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HISTORICAL CLIMATOLOGY OF THE SOUTHERN YUKON: PALEOCLIMATIC RECONSTRUCTION USING DOCUMENTARY SOURCES FROM 1842-1852

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HISTORICAL CLIMATOLOGY OF THE SOUTHERN YUKON

Paleoclimatic Reconstruction using Documentary Sources from 1842-1852

by

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Abstract

Paleoclimatic research in Canada has largely focused on the use of physical proxy data, such as lake sediments, tree rings and ice cores. However, weather information from historical documents also has the potential to provide a wealth of climatic data. Historical documents offer many advantages over traditional physical proxies, including high temporal resolution and accurate dating. Journals from three Hudson's Bay Company (HBC) posts (Frances Lake, Pelly Banks and Fort Selkirk) in the southern Yukon Territory were analysed for weather. Climatic data were present in two forms: direct data (i.e. references to temperature, precipitation, wind and cloud conditions) and indirect data (i.e. ice activity, biological, human impacts and miscellaneous remarks).

A hierarchical coding scheme was applied to the journals, allowing for frequency counts of conditions. Weather information from the three journals was used to construct a seasonal warm/cold index for the period 1842-1852. The most common feature during the historical period was the dominance of mild winters throughout all years, which may be linked to the end of the Little Ice Age in the southern Yukon. As well, 1849 suffered from a six-month cold period. Historical temperature readings from the Frances Lake journals for the period December 1842 to May 1844 provided an alternative data source for verification of the index. Comparison of the historical temperature record to modern climate normal station data revealed that at least one of the months on record (February 1844) was warmer than any February from the 1971-2000 normal period. The number of precipitation days per month reported at the three posts was well below normal in the majority of cases. However, it is argued that this difference is due to a lack of transcription rather than a lack of occurrence.

Examination of the journals indicates that the weather did play a relatively important role in the posts' activities, at times hindering efforts to become self-sufficient. Frost activity during the growing season plagued farming operations and cold, windy winters hindered hunting. However, the weather was not the main reason that the posts had difficulties becoming self-sufficient. Unfamiliarity with the region and inadequate supplies from the HBC were the main culprits.

Acknowledgements

The idea for this thesis came from Ernest Shackleton's epic narrative "South: The Endurance Expedition" (1914-1916) which chronicled his crews' struggle for survival in inhospitable Antarctic waters. I found the book fascinating and full of detailed information on the environment, particularly the weather. This book gave me the idea of doing research that combined my interest in exploration literature with my education and experience in geography and climate change. In the end, my study area shifted from the extreme south to the Canadian North. The Hudson's Bay Company journals became my historical documents of choice and the Yukon Territory was substituted for Antarctica because it was one of the last regions to be explored in Canada.

This thesis is the culmination of independent studying and exploration into academia. It has given me the opportunity to grow more fluent in northern Canadian history and develop a passion for historical research that is blended with quantitative methods. At times, the work seemed frustrating and pointless, particularly at the half-waypoint, which I suspect is common in most graduate work. But I can safely say that I am more interested in the subject now, at the completion of this work, than I was at the beginning.

There are many people I would like to thank for their assistance during my graduate studies. My supervisor, Robert Gilbert, taught me to become very self-sufficient by letting me find my own way in the research field. His comments on the work and his broad knowledge of a myriad of topics were always helpful. I am also grateful to him for giving me the opportunity to take part in a once-in-a-lifetime expedition to Antarctica. It is a trip I will never forget and it allowed me to visit the icy Antarctic waters that Shackleton so grippingly wrote about. As well, I would like to thank the geography main office staff, Kathy, Shelia, Sharon and Joan. Their assistance has been instrumental in my successful navigation of Queen's bureaucracy. I would also like to thank the professors for whom I have been a Teaching Assistant in the department. Prior to coming to Queen's, I was adamant in my lack of desire to teach. However, my teaching experiences at Queen's have been the most surprising and rewarding part my graduate stay. I have developed a strong passion for teaching at the higher education level and I appreciate the opportunity to have worked with professors who have all helped shape my skills and opinions regarding the field.

The staff members at the National Archives of Canada, the Hudson's Bay Company Archives and the Yukon Archives were all incredibly generous with their time and assistance. In particular, I would like to thank the Yukon Archives' staff, who allowed me to become a permanent fixture at the archives during my stay in Whitehorse. Clara Rutherford was especially friendly and I thank her for introducing me to the Kopper Kettle restaurant! My office-mates, Brock and Kristie (aka "Pants"), who are also at various stages in their masters research, have given me some perspective on graduate studies and have provided a well-needed sounding board. Prior to their arrival, I was the sole occupant of my office and their company has been much appreciated!

Last but not least, I would like to thank my family for their support during my studies. My parents, both trained in the field of education, have instilled in me a strong desire to learn. Their support in helping me move to Kingston was very appreciated and their visits have provided much-needed distractions. My father proved himself to be a capable field assistant in the Yukon – his ability to navigate forests without a compass or GPS has made me believe he is a "geographer in hiding". My mother's ability to pack an arsenal of camping gear into two bags amazes me still to this day. I am also grateful for my parents' restraint in asking the

dreaded question: “How long until you are done?” (at least until the last four months of my program). I am thankful to my sister, Heidi, and brother, Nathan, for giving me a glimpse into their lives as full-time employees in the field of sales. It has shown me that, at times, academia and business are not all that different and that many of my academic skills are transferable to the real world. Their ability to occasionally forget my field of study or degree program has shown me that school itself is not the most important thing; rather, it is what you do with that knowledge.

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Chapter 1: Introduction

It has recently been announced that 2005 tied for the third warmest year in Canada since nationwide records began in 1948 (Environment Canada 2006). Globally, 2005 was the warmest year in over a century followed by 1998, 2002, 2003, and 2004 (NASA 2006). This warming trend, which has been seen both regionally and globally since the late 1800s, has sparked much debate as to its causes and precedence. Regardless of whether the warming is natural, anthropogenic or a combination of both, this rate of warming has not occurred for at least the last 1000 years (Jones et al. 1998; Mann et al. 1999; Houghton et al. 2001; Mann and Jones 2003).

Studies on global warming have emphasized the uncertainty associated with their findings and the need for further paleoclimatic studies to "fill in the gaps" (Bradley and Jones 1995; Houghton et al. 2001). In order to better understand this current warming trend, accurate time-series reconstructions of the highest resolution possible are needed. The majority of temperature and precipitation reconstructions have been based on natural or physical proxy data such as tree-rings, lake and ocean sediments, ice cores and corals. These physical proxies exhibit strong relationships with certain climate parameters, such as temperature, and can be used to reconstruct climatic time-series over a thousand years or more. However, the temporal resolution leaves something to be desired. At best, physical proxies can be used to reconstruct monthly or seasonal values, and often the resolution may only be at the annual level. So from where do we get high-resolution climatic data? The answer is historical documents.

Historical Documents in Paleoclimatology Research

The term "proxy" refers to any data (either man-made or natural) that measure climate indirectly (e.g. ice freeze up and tree-ring width are both temperature proxies). Historical documents offer two distinct advantages over physical proxies. First, they have the potential to offer climatic data in a higher resolution format, such as hourly or daily data. Second, historical documents have the ability to present climatic information in both direct and indirect formats. Direct references to include references to temperature (e.g. warm, cold) and precipitation (e.g. dry, wet). Indirect references are references to factors that are influenced by climate, such as ice break up and freeze up on rivers and lakes, fire activity, plant flowering, droughts and flooding. Historical documents have been highly exploited in certain regions such as Asia, Iceland, and Europe (Ko-Chen 1973; Ogilvie and Jónssón 2001; Bradzdil et al. 2005). They have been used to reconstruct climatic time series, including information on drought and flood frequency, and temperature and precipitation anomalies, as far back as 3000 BC (Ingram et al. 1981). However, the distribution of historical documents is uneven. Some regions, such as Europe and Asia, are very well represented. However, other regions, such as Africa and North and South America, are poorly represented, partially due to the shorter duration covered by historical documents and the difficulty in locating suitable material over a large region (Ingram et al. 1981; Wigley et al. 1981). Figure 1 illustrates the division between physical and man-made proxy data.

