal and knew about their preference for ice patch habitats.

Based on this study the following recommendations are made for future research:

1) There is a need for more detailed studies on the chionophytes and chionophilous plant communities associated with alpine plants and the climatic conditions effecting phenological variability between locations.

2) Collection of modern fecal material from the ice patches. Sampling should also include the collection of moss pollsters along altitudinal gradients from the sub-alpine to alpine to evaluate the distribution of modern pollen rain.

3) Conduct more intensive sampling and radiocarbon dating of caribou dung from specific layers across ice patches for greater horizontal/chronological control. This will help to further document the internal stratigraphy of each layer, address issues regarding inversions of radiocarbon dates, and further evaluate taphonomic processes effecting dung.

4) Carry out complementary microhistological and pollen analyses on specific modern and ancient dung pellets. This will provide a fuller picture of caribou diet and taphonomy.

5) Link more intensive studies of ice patches in the alpine to specific archaeological sites at lower elevations (e.g. sub-alpine and lowland sites around lakes). This might be done through radiocarbon dating, and the identification of the White River Ash at both lower elevation and ice patch sites (see Meulendyk 2010). This will assist in better documenting the

chronological relationships between ice patch hunting in the alpine and specific archaeological components of sites around Alligator Lake and Fish Lake. It is also important to identify artifacts and examine faunal remains from archaeological assemblages at lower elevation sites to assist in identifying site function. This will assist in building a regional picture of land-use in the area.

6) Carry out additional zooarchaeological research on ice patches including an analysis of seasonal indicators, such as butchered caribou (antlers) and teeth (tooth eruption rates). Isotope studies might also provide additional information on the seasonal use of ice patches (see Balasse et al. 2009; Britton et al. 2009; Byers and Hill 2009). The isotopic composition of tooth enamel is directly related to environment and diet formation (see Britton et al. 2009). Enamel is laid down and mineralized in a broadly sequential fashion. Since the enamel is not remodeled once it is formed, its isotopic composition will reflect diet, location and climate throughout the growth and mineralization process (Britton et al. 2009). A number of studies have shown that seasonal changes in oxygen isotope ratio are reflected in enamel (see Britton et al. 2009). There are several dated caribou mandibles from ice patches. Any mandibles with intact teeth may provide a useful study to establish if seasonality can be detected in these animals.

Additional zooarchaeological analyses at ice patches should include a taphonomic study that examines age and sex profiles of animals and identifies signatures that indicate human hunting versus scavenging (Kooyman et al.

2006). These zooarchaeological studies will provide a more complete picture of seasonal use of ice patches by humans and caribou (and potentially other animals) and will assist in further clarifying ice patch site function. These additional studies will further our understanding of land-use pattern in the southwest Yukon and will contribute to a greater understanding of caribou hunting, and mobility strategies for northern hunter-gatherers in mountainous regions.

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: WINTER (Replicate 1; Pollen counts to 200)

Sample No.	Pinus	Picea	Betula	Alnus	Abies	Salix	Cyperaceae	Ericales	Artemisia	Poaceae	Equisetum	Pedicularis	H.S. Aster
1	45	31	55	33	4	8	13	5	2	1	2	0	1
2	62	24	62	21	8	5	3	8	2	0	1	0	2
4	13	43	59	41	3	10	12	2	1	0	4	0	0
5	38	22	101	18	2	1	0	12	0	2	0	0	1
6	44	26	91	11	6	5	1	7	1	1	0	0	0
7	59	15	63	35	11	9	0	4	1	1	0	0	0
10	60	30	58	17	11	7	1	2	3	1	0	0	1
12	42	40	56	24	13	4	1	9	0	5	1	0	1
13	35	33	63	24	11	12	0	11	3	2	0	1	3
15	35	38	53	15	24	5	1	3	5	5	5	0	3

APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: WINTER (Replicate 1; Pollen counts to 200)

Sample No.	Tsuga	Caryophyllaceae	Populus	cf. Fritallaria	Astragalus	Rannunculus	Callitriche	Unk Type H	Unk Type J	Unk Type K	Unk Misc.	Indet.
1	0	0	1	0	0	0	0	0	0	0	1	1
2	1	0	0	0	0	0	2	0	0	0	0	1
4	0	0	2	1	3	0	0	0	0	1	0	2
5	0	0	0	0	0	0	0	0	0	0	0	10
6	0	0	0	0	3	1	0	3	0	0	1	3
7	0	1	0	0	0	0	0	0	0	0	0	3
10	0	0	0	0	0	1	0	1	0	0	3	3
12	0	0	0	0	0	0	1	0	0	0	1	6
13	0	0	0	0	0	0	0	3	0	0	0	1
15	0	0	0	0	0	2	0	0	2	0	0	4

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: WINTER (Replicate 1; Pollen counts to 200)

Sample No.	Totals	Lycopodium	Comments
1	200	35	one pellet
2	199	68	hard to count;one pellet
4	188	45	one pellet
5	197	131	clumps of organic debris obscure some pollen; clusters of pinus/picea obscured; good eg. of ericales; one pellet
6	193	54	lots of organic debris; material obscured
7	198	59	one pellet
10	191	54	one pellet
12	196	62	one pellet
13	198	48	lots of organic debris; one pellet
15	192	80	one pellet

APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: SPRING (Replicate 1; Pollen counts to 200)

Sample No.	Pinus	Picea	Betula	Alnus	Abies	Salix	Cyperaceae	Artemisia	Ericales	Poaceae	Equisetum	H.S. Aster	Unk Type D	Rannunculus
1	53	24	74	28	5	1	13	6	1	2	0	0	0	0
2	60	21	28	31	7	12	12	14	8	0	0	2	1	0
3	32	11	31	57	4	12	22	15	2	3	0	6	0	2
4	80	21	71	24	6	16	12	10	1	1	0	0	0	0
5	53	14	58	22	5	16	18	3	6	4	3	2	0	0
6	61	12	45	32	3	20	15	4	0	0	1	1	0	0
7	98	27	34	26	5	13	11	16	1	0	0	0	1	0
8	89	12	53	7	3	10	10	4	2	1	0	1	0	0

APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: SPRING (Replicate 1; Pollen counts to 200)

Sample No.	Unk Type F	Unk Type H	Unk Type I	Unk Type J	Unk Type L	Unk Misc.	Indet.	Totals	Lycopodium	Comments
1	0	0	0	0	0	1	1	207	35	
2	1	0	0	0	0	1	4	196	41	
3	0	1	0	1	0	0	1	197	88	
4	0	0	0	0	0	1	3	242	28	
5	1	0	1	2	0	2	0	204	25	
6	1	0	0	0	1	1	0	194	31	
7	0	0	0	0	0	0	0	232	27	
8	2	0	0	1	0	0	0	192	14	

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: SUMMER (Replicate 1; Pollen counts to 200)

Sample No.	Pinus	Picea	Betula	Alnus	Abies	Salix	Cyperaceae	Ericales	Artemisia	Poaceae	Equisetum	Pedicularis	H.S. Aster
1	70	13	16	4	0	50	11	1	7	2	0	0	3
3	42	8	13	5	1	111	8	0	0	2	19	19	1
5	44	15	14	9	5	21	14	4	9	12	4	0	0
6	45	12	2	8	0	40	53	0	0	4	7	0	19
7	33	8	10	7	3	122	12	2	0	0	3	10	3
8	44	11	7	6	1	12	70	1	0	3	1	0	21
11	28	8	4	16	1	82	89	0	1	2	1	5	2
12	6	1	4	7	1	91	28	1	4	1	0	0	1
13	12	1	3	11	2	15	35	1	2	0	2	9	8
14	32	12	29	20	2	32	9	4	3	6	6	3	1
16	31	16	19	14	2	87	17	2	0	2	2	0	3
17	14	6	7	7	1	49	63	2	6	4	26	4	2