Canada is one of the regions that is lacking in paleoclimatic research using historical documents. Historical documents can enrich paleoclimatic time-series by increasing temporal resolution and improving accuracy. Comparatively, Canada is considered a younger region than Europe and Asia in terms of settlement by non-indigenous populations that produced written records. Consequently, the coverage provided by historical documents is much shorter. The earliest records are from the early seventeenth century and the majority commence in the eighteenth and nineteenth centuries. Despite this shorter temporal coverage, Canada has the potential to contribute significantly to the field of historical climatology. Early explorers and settlers produced numerous historical documents including early newspapers, letters, and diaries. Fortunately, some of those documents contain references to the weather.

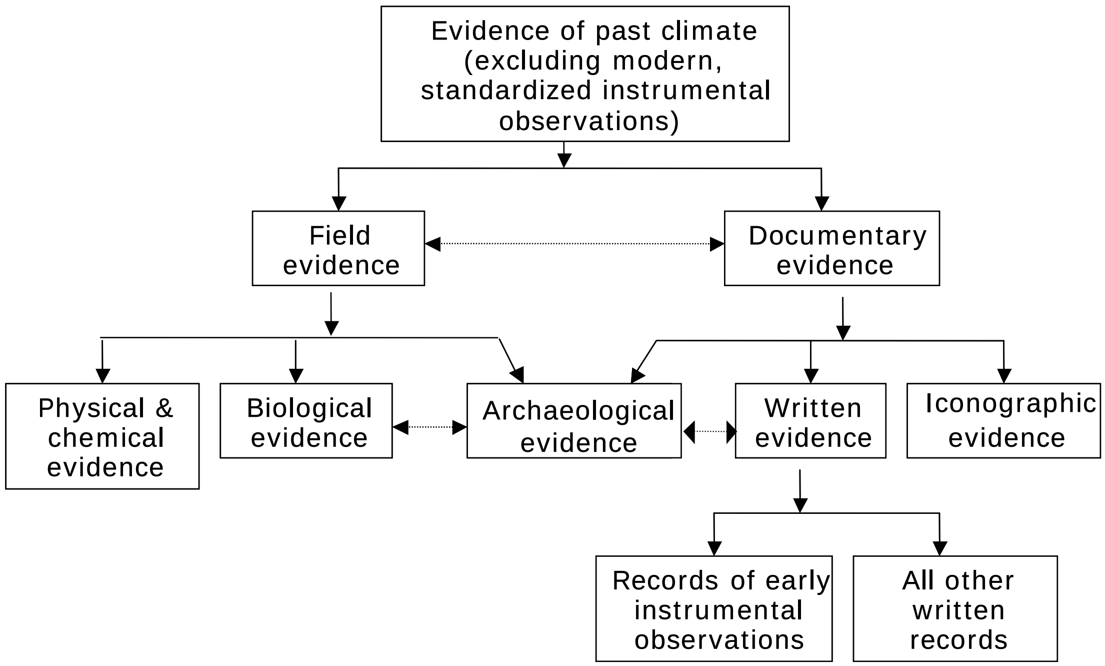


Figure 1: Categories of man-made (i.e. documentary) and physical (i.e. field) evidence used in paleoclimatic studies (from Ingram et. al. 1981).

Historical Climatology in Canada: The case for Yukon Territory

This study was undertaken to determine the effectiveness of historical documents in paleoclimatic research in the southern Yukon Territory. It is hypothesized that the Yukon Territory provides a unique opportunity for the application of historical climatology research in Canada. Paleoclimatic research using natural archives is relatively well established in the region because it offers sites that are both climatically sensitive and free from human disturbance. The climate history of the Yukon, particularly the last 500 years, is reasonably well defined from tree rings, lake sediments and ice cores (e.g. Briffa et al., 2002a, 2002b; Holdsworth et. al., 1992; Jacoby and D'Arrigo, 1989; Luckman and Wilson, 2005; Moore et. al., 2001, 2002; Wake et. al., 2002). However, there are still issues with the records in terms of resolution and accuracy, which historical documents may help resolve.

Documentary sources on the Yukon Territory commenced in 1825 when John Franklin first mapped the northern coastline in search of the Northwest Passage. The Territory was further opened up in the 1840s by the establishment of the Hudson's Bay Company's (HBC) fur-trading posts (Wright 1976). From the 1860s onwards, the region became more settled, particularly by Anglican and Protestant missionaries eager to convert the indigenous population. A gold find in 1896 at Bonanza Creek spawned a mass migration of gold seekers to the territory. Within two years, the population of Dawson City had increased to 16,000. The mass migration, as well as a dispute regarding the border between the territory and Alaska, encouraged the establishment of a police force in the region. The Northwest Mounted Police first arrived in the Yukon in 1895, establishing its first post at Forty Mile, north of present-day Dawson City (Wallace 2000). Figure 2 provides an overview of the HBC posts in the Yukon as well as early exploratory routes by Robert Campbell, Chief Factor of the HBC.

Focus was given to the southern Yukon rather than the entire territory for several reasons. First, the oldest historical documents for the territory are from in the southern half, south of 65^{o}N. As well, the majority of the documentary sources that contained the desired weather information are from the southern region. Second, paleoclimatic research in the southern region is well established using tree rings, lake sediments, and the Eclipse Icefield ice core. Thirdly, the entire Territory is quite large and not climatologically discrete (Wahl et al. 1997). It is unlikely that documentary sources from an area almost 500,000 km^2 in size would represent a coherent regional climatic signal, since authors would be recording only local weather conditions influenced by differences in latitude, elevation and topography. By narrowing the area of focus, it is hoped that there will be greater agreement between the weather information recorded.

Historical Documentary Sources in the Yukon

The historical record in the Yukon is shorter than most areas of Canada because it was one of the last regions to be explored. However, as outlined in the section above, there are many potential sources for historical documents beginning from 1840. Many different types of texts are used in historical climatology research. The most common texts are diaries, journals, letters, logbooks, government records and narratives. Additional sources include myths, ancient inscriptions, annals, chronicles, early journalism and private estate records (Ingram et al. 1981). The type of text under consideration can greatly influence the nature of the information contained within and the circumstances under which it was recorded. Table 1 outlines the major categories of the historical documents initially consulted for this study. Appendix 1 lists all the sources initially reviewed for the study. The type of text, time period coverage and a brief description of all the texts are provided in the appendix.

Over 80 sources from the National Archives of Canada (NA), the Yukon Archives (YA) and the Hudson's Bay Company Archives (HBCA) were initially consulted for the study. The texts included diaries, narratives, government records, letters and publications. The majority of the texts date from 1880 and later, when migration to the Yukon Territory increased, particularly due to the Gold Rush. Weather information was recorded within some of the texts, but numerous issues arose including location, duration, homogeneity, and motivation. For some of the records it was difficult to determine the exact location since the author was travelling as he recorded information (e.g. George M. Dawson, Charles Constantine and Otto Julius Klotz). In other instances, the length of the record was very short (e.g. a few months) or references to weather were not consistent enough for use in an individual reconstruction. The motivation of the author was also considered, particularly with regards to published accounts (e.g. government records, newspaper articles, books). Some authors may have exaggerated weather accounts to create a more entertaining

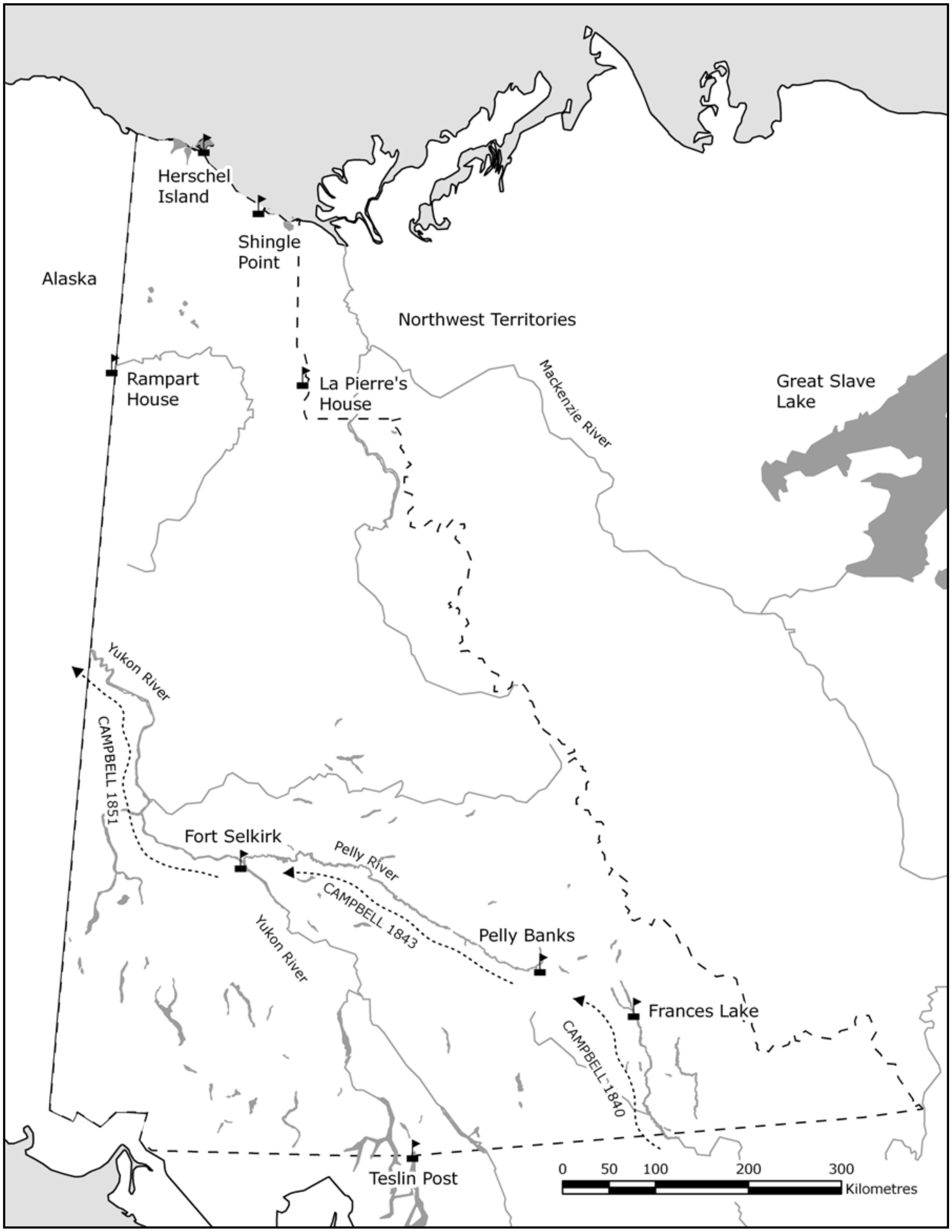


Figure 2: Early exploratory routes in the Yukon Territory and the location of the Hudson's Bay Company posts used in this study. The present-day Yukon River was known as the Lewes (or Lewis) in the Fort Selkirk journals.

picture of the Yukon. But the main determinant against using the majority of records was the time period. The earliest weather records began in 1842. However, there is a large gap in data from 1852 to the 1880s.

Table 1: Major categories of historical documents

Document Type	Examples	Period	Resolution
Official journals	NWMP posts (B division)	1898-1938	Daily
	HBC posts (southern Yukon)	1842-1851	
Personal diaries	Hugh S. Bostock	1897-1926	Daily, weekly or monthly
	Robert Campbell	1808-1851	
	Charles Constantine	1870-1908	
	George Dawson Mercer	1887	
	Otto Klotz	1866-1923	
Narratives	GSC		Monthly or seasonally
	Nevill Armstrong	1984-1926	
	Hugh S. Bostock	1897-1926	
	Lawrence J. Burpee	1697-1945	
Official correspondences	NWMP (B division)	1898-1938	Daily, monthly or seasonally
	HBC (southern Yukon)	1840-1851	
Private letters	Bishop William C. Bompass	1865-1900	Daily, monthly or seasonally
Early newspapers	Ben E. Ball	1899	Daily
	Bennett Sun	1899	
Government documents	Hugh S. Bostock	1898-1933	Monthly or seasonally
	White Pass and Yukon Route	1898	

Ultimately, only the earliest and most reliable records were used in the final analysis. These records are from three Hudson's Bay Company (HBC) posts: Frances Lake, Pelly Banks and Fort Selkirk. The majority of the Canadian historical climatology studies have utilized the wealth of environmental and weather-related information stored in HBC post journals (Moodie and Catchpole 1975; Moodie and Catchpole 1976; Wilson 1982; Rannie 1983; Wilson 1985; Wilson 1988; Ball 1995). These studies have demonstrated that the detailed, daily journals can provide both reliable qualitative and quantitative climate data. The three posts provide almost continuous daily weather data for the period 1842-1852.

Frances Lake

Frances Lake (Figure 2), also known as Fort Frances and Pelly Banks, was the first HBC post established in the Yukon Territory. The post operated for 10 years, but only the first four years of the post's operations are covered by the journals (HBCA B.73/a/1; B.73/a/2; B.73/a/3; B.73/a/4). After exploring the region in 1840, Robert Campbell established the post in 1842 at the fork of the east and west arms of Frances Lake in the southeast portion of the territory (HBCA B.73/a/1). The lake and post were named after Lady Frances Simpson, the wife of Sir George Simpson, a governor of the HBC (Voorhis 1930). The fort was successful during the time Robert

Campbell ran the post as its Clerk. However, in the late 1840s Frances Lake began to deteriorate under different leadership because Campbell was occupied with establishing Fort Selkirk and maintaining Pelly Banks. The post was abandoned in the winter of 1848/49, likely due to a lack of provisions and poor trading. By the fall of 1850, the fort had been rebuilt due to the efforts of James Green Stewart who worked closely with Campbell at Fort Selkirk (Campbell 1958). The post was dismantled in May 1851 and the remains were later burnt. The Frances Lake journals cover the period July 1842 to May 1846. The first half of the post's existence is well documented, with only one month missing (June 1843) entirely. The journals for the remainder of the post's duration have not survived.

Pelly Banks

Pelly Banks (Figure 2) was established in 1845. It was located on the east bank of Campbell Creek on the Pelly River. The post was less than 150 km from Frances Lake, allowing frequent travel between the two posts. Pelly Banks is not to be confused with Fort Selkirk, which at times was referred to by the same name, since the fort was established at the forks of the Pelly and Lewes rivers. Information on Pelly Banks is less abundant; the post journals are not held in the HBCA in Winnipeg, Manitoba but within the Robert Campbell fonds at the National Archives of Canada (NA MG19-A25). There is some confusion concerning when the post was established. Many sources cite 1846 as the start date. Robert Campbell's personal journal cites the spring of 1846 as the date when the first buildings were established at Pelly Banks for the purpose of trading (Campbell 1958). However, he also notes that in the winter 1842/43 he sent some of his men to Pelly Banks to build a house. The Pelly Banks post's journals, entitled "Journal of Occurrences at Pelly Banks 1845-1847", begin in October 1845. The first volume of the journal (from October 1845 to April 1846) overlaps with the last part of the Frances Lake journal. However, it is sparse at best, and likely represents Campbell's visits to the site prior to its establishment as a trading post. The second volume, May 1846 to April 1847, is considerably more detailed. Journals for the site are only available up to April 1847, although it is known that the post operated for a much longer duration since references to the post are made in the Frances Lake journals and in Robert Campbell's personal journals up to 1850. Pelly Banks suffered a notorious fate. On November 30, 1849, the post burned down; the men suffered starvation and some resorted to cannibalism (Campbell 1958).

Fort Selkirk

Fort Selkirk is the best documented HBC post in the southern Yukon. The post operated for 52 months and fortunately, post journals exist for the entire duration of the post's life (NA MG19-D13). Robert Campbell founded the post in May 1848 at the fork of the Pelly and Lewes (present-day Yukon) rivers (Figure 2). Campbell refused to refer to the post as "Fort Selkirk", instead using the name "The Forks" or the "Forks of the Lewes and Pelly" (Johnson and Legros 2000). The post was originally located on the east bank of the Yukon River, at the forks between the two rivers. In the spring of 1852, the post was relocated to higher ground on the west side of the Yukon River at its confluence with the Pelly due to flooding problems. The new site was approximately three kilometers south of its original position. The post was fraught with problems. Men at the Fort Selkirk post regularly suffered from a lack of provisions since the nearly 1800 km supply route from the HBC post Fort Simpson (Northwest Territories) via Frances Lake and Pelly Banks was too long. At one point, the post went 18 months without being resupplied. On August 22, 1852, Chilkat Indians, who resented the fur-traders' intrusion into their trading territory, attacked the post, forcing its evacuation. Despite Campbell's recommendation that the post be rebuilt, it was abandoned. The abandonment of Fort Selkirk marked the end of the HBC's influence in the southern Yukon Territory. Only the posts in the far north (Rampart House and La Pierre's House) operated during the nineteenth century. Table 2 outlines the basic details concerning the posts' duration of operations and records.