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: SUMMER (Replicate 1; Pollen counts to 200)

Sample No.	Tsuga	Caryophyllaceae	Fritallaria	Epilobium	Polemonium	Astragalus	Oxyria	Unk Type D	Rannunculus	Unk Type H	Unk Type I	Unk Type J	Unk Type K
1	0	0	0	0	0	0	0	0	3	0	0	0	0
3	0	0	0	0	0	2	0	0	1	0	0	0	0
5	0	0	0	12	1	0	16	0	1	0	0	0	0
6	0	0	0	0	0	7	8	2	0	0	0	0	0
7	1	0	0	0	0	10	0	2	0	0	0	0	0
8	0	1	0	0	0	6	1	0	0	2	0	0	0
11	0	0	0	0	0	0	1	0	1	0	0	2	15
12	0	0	0	0	0	0	0	0	0	0	1	0	49
13	0	0	13	0	30	19	7	2	10	0	0	0	1
14	0	0	0	8	0	0	19	0	10	0	0	0	0
16	0	1	0	1	2	0	0	0	1	0	0	0	0
17	0	0	0	2	0	0	3	0	4	0	0	0	0

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: SUMMER (Replicate 1; Pollen counts to 200)

Sample No.	Unk Type L	Unk Type M	Unk Misc.	Indet.	Totals	Lycopodium	Comments
1	0	3	4	8	177	591	low pollen counts;
3	0	0	2	3	229	30	
5	6	0	2	11	151	86	some pollen obscured
6	0	0	0	3	190	44	lots of organic debris; hard to count
7	0	0	1	1	213	38	lots of organic debris; hard to count; good preservation
8	1	0	4	8	177	76	
11	0	0	0	0	239	12	
12	0	0	0	0	145	19	
13	0	7	3	1	101	21	lots of different types of taxa; good slide to compare with ref mtl.
14	3	0	3	1	159	45	
16	1	1	1	1	195	88	
17	0	0	1	1	191	140	

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: FALL (Replicate 1; Pollen counts to 200)

Sample No.	Pinus	Picea	Betula	Alnus	Abies	Salix	Cyperaceae	Artemisia	Ericales	Poaceae	Equisetum	Pedicularis	H.S. Aster
1	42	32	25	20	1	18	21	13	4	5	3	4	0
2	43	22	93	20	1	3	7	5	2	0	0	0	1
3	115	32	7	13	0	10	6	10	0	3	1	0	2
4	115	12	3	24	4	11	4	16	0	4	1	0	4
5	73	33	45	26	4	2	2	3	0	1	3	1	0
6	46	30	40	15	13	6	2	2	3	1	1	2	1
7	43	41	57	10	10	12	4	4	3	2	4	0	1
8	61	41	38	19	17	10	2	3	3	0	4	0	0
9	104	27	9	10	11	9	3	6	0	5	2	0	6
10	36	45	39	18	12	7	5	5	9	2	1	0	0
11	82	41	9	17	13	4	0	15	0	4	4	0	0

Sample No.	Tsuga	Unk Type A	Astragalus	Unk Type C	Unk Type D	Rannunculus	Unk Type F	Callitriche	Unk Type J	Unk Type K	Unk Misc.	Indet.
1	0	2	0	0	2	0	0	3	0	1	2	5
2	0	0	0	3	1	0	0	0	1	0	1	10
3	0	0	0	0	1	1	0	0	0	0	0	3
4	0	0	1	0	1	0	3	0	0	0	0	1
5	0	0	0	0	0	1	0	4	0	0	0	3
6	0	0	0	0	4	1	2	2	0	0	1	4
7	0	0	0	0	0	0	0	1	1	3	0	4
8	1	0	0	0	1	0	0	0	2	0	1	3
9	0	0	1	0	0	2	0	0	3	0	0	4
10	1	0	0	0	5	2	0	0	3	0	1	8
11	0	0	0	6	1	5	0	0	1	0	0	1