Table 2: Hudson's Bay Company post details for the southern Yukon Territory

Post Name	Location	Established	Closed	Journal coverage
Frances Lake	61° North 129° West	1842	1852	July 1842-May 1846
Pelly Banks	61° North 131° West	1845	1850	Oct. 1845-Apr. 1847
Fort Selkirk	62° North 136° West	1848	1852	May 1848-Aug. 1852

Climate of the Yukon

The climate of the Yukon is one of the most extreme and varied in Canada due to its topography and geographic location. Kendrew and Kerr (1955) and Wahl et al. (1987) both provide extensive analysis of the climate of the Yukon. In general, the climate is controlled by air masses from the west and the north. Warm, moist air from the Pacific moves eastward into the region. However, the St. Elias mountain ranges, which run along the western border between the Yukon Territory and Alaska, block the warmer, wetter air from reaching the interior. Cold, dry air from the Arctic moves southward into the Yukon, contributing to extreme winter conditions. Therefore, the climate is considered to be continental sub-arctic characterized by long, dry, cold winters and short, dry, warm summers (Kendrew and Kerr 1955; Wahl et al. 1987). Temperatures in the Yukon range from a high of 36.1°C in summer to as low as –60°C in the winter. In fact the coldest temperature ever recorded in Canada, -63°C, was in Snag on February 3, 1947. Annual precipitation also varies widely due to orographic effects. Table 3 outlines some climate parameters for selected climate normal stations in the Yukon Territory.

Wahl et al. (1987) divided the territory into nine climatic regions representing mesoscale climate. Frances Lake and Pelly Banks both fall within the Liard Basin climatic region. This region is characterized by moderate precipitation (400-600 mm annually) and has more days of precipitation than any other climatic zone. The summers are warm and the winters may experience protracted cold periods due to entrenched Arctic air masses. Fort Selkirk, which is located northwest of Frances Lake and Pelly Banks, is located in the Central Yukon Basin climate region (Wahl et al. 1987). Precipitation is this area is less than the Liard Basin region (300-400 mm annually) and it falls mostly in the summer. Temperatures are variable and extreme. Overall, the summers are warm and the winters may have severe, protracted cold spells.

Table 3: Climatic conditions for selected Yukon meteorological stations (based on 1971-2000 normal period)

Station Name	Annual average temperature (°C)	January* average temperature (°C)	July* average temperature (°C)	Annual precipitation (mm)
Whitehorse A	-0.7	-17.7	14.1	267
Teslin A	-1.2	-19.2	13.9	343
Faro A	-2.2	-21.5	15.0	316
Watson Lake	-2.9	-24.2	15.1	404
Mayo A	-3.1	-25.7	16.0	312
Pelly Ranch	-3.9	-27.5	15.5	310
Dawson A	-4.4	-26.7	15.6	324
Old Crow A	-9.0	-31.1	14.6	265

For all stations, January and July average monthly temperatures represent the coldest and the warmest months respectively for the year.
(Environment Canada 2004)

Meteorological Station Data

Environment Canada began collecting weather data in the 1840s in Canada. However, the earliest reliable instrumental records for the Yukon Territory commenced in Dawson City and Whitehorse around 1900, and records for the rest of the region start between 1920 and 1960. The records are too sporadic for a good spatial coverage and duration of particularly the earliest portions. The majority of Environment Canada's meteorological stations were set up in the mid-twentieth century. Since then, 122 stations have been established in the region, although not all the stations are currently active and numerous stations are in close proximity to one another. Table 4 outlines the temporal data coverage of 17 stations with climate normal data (1971-2000), while Figure 3 shows the location of all weather stations in the territory, regardless of whether the stations are currently active.

Historical Climatology: A Primer

The use of documentary data for paleoclimatic reconstruction falls under the branch of science called "historical climatology". Following Pfister et al. (2001), historical climatology is defined "as a research field situated at the interface of climatology and (environmental) history, dealing with mainly documentary evidence and using the methodology of both climatology and history" (Bradzdil et al. 2005). Historical climatology bridges the gap between traditional paleoclimatic research and environmental history. It uses man-made proxy data, such as written works, paintings and photographs as the primary source in lieu of physical proxies or field evidence. The three main objectives of historical climatology are as follows:

1. to reconstruct the temporal and spatial patterns of weather and climate prior to the period of modern instrumental records,
2. to investigate the impact of climate variability and extremes on past societies, and
3. to explore past discourses and social representations of climate.

(Bradzdil et al. 2005)

The focus of this study is on the first objective – the reconstruction of the climate of the Yukon prior the modern instrumental record, specifically from 1842-1852 (the duration of the posts' journals). The second objective is briefly explored as well, in order to investigate if and how the climate conditions during the posts' life affected operations.

Table 4: Climate normal stations for the Yukon Territory

Station Name	Latitude (deg)	Longitude (deg)	Elevation (m)	Coverage	Earliest data	Class
Beaver Creek A	62° 24' N	140° 52' W	649	1971-2000		B
Braeburn	61° 28' N	135° 47' W	716	1974-1995		C
Burwash Landing A	61° 22' N	139° 03' W	807	1971-2000	Oct. 1966	A
Dawson A	64° 02' N	139° 07' W	370	1976-2000		B
Faro A	62° 12' N	133° 22' W	717	1977-2000		C
Johnsons Crossing	60° 29' N	133° 18' W	690	1971-1995		C
Komakuk Beach A	69° 35' N	140° 11' W	7	1971-1993		C
Mayo A	63° 37' N	135° 52' W	504	1971-2000	Jun. 1925	A
Mayo Road	60° 52' N	135° 10' W	655	1983-2000		D
Old Crow A	67° 34' N	139° 50' W	251	1971-2000	Sep. 1951	B
Otter Falls NCPC	61° 02' N	137° 03' W	830	1980-2000		C
Pelly Ranch	62° 49' N	137° 22' W	454	1971-2000		A
Shingle Point	68° 57' N	133° 17' W	49	1971-1993		C
Teslin A	60° 10' N	132° 44' W	705	1971-2000	Oct. 1943	B
Watson Lake A	60° 07' N	128° 49' W	687	1971-2000	Oct. 1938	A
Whitehorse A	60° 42' N	135° 04' W	706	1971-2000	Apr. 1942	A
Whitehorse Riverdale	60° 43' N	135° 01' W	643	1971-2000		B

Class "A": No more than 3 consecutive or 5 total missing years between 1971 to 2000.
Class "B": At least 25 years of record between 1971 and 2000.
Class "C": At least 20 years of record between 1971 and 2000.
Class "D": At least 15 years of record between 1971 and 2000.
(Environment Canada 2004)

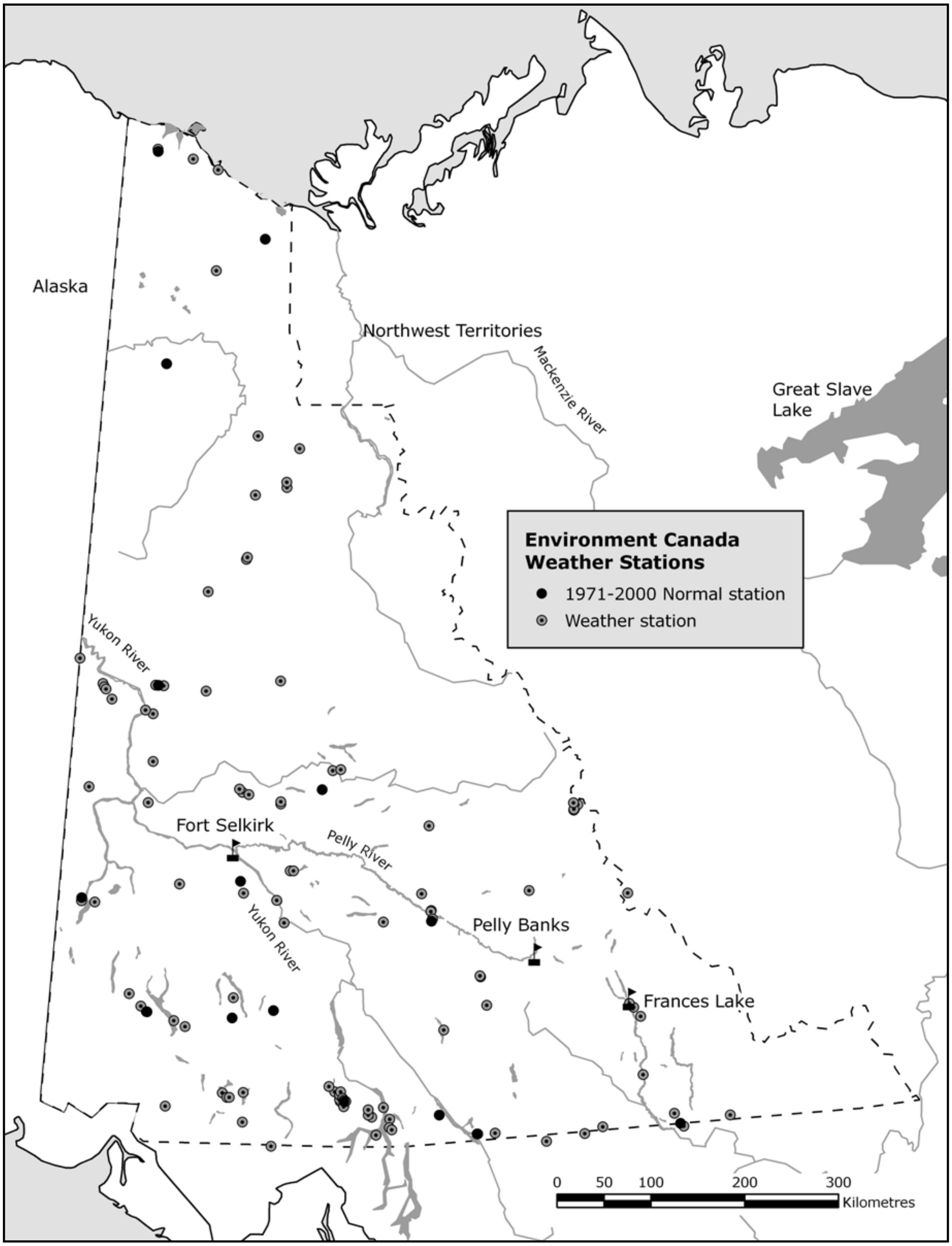


Figure 3: Environment Canada meteorological stations in the Yukon Territory that are currently operating or have operated at some point in the past.

Chapter 2: Literature Review

> *"Climate is a function of time. It varies; it is subject to fluctuations; it has a history."*
>
> Emmanual Le Roy Ladurie,
> Times of Feast, Times of Famine

Historical climatology attempts to extract the climatic history of primarily the last 1000 years, as well as to investigate the impact and discourse of climate on society at that time. From the outsider's perspective, it appears that this field can be approached in two different ways: by historians who are interested in the role of climate on past societies, and by climatologists who are interested in what past societies can tell us about the climate. This difference in approaches has the ability to diminish the potential impact of historical climatology on the field of paleoclimatology. Whereas historians tend to understand primarily the context of the climate information that is stored in historical texts, climatologists instead focus on the climatic information without regards to critical historiography. Consider the following quotations:

> "Cold & hard frost last night blowing & snowing & miserable in the extreme... Nothing but starvation all over."
>
> (Fort Selkirk - May 5, 1851)
> (NA MG19-D13)

It could be argued that a climatologist familiar with normal weather conditions for the region would interpret this quotation as an indication of an abnormally cold spring due to the references to cold, frost, snow and starvation. However, a historian may interpret the comment quite differently, taking into consideration the context of the comment. What is the writer's health and housing conditions at this point? A poorly made shelter and a sickly writer may feel the cold more than a healthy, well-housed man. Also, was the writer provided with adequate food supplies at the onset of the season? If not, the starvation may be attributed to inadequate supplies, not an abnormally cold winter and spring. Thus, it is only when both the climatologist's and historian's approaches are combined that the most reliable interpretation can be made.

The Evolution of Historical Climatology

The use of historical documentary data for climatic reconstruction was first introduced by Brooks (1926). Research interest in historical climatology grew in the 1960 and 1970s, in part due to the realization that the climate of Earth was not a constant factor but was ever-changing. Concerns about anthropogenic impacts on climate led to an increased interest in the climate of the Holocene. An early pioneer in this field was Hubert Lamb, whose seminal book, *Climate History and the Future* (1977), solidified the link between paleoclimatic research and future predictions of climate. Much of the initial focus in the field of historical climatology was on locating and assessing suitable historical texts located within libraries, archives and personal collections. As well, researchers began to create databanks of documentary and natural information, most notably the EURO-CLIMHIST (Pfister and Dietrich-Felber 2006). Early in the creation of the field, researchers called attention to the need for a standardized approach for analyzing documentary data (Bell and Ogilvie 1978;

Ingram 1978). However, the uniqueness of historical texts and the various types of information stored within often requires researchers to either adjust existing methods or to adopt new practices for interpretation.

The early stages of historical climatology research focused on qualitative approaches resulting in descriptive narratives of climate. As a result, the research was often relegated to supplementary information, used only as an after-thought when natural proxy data were unavailable. Ingram et al. (1981) commented on one of the main problems in this type of work. Scientists have "had to learn the painful lessons in the use of historical records, while historians themselves … have been slow to volunteer their expertise" (Ingram et al. 1981). Moodie and Catchpole (1975) further elaborated on this dichotomy between scientist and historian, stating:

> … in exploring the historical past… the scientist must resort to entirely different and unfamiliar kinds of evidence. In doing so, he must pose his questions in a way that are more akin to those of the historian than those of his colleagues. Like those of the historian, his questions must be formulated with as much regard for the nature of the evidence as for the problem under investigation. To the historical scholar … the questions of the environmental scientist are often crude instruments in a very delicate surgery. (p. 4)

Fortunately, both historians and climatologists recognized this gap and have made a concerted effort to examine historical texts with an eye to the past, taking into account as many externalities as possible (Moodie and Catchpole 1975; Ingram et al. 1981; Jones et al. 2001). Problems in different research strategies began to decrease because new methodologies, with which natural scientists were more comfortable and familiar, were developed. In the 1970s, content analysis was borrowed from the social science field as a method that could be used to transform the written word into a number (Moodie and Catchpole 1975; 1976). Content analysis is used to determine the presence of words or concepts in texts as well as break down materials into manageable categories and relations that can be easily quantified and analyzed (Weber 1990). Methodological tools such as these lent credibility to historical climatology research but there was also a downside. The intense focus on quantification of written records led, at times, to a decrease in analysis. Papers concentrated on the production of graphs, charts and distribution tables without a strong focus on interpretation and its problems. However, this quantitative focus was the much-needed first step in the quantification of written records, which allowed comparison of results. Ultimately it facilitated the integration and comparison of natural and man-made archives. In the 1980s and 1990s, historical climatology work began to focus on both a qualitative and quantitative interdisciplinary approach. Publications began to multiply that focused on excerpts from written records including the form and type of information transcribed, as well as the nature and style of the texts themselves (e.g. Ball 1995; Rannie 2001). Gradually the rules for critical historiography have been refined in an effort to establish a baseline for reliable and objective analysis of all historical evidence for historical climatological research (Jones et al. 2001).

Methodologies in Historical Climatology

One of the major contributions of the historical climatology literature is the development of robust and standardized methodologies that can be applied to historical documents from all regions. The methodologies employed with historical data are not as straightforward as for physical proxy data. The individuality of each historical document calls for a unique approach. However, the methods employed should be applicable in some form to other historical documents in order to demonstrate validity and comparison of results.

There are numerous methodological tools that can be employed to extract climatic information from written records. Content analysis, as indicated previously, is a common tool and has its roots in the social sciences. Content analysis is used to determine the presence of words or concepts in textual, audiogenic or iconographic sources. Extracted measurements can be used to make valid inferences about information presented in the text and about the writer, the audience and the culture in which the text was written. There are two main categories of content analysis: conceptual (or thematic) analysis and relational (or semantic) analysis. Conceptual analysis determines the presence and frequency of concepts and often generates "frequency counts". Concepts can be represented by individual words, phrases or collections of words. Relational analysis goes beyond conceptual analysis in that it examines how identified concepts are related to each other within the texts. It has also been called contingency analysis and is described as asking "…not how often a given symbolic form appears in a text, but how often it appears in conjunction with other symbolic units" (Weber 1990). The greatest strength of content analysis is its ability to convert historical observation into numerical form, which facilitates comparison with contemporary data sets. Content analysis permits the application of mathematics and statistics to historical texts, thereby lending credibility to sources that have been often overlooked or discredited in the past.