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APPENDIX A - MODERN DUNG IBEX HERD RAW DATA: FALL (Replicate 1; Pollen counts to 200)

Sample No.	Total	Lycopodium	Comments
1	188	69	Lots of organic debris; lots of fungal; one pellet
2	197	236	Lots of clumped organic debris; one pellet
3	199	30	Lots of organic debris; hard to count; lots of pinus; one pellet
4	198	25	Lots of organic debris; one pellet
5	193	74	Lots of fungal; one pellet
6	162	30	one pellet
7	191	75	one pellet
8	198	46	one pellet
9	192	42	one pellet
10	179	64	Lots of organic debris; hard to count; one pellet
11	189	45	one pellet

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APPENDIX B - GRANGER RAW DATA - POLLEN COUNTS

Sample	Depth m (from base)	Date	Picea	Pinus	Abies	Alnus	Betula	Salix	Cyperaceae	Equisetum	Artemisia	Poaceae
1	10.6		96	141	8	56	7	18	39	24	7	0
2a	10.3	1600+/-50	60	27	9	60	20	25	60	1	23	2
2b	10.3	1600+/-50	47	8	4	24	6	262	11	0	9	0
2c	10.3	1600+/-50	38	31	8	42	13	99	104	15	24	5
3	9.2		76	85	8	111	8	15	42	16	11	7
7	7.5		78	6	0	36	8	14	32	11	2	1
7c	7.5		28	5	1	20	15	35	206	0	14	1
10b	6		33	1	2	10	13	4	30	1	54	0
12	4.8		128	16	9	65	30	21	48	28	40	0
12b	4.8		61	0	1	26	4	15	35	1	45	0
15	3.7	3850+/-50	175	57	6	44	19	16	46	9	23	0
17	2.6	4780+/-80	174	5	4	55	32	8	67	16	21	2
18	2.3	7500+/-60	35	5	2	8	3	5	34	0	4	1
19	1.5	8330+/-60	55	3	5	55	40	17	154	19	28	19
20	0.7	7890+/-80	97	0	1	23	17	12	29	0	11	3
21	-0.1	7990+/70	29	0	1	12	339	1	24	2	9	0
21a	-0.1	7990+/70	24	2	9	16	310	3	32	1	12	0
21b	-0.1	7990+/-70	27	1	7	15	303	3	25	0	19	2
21c	-0.1	7990+/-70	70	2	18	44	102	1	81	1	47	0

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APPENDIX B - GRANGER RAW DATA - POLLEN COUNTS

Sample	Ericales	H. S. Aster	Epilobium	Polemonium	Pedicularis	Caryophyllaceae	Chenopodium	Callitriche	Unk Type B	Unk Type C	UnkType X	Unk Type F
1	1	0	0	0	0	1	0	0	0	0	0	0
2a	3	1	2	0	0	0	0	0	0	2	0	6
2b	0	3	0	18	0	2	1	0	0	0	0	4
2c	1	5	0	3	0	0	0	0	0	4	1	3
3	2	6	0	0	0	0	0	1	0	0	0	0
7	3	3	0	0	0	0	0	0	0	0	0	0
7c	0	32	0	1	15	1	0	0	0	0	1	25
10b	1	5	0	0	0	0	0	0	0	0	3	0
12	2	3	0	0	0	0	2	0	0	0	0	0
12b	0	60	1	1	0	1	0	0	8	0	9	16
15	2	2	0	0	0	0	0	0	0	0	0	0
17	5	1	0	0	0	0	0	0	0	0	0	0
18	0	1	0	0	0	0	0	0	0	0	0	0
19	1	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
21a	0	0	0	1	0	0	0	0	0	1	0	0
21b	1	0	0	0	0	1	0	0	0	0	1	0
21c	24	1	0	0	1	0	0	0	0	0	0	0

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APPENDIX B - GRANGER RAW DATA - POLLEN COUNTS