The first application of content analysis in environmental research was by Moodie and Catchpole (1975; 1976). The authors used this method to identify dates of freeze-up and break-up of estuaries on Hudson Bay from 1714-1871. The dates were derived from daily journals kept by personnel at the Moose, Albany, Hayes and Churchill outposts of the Hudson's Bay Company. The researchers went to considerable length in outlining the appropriate methodology for content analysis in environmental research and their report provides a useful basis on which further studies were modelled. Moodie and Catchpole identified stages that are helpful when employing content analysis. It is important to note that these stages are not sequential or independent of each other, and thus require the researcher to carefully consider many factors before fully using the content analysis. Generally, the stages are:

- identify theoretical framework of reference and historical sources,
- identify contemporary and historical standards and norms,
- identify the question,
- resolve the question into categories,
- perform unitizing and coding,
- test reliability on sample data set,
- operationalize the content analysis, and
- test validity.

Content analysis is not the only quantitative methodological tool used in historical climatology. Frequency curves and distribution tables are often utilized and require many of the same procedures used in content analysis. These methods require categorization of information. For example, using documentary sources Rannie (1999) developed runoff categories of very low, low, normal high, very high and unclassified in his reconstruction of floods in southern Manitoba prior to 1870. Categorizations are useful but must be thoroughly researched and explained. Distribution tables are valuable tools as well, since they illustrate temporal changes. Rannie (2001) used this technique in his study of grass fires in the Canadian prairies prior to 1870.

The creation of temperature and precipitation indices is one of the more common applications of quantitative analysis in historical climatology (Pfister 1980; Nicholson 2001; Nash and Endfield 2002). Thermal (warm/cold) and precipitation (wet/dry) indices have been developed with regards to many of the rules of content analysis. Indices are particularly useful when converting qualitative references to quantitative measures because the indices themselves are relative in nature and can take a variety of factors into consideration. Generally, indices range from negative to positive values with a value of zero reflecting normal conditions. One of the drawbacks of an index is that a certain amount of subjectivity is involved in its construction and therefore researchers must strictly outline the criteria used. Unfortunately, some authors fail to provide sufficient information to duplicate the methodology in other studies.

Regardless of the methodology chosen, it is advisable to incorporate both qualitative and quantitative data and present the finding in both ways. Extensive use of quotations can help illustrate the exact conditions experienced by the authors and serve as a reference point for the quantification of texts (Ogilvie and Jónssón 2000; Nordli 2001; Rannie 2001). Indices alone lose meaning unless they are put into context.

Studies in Historical Climatology

Extensive work with historical documents has been conducted in Iceland, Europe and Asia. The focus of the work has been on the discovery, validation, analysis and compilation of texts. The benefit of conducting work in these regions is that the historical records extends much farther back in time compared to Canada (Table 5). The oldest reconstructions based on written records date back to 1000 BC in China (Fang 1993). Reconstructions in Iceland and parts of Europe date back to 1000 AD (Ogilvie and Jónssón 2000), while reconstructions in Canada have extended the climate record only 300 years into the past (e.g. Ball 1995; Catchpole 1983). Historical climatology research in Iceland, Europe, China and Africa has also devoted more time to exploring the impact of the climate on society. Such research is sorely missing in Canadian studies.

Table 5: Earliest written records by region

Area	Earliest date
Egypt	3000 BC
China	2500 BC
Southern Europe	500 BC
Northern Europe	0
Japan	AD 500
Iceland	AD 1000
North America	AD 1500
South America	AD 1550
Australia	AD 1800

(From Ingram et. al. 1981)

Historical climatology research in Canada is relatively young. The first studies were published in the 1970s (Moodie and Catchpole 1975; 1976). During the 1980s, the number of Canadian studies published increased. However, since then progress appears to have lagged in comparison to work from other regions. The limited work published in the 1990s seemed split between reviews of previous work (e.g. Ball 1995; Catchpole 1995) and new forays into the field (e.g. Kay 1995; Rannie 1999, Slonosky 2003).

The majority of Canadian studies have focused on the climatically sensitive Canadian North, which is the source of some of the earliest documentation of Canadian environmental conditions. A number of studies have demonstrated the applicability of HBC records, both post journals and ship logbooks, in historical climatology. Historical documents have been particularly useful for providing information on river freeze-up and break-up in the Canadian north (Mackay and Mackay 1965; Moodie and Catchpole 1975) as well as the Red River in Manitoba (Rannie 1999). Moodie and Catchpole's reconstruction of freeze-up and break-up dates of four Hudson Bay estuaries indicated that the historical dates were not inferior in quality to those obtained through the modern meteorological station record. Unfortunately, the authors did not relate the freeze-up and break-up dates directly to climate (i.e. temperature). Ball (1995), however, did use both early instrumental records and historical information from two HBC posts in Manitoba to create indices of mild and cold winters for the western Hudson Bay for 1715-1850. Despite a lack of information on the type or location of weather instruments used at HBC posts in the Hudson Bay region, early instrumental records were shown to pass the quality control procedures used on modern Atmospheric Environment Service data (Wilson 1982).

Ship's logbooks from the Canadian north have been a source of climate information. Mariners were particularly concerned with environmental and weather conditions and took detailed hourly and daily readings of wind, water and weather conditions. Unfamiliarity with the climate could cause delays in delivering personnel and shipments or, worse, result in loss of life. As well, it was common for expeditions to include scientific personnel whose role was to properly document new environments, which included weather observations and flora and fauna samples. Catchpole and others extensively used HBC logbooks for determining summer sea ice severity for the Hudson Strait and the Hudson Bay from 1751-1899 (Catchpole and Faurer 1983; Catchpole and Halpin 1987; Catchpole and Hanuta 1989). Kay (1995) examined early instrumental records from William Parry's 1822-23 expedition, in which his ship was frozen in ice near the modern-day weather station at Igloolik, Northwest Territories. Overland and Wood (2003) examined logbooks of 44 western Arctic expeditions from 1818-1910. Kay (1995) and Overland and Wood (2003) found that the weather conditions fell within the range of the modern climate.

A few studies have also demonstrated the value of other environmental data in addition to the traditional ice studies. Ball (1983) used the spring migration dates of geese as an indicator of climate change in the Hudson Bay region from 1714-1825. Geese migration was found to be a function of southerly or tail winds and an indicator of the onset of spring. However, Ball did not discuss how variations in arrival dates reflected changes in the onset of spring. Historical data on flooding activity in the Red River valley (Manitoba) have been used to better understand precipitation regimes prior to 1870 (Rannie 1999). Historical accounts of grass fire in southern Manitoba were used to develop a hypothesis of a Great Grass Fire Era (late 1700s to late 1800s) linked to strategic burning and dry conditions (Rannie 2001).

Advantages and Disadvantages of Documentary Data

Traditional paleoclimatic research in the Yukon has focused on physical proxies such as tree rings, lacustrine sediments, and ice cores because the climate signal is relatively well defined and quantifiable. However, physical proxies do have limitations, which can be overcome by using documentary data. The temporal resolution of physical proxies can vary widely. Tree rings and varves can provide information on the seasonal scale, but some lacustrine sediments and ice cores may only have a temporal resolution of years to decades. Documentary data, such as a daily weather journal, can have a temporal resolution of minutes or hours, although daily data are more common. This high temporal resolution is unique to documentary data and allows it to capture short-term, extreme climatic events that may be missed in physical proxy data. The capturing of extreme events by documentary data is particularly important, since global warming is anticipated to increase both the frequency and magnitude of extreme events (Houghton et al. 2001).

Documentary data can allow highly accurate dating of events. Written records, such as personal and official journals and letters and early newspapers often associate events with exact dates. Dating of physical proxies must rely on radiometric measures such as ^{14}C, ^{210}Pb or ^{137}Ce or on the presence of time-stratigraphic markers such as tephra. These dating techniques are not exact and may result in dating errors that exceed 50 years (Bradley and Jones 1995).

Generally, physical proxies are limited to a seasonal climatic signal for only a few climatic parameters. Tree-ring growth in the Yukon has been linked to summer temperatures, degree days and precipitation (Fritts 1976; Jacoby et al. 1985; Szeicz and MacDonald 1995; Youngblut and Pisaric 2004). Ice cores from the Yukon's Mount Logan and the Eclipse Icefield are associated with synoptic pressure patterns, summer temperature and winter accumulation (Holdsworth et al. 1995; Wake et al. 2002). In contrast, documentary data have the potential to provide information on a multitude of climatic factors in two categories: direct and indirect data (Ingram et al. 1981).