Sample	Claytonia	Saxifraga	Oxyria	Unk Type M	Unk Misc.	Indet.	Totals	Lycopodium	Comments
1	0	3	2	0	4	1	396	666	Some Pinus looks re-worked
2a	0	2	4	0	1	1	287	520	Individual pellet; Cyperaceae cluster
2b	0	0	2	0	2	4	371	189	Individual pellet; Salix clusters present
2c	3	0	4	0	7	1	379	138	Individual pellet
3	0	0	2	0	3	2	379	328	Some Pinus looks re-worked
7	0	0	0	0	0	0	188	490	Individual pellet
7c	1	0	0	0	1	0	325	396	Individual pellet; Pinus looks re-worked
10b	0	0	4	1	1	3	148	252	Individual pellet; 3 slides counted
12	0	0	4	0	4	1	385	562	Individual pellet; Lots of organic debris; some Pinus looks re-worked
12b	1	3	13	0	1	3	188	139	Individual pellet
15	0	0	0	0	0	1	395	1044	Some Pinus looks re-worked
17	0	1	1	0	7	3	384	1111	Some Pinus looks re-worked;some large, robust Alnus
18	0	0	0	0	0	0	97	544	Some Picea looks re-worked; high counts of bissacate fragments
19	0	0	1	0	0	0	395	865	Some Picea looks re-worked; Betula cluster present
20	0	40	0	0	0	0	193	783	n/a
21	0	0	0	0	0	0	417	47	n/a
21a	0	1	0	0	1	0	409	71	
21b	0	0	0	0	1	0	402	63	Several clusters of Betula present
21c	0	3	0	0	4	4	366	168	

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APPENDIX C - FRIDAY CREEK RAW DATA - POLLEN COUNTS

Sample	Depth	Date	Picea	Pinus	Abies	Alnus	Betula	Salix	Cyperaceae	Equisetum	Artemisia	Polemonium
1	88	460+/-60	58	105	8	11	12	66	60	35	12	5
1a	88	460+/-60	8	4	0	12	10	19	18	0	12	0
1b	88	460+/-60	20	22	1	7	4	83	78	7	7	6
1c	88	460+/-60	5	9	0	10	4	31	252	0	9	2
1d	88	460+/-60	3	1	0	12	11	50	45	2	8	1
2	83		76	113	2	10	10	42	106	2	10	5
2a	83		65	100	9	27	8	75	40	4	29	3
2c	83		55	39	14	36	18	50	115	9	26	1
3	80		53	177	17	21	18	29	12	28	12	0
3a	80		45	21	2	15	6	271	88	2	4	1
3b	80		29	41	3	23	11	39	126	2	24	15
3d	80		9	1	0	13	9	71	44	0	25	14
4a	77	1650+/-60	40	23	7	36	10	83	99	12	21	2
4b	77	1650+/-60	6	0	0	1	11	11	12	1	6	2
5	74		79	71	4	14	8	46	33	7	50	4
6	70		50	43	4	12	5	12	32	25	68	0
7	67	1660+/-50	93	30	5	19	4	48	37	87	18	1
7a	67	1660+/-50	9	0	0	13	10	22	32	0	66	5
9	61		48	10	7	31	141	36	26	2	67	1
12	50		60	28	1	14	5	67	42	26	6	23
12c	50		42	12	2	25	8	26	96	3	114	0
12b	50		11	0	0	22	8	18	27	1	22	1
12d	50		36	11	6	25	9	19	88	2	57	1
13	45		11	10	3	18	8	46	55	4	173	3
13a	45		2	0	0	6	1	7	9	0	51	2
13d	45		2	3	0	11	5	7	10	0	106	3
14	40	3550+/-70	14	1	1	11	15	27	50	9	246	2
14a	40	3550+/-70	21	2	1	27	21	19	32	0	47	9
15	36	3830+/-40	73	17	2	40	15	28	53	35	65	1
15a	36	3830+/-40	8	1	1	52	20	24	50	1	94	14
15b	36	3830+/-40	75	9	3	24	0	26	193	5	48	2
15c	36	3830+/-40	1	0	0	21	4	9	12	0	64	5
17	0	4200+/-80	104	3	1	150	14	30	28	33	21	1
17a	0	4200+/-80	98	11	13	88	18	37	73	0	37	1
17b	0	4200+/-80	45	1	1	51	18	47	65	0	53	7
17c	0	4200+/-80	67	4	8	59	27	46	78	0	38	0