Direct data includes reference to actual climate parameters, such as temperature and precipitation. These references can be qualitative (e.g. "Weather warm and sultry." Frances Lake, June 28, 1844) or quantitative (e.g. "Weather remarkably warm. Thermometer rose to 83 [ºF]." Frances Lake, June 14, 1844). Indirect documentary data refer to the impact of the weather either on the environment or mankind. Indirect references may include information on ice and frost activity, vegetation, and bird migration. This availability of both direct and indirect sources allows a larger variety of climatic data to be extracted from documentary sources than physical proxies. Documentary data also allows for the easy separation of climate parameters from one another. An author can state whether is it warm or rainy, thus identifying the associated climatic parameter. But in the case of some physical proxies, the climate signal may be entangled with other climatic parameters.

Yet, documentary data do have their pitfalls. Often the data are not continuous. For example, the summer months for the HBC posts encompassed the time when the men left the post to explore the surrounding area, delivered the furs amassed during the previous year to a central post (Fort Simpson) and collected new supplies for the upcoming year. As a result, daily entries for the summer months may be lacking at the beginning or end of the month or an entire month may be missing (e.g. Frances Lake, June 1843). Also, documentary data for a site may be available for only a short time period (e.g. one month). Discontinuous data are also a problem for physical proxies as well. Reconstructions for a specific location or a region cannot be performed using written sources that are largely non-continuous or a single source that is very short in duration.

One of the most problematic issues in historical climatology is the lack of an overlap period between the documentary data and the modern instrumental record. Generally, the onset of modern weather station data simultaneously heralds the end of the written descriptive record. This is also the case in the Yukon. The introduction of Environment Canada weather stations in the region in the early and mid-twentieth century resulted in a lack of descriptive (i.e. qualitative) weather data. Without an overlap between the historical and modern record, the calibration and verification procedures that are normally applied to physical proxies are meaningless. Without the overlap period, it is very difficult to quantify the descriptive historical data in a manner similar to physical proxies. Because of the lack of an overlap period, the quantification of the HBC journals from the southern Yukon posts is somewhat limited.

Issues to Consider

The greatest limitation in using documentary data for paleoclimatic reconstruction is the author. The objectivity of the author is paramount and without it, the validity of reconstructions is called into question. The rules of critical historiography require that as much attention be paid to the nature of the writer and the environment in which he or she is writing, as to the details he or she is recording. Written documents at best can be considered highly objective records, likely in the case of ship's logbooks, or at worst, highly subjective material, such as personal letters. However, in order to determine the subjectivity of a record, one must consider many questions, including (Ingram et al. 1981):

- What is the text format?
- What or whom was the text written for?
- How was the text written? Where? When?
- Who is the author?
- What is the social background to the text?

This list is by no means definitive but it does raise major issues that one must take into consideration when reading and analyzing historical documents for any type of information, including climate data. How the sources used in this study stack-up relative to these questions is addressed in Chapter 3.

Researchers much also consider the issues of contemporaneity, propinquity, faithful transmission, and dating when consulting historical documents (Ingram 1978). Contemporaneity addresses the issue of whether the author is writing about an event that has occurred in his or her recent memory or the distant past. Generally, journals, logbooks and narratives are contemporary sources. In the case of the HBC posts, all of the authors were recording information on what could be considered a daily basis due to the specific information on weather that was recorded, such as wind direction and strength.

Propinquity refers to whether the author was writing about an event that occurred near to him or far away. This issue is partly addressed in the question of faithful transmission. Is the author writing from first-hand experience, or from an interview of someone with first-hand reports? If the author is writing about an event that occurred far away from him but has spoken to someone with a first-hand account, then reliability may not be as poor as if the author was recording an event from information obtained by hearsay or other less reliable written records. The journals of the three HBC posts under consideration were all housed at the posts and men who actually resided there made entries. However, there is some debate concerning the later entries of Fort Selkirk's journals, which is addressed in Chapter 3.

Another dimension of dating is also a key issue. Researchers must recognize when using multiple sources that the same event may be recorded by different authors with different dates, names and varying descriptions. This is especially important when attempting to reconstruct the occurrence of extreme weather events like floods and snowstorms. Since extreme events are rare, they are likely to have a greater impact and be noticed more. Thus, the written record may reflect a bias to such events. Researchers must pay close attention in order to avoid omission or replication of events, as well as the inclusion of events for which there is no reliable information. The issue of dating is particularly relevant to the HBC journals. The dates for each entry are faithfully recorded, although there are instances when an incorrect date is recorded- likely due to forgetfulness on the author's part. These errors are easy to rectify by considering the dates of the entries before and after the incorrectly dated entry. Table 6 summarizes the advantages and disadvantages of historical documents in paleoclimatic research.

Table 6: Advantages and disadvantages of historical documents

Advantages	Disadvantages
High time resolution	Not always continuous
Separation of weather/climate parameters	Restricted to only simple mathematical elaboration and interpretation
Accurate dating	May cover a very short time period
No seasonal restrictions (data available throughout the year)	Terminology not well defined (e.g. What does "cold" mean?)
Both direct and indirect reference	Hard at times to determine exact location
Highlight on extreme conditions	Author not always objective

Study Niche

Researchers such as Ball, Catchpole, and Rannie have demonstrated the usefulness of HBC records in historical climatology. However, all of these studies were based on the long-term (i.e. more than 50 years) and, at times, concurrent records. The challenge of this project is to apply their methodologies to a much shorter-term record (10 years). Little work has been published using short-term records. Kay's (1995) work on the early meteorological record of William Parry's had the advantage of access to an early temperature record. Slonosky's (2003) work on the weather diary of Jean-François Gaultie of Quebec covers the short time period of 1742-1756. But the work is primarily based on daily temperature records, not qualitative weather references. Only one of the three HBC post journals examined for this study contains a temperature record and it spans approximately 18 months (December 1842 to May 1844).

In Canada, there are a limited number of studies that have used historical documents as the primary paleoclimatic archive; generally written records have been used in a supplemental manner (e.g.Gilbert and McKenna Neuman 1988). Ball (1995) did the reverse and used tree-ring data for comparison to his historical data set. Regardless, paleoclimatic research is strengthened by the incorporation of both physical proxies and man-made archives. The limitations and advantages of each method complement the other. But the majority of studies in Canada have used physical proxy archives, while only a handful have used historical sources (e.g. Moodie and Catchpole 1976; Catchpole and Faurer 1983; Rannie 1983; e.g. Ball 1995). These studies have demonstrated the successful application of historical climatology research in a country with numerous untapped sources.

Jones et al. (2001) caution that the research effort in the field has possibly declined since 1979 compared to work produced using natural proxies. This decline may reflect the time it takes to become proficient in the languages of the past and the effort needed to acquire the experience to interpret the “significance of historical records in the correct social and contemporary context.” Also, the assessment of records in some of the most studied areas may offer up fewer clues. The need now is to move research to geographical areas that have not been exploited, such as South America, Africa and North America.

A Note on Terminology: What does “Historical” Really Mean?

The field of historical climatology has been subject to debate over terminology. A brief review of the debate is given in order to establish the use of terminology for the study. Le Roy Ladurie (1971) introduced the term “documentary evidence” in reference to human records, while Lamb (1977) introduced the term “historical evidence” in reference to information contained within historical written documents. Currently, the term “historical” has a much broader meaning. It does not just reference written material but also to iconic and pictorial sources.

A number of researchers now argue that the term “historical climatology” has a broader meaning and refers to both human-made and natural proxy data used for climatic reconstruction prior to the period of instrumental observations (Pfister et al. 1999; Bradzdil et al. 2005). They argue that the term has been misused and employed as a synonym for time-series analysis and even instrumental data (e.g. US Historical Climatology Network, Canadian Historical Climate Dataset) and it should be abandoned until a new, more reflective term is accepted. This researcher’s view of the current body of literature is that the terms “historical climatology” and “historical data” have been used predominantly to refer to historical documents, not other paleoclimatic physical proxies. For this study the terms “documentary data/sources” and “historical data/sources” are used interchangeably to refer to written information that may contain climate-related information. Natural archives or physical proxies refer to paleoclimatic proxies such as tree rings, lake and ocean sediments, ice cores and corals.

Chapter 3: Methodology

There are at least five steps required for analysing documentary data. The first step involves investigating the reliability of the texts by applying the rules of critical historiography. Second, one must categorize the data into direct and indirect measurements of climate. Subcategories must be developed in order to understand the nuance of the data available. Third, the categorized data may be quantified using monthly, seasonal and annual frequency counts, averages and totals. Fourth, if possible, the data should be combined into climatic indices highlighting normal and extreme periods. Finally, the data must be viewed in light of the current climate normal period (1971-2000) if possible. It should be noted here that all quotations from the post journals presented in this paper are left in the original format. No editing, other than the insertion of the occasional word or phrase for clarity or the truncation of a sentence, has occurred.