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APPENDIX C - FRIDAY CREEK RAW DATA - POLLEN COUNTS

Sample	Poaceae	Ericales	H. S. Aster	L.S. Aster	Epilobium	Tsuga	Roseaceae	Caryophyllaceae	Chenopodium	Pedicularis	Unk Type B	Unk Type C
1	8	1	7	0	0	0	0	1	0	0	0	9
1a	0	1	24	0	2	0	0	1	0	0	0	0
1b	0	0	80	0	0	0	0	11	0	11	0	0
1c	0	1	31	0	0	0	0	4	1	6	0	0
1d	0	1	3	0	0	2	0	2	0	3	0	0
2	13	1	9	0	0	1	0	2	0	0	0	1
2a	0	0	17	0	0	0	0	1	0	17	1	0
2c	4	1	16	0	1	0	0	4	0	0	0	4
3	0	0	0	0	3	0	0	0	0	0	0	6
3a	0	0	6	0	0	0	1	0	1	22	1	0
3b	2	1	15	0	0	0	0	2	0	0	0	2
3d	0	2	67	0	2	0	0	8	0	1	0	0
4a	8	1	18	0	0	0	0	4	1	4	1	0
4b	1	0	21	0	0	0	0	1	1	0	0	0
5	7	4	8	0	0	0	0	1	0	0	1	5
6	0	0	11	3	0	0	0	0	0	0	0	1
7	2	0	10	0	0	0	0	1	0	0	0	4
7a	1	0	37	0	0	0	0	5	2	3	0	0
9	27	1	8	0	0	0	0	0	0	0	0	3
12	1	1	38	0	0	0	0	1	0	0	0	4
12c	11	0	15	0	0	0	0	5	0	0	0	6
12b	0	1	5	0	0	0	0	0	0	2	0	0
12d	2	2	6	0	0	0	0	0	0	0	9	6
13	10	2	8	0	0	0	1	2	0	0	3	3
13a	0	0	7	0	0	0	0	1	0	0	0	0
13d	0	0	30	3	0	0	0	1	0	0	0	0
14	10	1	8	0	1	1	0	0	0	0	0	13
14a	0	1	51	0	0	0	0	7	0	0	0	0
15	4	2	7	0	0	0	4	0	0	0	0	6
15a	0	0	65	0	0	0	0	1	0	0	0	0
15b	0	0	9	0	0	0	0	0	0	0	0	0
15c	0	0	13	0	0	0	0	1	0	1	0	0
17	0	2	6	0	0	0	1	0	0	0	0	4
17a	0	3	10	0	0	1	0	7	0	4	0	0
17b	2	2	36	0	0	0	0	2	0	1	0	0
17c	1	4	16	0	0	0	0	3	0	17	0	0

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APPENDIX C - FRIDAY CREEK RAW DATA - POLLEN COUNTS

Sample	Rannunculus	Unk Type X	Unk Type F	Unk Type G	Unk Type H	Claytonia	Saxifraga	Oxyria	Unk Type L	Rumex	Indet.	Unk Misc.
1	0	0	0	0	0	3	0	6	0	0	3	0
1a	0	41	6	0	0	16	0	5	0	0	13	2
1b	0	2	34	0	6	15	0	9	0	0	9	3
1c	0	1	3	0	0	16	2	4	0	0	7	5
1d	0	1	10	0	0	6	0	6	0	1	13	8
2	0	2	0	0	0	2	0	6	0	0	1	0
2a	1	11	2	0	1	0	3	9	0	0	8	3
2c	2	2	8	0	0	0	2	5	4	2	5	4
3	0	0	0	0	0	0	0	1	0	0	2	0
3a	0	0	0	0	0	1	0	0	0	2	6	9
3b	0	1	8	0	0	18	0	23	0	19	6	7
3d	0	4	0	0	13	21	2	6	0	0	19	7
4a	0	0	6	4	8	1	1	0	0	0	6	7
4b	0	4	2	0	0	0	0	1	0	0	4	0
5	7	19	0	0	0	4	0	0	0	0	3	0
6	24	0	1	0	0	6	0	0	0	0	0	0
7	0	5	5	0	0	1	0	0	0	0	5	0
7a	1	25	2	0	8	17	0	11	0	0	8	4
9	0	1	1	0	0	0	0	0	0	0	0	0
12	6	10	4	0	0	4	0	0	0	0	1	0
12c	4	9	0	0	0	12	0	13	0	0	5	6
12b	0	1	7	0	0	0	1	9	0	1	2	4
12d	3	4	3	0	0	4	0	6	0	2	9	4
13	0	13	0	0	0	6	0	4	0	0	1	0
13a	0	1	1	0	7	0	0	5	0	0	7	1
13d	0	33	0	0	0	1	3	1	0	2	6	0
14	0	3	0	0	0	2	0	0	0	0	0	0
14a	1	17	1	0	1	1	0	9	0	0	8	5
15	1	7	5	0	0	0	0	18	0	0	8	0
15a	1	6	7	0	0	3	1	43	0	0	13	0
15b	0	5	0	0	3	1	0	5	0	9	2	1
15c	0	2	0	0	0	0	1	0	0	0	4	0
17	0	0	1	0	0	0	0	1	0	0	1	0
17a	0	7	7	0	0	0	0	2	0	0	2	0
17b	0	28	12	0	4	0	2	1	2	3	12	2
17c	0	0	11	0	1	0	1	0	0	2	6	4

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APPENDIX C - FRIDAY CREEK RAW DATA - POLLEN COUNTS

Sample	Total	Lycopodium	Comments
1	372	168	Single pellet, Lots of organic debris
1a	83	408	Single pellet
1b	235	159	Single pellet
1c	322	176	Single pellet
1d	133	254	Single pellet; 3 slides counted
2	376	107	Lots of organic debris; Picea, Pinus possibly re-worked
2a	360	484	Single pellet, 3 slides counted
2c	363	299	Single pellet
3	367	522	Some Picea, Pinus look worn, re-worked, Alnus crumpled
3a	455	118	Single pellet;
3b	313	89	Single pellet, clusters of Unknown Type M
3d	186	167	Single pellet, 3 slides counted
4a	333	513	Single pellet, Some Alnus larger, more robust; Cyperaceae cluster, 3 slides counted
4b	50	152	Single pellet; 3 slides counted
5	316	180	Lots of organic debris in spots
6	251	566	Some nice Pinus
7	342	206	Single pellet, Some Pinus, Picea look re-worked, Alnus small, crumpled
7a	157	222	"chunk;" Cyperaceae cluster
9	369	534	Single pellet; Some Pinus looks re-worked; Salix cluster present
12	272	366	Single pellet; Some Pinus looks re-worked
12c	328	160	Single pellet
12b	110	642	Single pellet; 3 slides counted
12d	254	174	Single pellet
13	331	179	Single pellet; Cyperaceae cluster
13a	78	203	Single pellet; 3 slides counted
13d	147	342	Single pellet, 3 slides counted
14	376	132	Single pellet
14a	179	269	Single pellet; Lots of organic debris; Cyperaceae cluster
15	329	598	Single pellet; Some Pinus looks re-worked
15a	265	207	Single pellet; 3 slides counted
15b	385	79	Single pellet
15c	116	95	Single pellet; 3 slides counted; lots of organic debris and clumping
17	385	488	Some Picea looks re-worked
17a	376	361	Single pellet
17b	288	397	Single Pellet; 3 slides counted
17c	327	535	Single pellet; 3 slides counted

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