Part 1: Establishing Reliability: Who, What, When, Where & Why

For this study the official journals of three Hudson's Bay Company (HBC) posts, Frances Lake, Pelly Banks, and Fort Selkirk are considered (HBCA B.73/a/1 -4; NA MG19-A25; NA MG19-D13). In order to use the weather information stored within the post journals, the reliability of the texts must be established. In other words, one must determine:

- Who was the author?
- What did they write about?
- When did they write?
- Where did they write?
- Why did they write?

Once these questions are addressed and the rules of critical historiography are satisfied, the texts can be used for paleoclimatological research.

Official post journals were used to record daily events at each post, including work performed by employees, visits and trading by natives, and the weather. The senior officer (i.e. the post master) at the post maintained the journals. If the senior officer was away, the next senior-level employee took over the duties. The majority of the journals were signed and dated at the end to signify that the senior officer had reviewed and approved the entries. Post journals were usually split into volumes. Each volume represented an outfit year, which commenced in the summer or early fall and ended in the following spring or summer. The end of the journal heralded the time when the furs collected for the year were transported back to the main post for shipment overseas. For example, Frances Lake Outfit 1843 covered the period July 1843 to May 1844 (HBCA B.73/a/2).

Why?

The HBC had a vested interest in the accuracy of the post journals. The information contained within, whether it was references to weather, trade or descriptions of the surrounding territory, gave the HBC the advantage in controlling the fur trade. Also, maintaining posts in new territories was expensive both in terms of supplies and life, particularly in the northern posts where the inhospitable climate and improper planning could spell disaster. Ball (1995) noted that “Familiarity [with the weather] came from the all total control the weather had upon their lives”. The weather controlled animal numbers, hunting success and the fur-trade. It affected the how, when and where of transportation. But at the most basic level, it determined the food supply. Poor weather conditions influenced hunting and fishing, the transport of supplies from other posts and ships, and the agricultural activities at the posts. The HBC desired each of its posts to be self-sufficient. To ensure the success and self-sufficiency of the posts, it was imperative that the company and its men had as much knowledge of the region as possible. Thus, the company instituted specific policies that required its servants to keep detailed entries, which were submitted regularly to the Governor. Employees who did not make detailed entries were chastised.

Although no direct reference has been found in the three post journals under examination to indicate what specific instructions were given to the HBC authors regarding the information to be recorded, it can be assumed that the journals were treated as official documents and held to a certain standard. Information contained within other earlier HBC posts, such as York Factory, Moose Factory, Churchill and Cumberland House (Ball 1995), provide supporting information for the reliability of the post journals from the Yukon. In the early days of the expansion of the HBC into Canada, the company specified what information should be recorded in both its post journals and ship’s logbooks. It could be postulated that by the time the posts in the Yukon Territory were established, the practice of maintaining journals was so engrained in the company that specific written instructions were not supplied to the post masters, such as Robert Campbell.

The procedures for journals kept by British Admiralty officers might be similar to those imposed on HBC officers. The British Admiralty journals were considered the Admiralty’s property, just as the HBC journals were considered the property of the Company. The Admiralty imposed strict rules upon their officers concerning what to record. Instructions on recording could be found in the *Admiralty Manual of Scientific Enquiry*, which covered numerous fields such as astronomy, botany, geography, meteorology, geology, magnetism, and statistics (Herschel 1851). It was emphasized in each chapter that, regardless of the nature of the work, it was of utmost importance to develop a habit of maintaining a journal in a specific way.

> Most prominent amongst these general points is the necessity of acquiring a habit of writing down in a note-book, either immediately or at the earliest opportunity, the observations made and the information obtained. Where numbers are concerned, the whole value of the information is lost, unless the greatest accuracy is observed; and amidst the hurry of business or professional duties the memory is not always to be trusted.... And here it may not be appropriate to hold out a caution against too hasty generalization. A traveller is not justified in concluding that because a portion of a district, or continent, or island which he has visited is wooded or rocky, or otherwise remarkable, the whole district may be set down as similarly formed. He must carefully confine himself to the description of what he has himself seen, or what he has learned on undoubted authority.
>
> (Herschel 1851)

When and Where?

It is desirable that the HBC journals satisfy the rules of contemporaneity and propinquity. In other words, the entries were written very soon after they occurred (e.g. the same day) and that the author had first-hand experience concerning the information he was recording. The expectation that the Yukon journals satisfy these two requirements is reasonable. The journals were kept at the posts where the authors also resided. If the author left the post, the journal did not go with him; rather, the next senior man at the post took over the writing duties. Entries were recorded daily for the most part. Entries may have been updated throughout the day, as in the case of Frances Lake where multiple temperature readings were recorded in the morning, noon and night. In the case of the Admiralty's journals, it was expected that the entries would be kept on a daily basis (although the rigors of travel at times necessitated otherwise). The British Admiralty emphasized: "it is dangerous to trust much to the memory on such subjects; and if the observation be worth making, it is essential that it be correct" (Herschel 1851).

There is no indication in the post journals that any of the entries were recorded far after the fact. However, there is some issue with the third volume from Fort Selkirk. Three volumes make up the post's journals (NA MG19-D13). Two are co-written by Robert Campbell, the post's Senior Clerk (i.e. post master), and James G. Stewart (Assistant Clerk), covering the periods May 23, 1848 to October 19, 1849 (Volume One) and October 20, 1849 to December 31, 1851 (Volume Two) (Johnson and Legros 2000). Volume Three is written by Stewart only and covers the period January 1, 1852 to September 9, 1852. This third volume overlaps with the latter half of Volume Two and acts an alternative source. Both Volume Two and Three are named "Volume Two" in the journal's title and state they are continuations of the post's journal. For the purpose of this study, Stewart's individual "Volume Two" will be referred to as Volume Three. There is some debate whether the co-written Volume Two was written at a later date and that Volume Three was used primarily for note-taking and was at a later date developed in the co-written Volume Two (Johnson and Legros 2000). Also, Volume Three has a detailed account of the attack on Fort Selkirk in August 1852. Yet only Campbell, not Stewart was at the post during the attack. Therefore, the events recorded in Stewart's individual journal must have been taken from Campbell (either from a co-written official post journal or Campbell's own personal journal). However, the original document on which Stewart based his own description of the attack is unknown and neither Stewart nor Campbell make any mention of it. In 1850, Campbell records in a private correspondence that he lost all his papers and journals.

Who?

One of the most important issues that must be addressed is "Who is the author?" This can often be difficult to determine. In the case of the HBC posts, the author for every entry is not known except for the Fort Selkirk journals, which have undergone major scrutiny (Johnson and Legros 2000). In general, all the authors of the HBC journals were senior members of the HBC posts. These men were educated and had significant fur-trading experience. The men, for the most part, were familiar with the rugged terrain and extreme weather that the Canadian Northwest provided. A notable exception is P.C. Pambrum, whose lack of experience led to disastrous results at Frances Lake and Pelly Banks. Table 7 outlines the journal's authors (when known) as well as the post masters.

The exact author of each of the entries for the Frances Lake journals is unknown. Robert Campbell established Frances Lake in 1842 and was the author for the first volume for the outfit year 1842/43. Campbell was the post master for Frances Lake from 1842-1847 and was present at the post for the most part until the spring of 1846, when he left to establish Pelly Banks and later Fort Selkirk. William Hardisty was left in charge of Frances Lake for the winter of 1846/47 (Campbell 1958). In 1845, it is assumed that Hardisty was the post master and author since he signed the post journal for the outfit year 1844-1845. However, there are some entries in the Frances Lake journals (i.e. February 10, 1844, September 10 and 23, 1845), which mention Mr. Hardisty by name, indicating he is not the entry's author. However, a reference to Mr. Hardisty "and people" on March 29, 1847 in the Pelly Banks post, implies that Mr. Hardisty was in charge of Frances Lake. In the fall of 1847, James G. Stewart took over post master duties at Frances Lake, when Hardisty left over health issues. In March 1848, P.C. Pambrum took control of both Frances Lake and Pelly Banks, when Stewart and Campbell left the area to establish Fort Selkirk. Campbell did not look kindly on Pambrum, writing, "Mr. P. was well-known to possess neither the judgement nor the foresight nor the energy requisite at a remote & isolated charge like that, where everything so much depended on his own efforts..." (Campbell 1958). Journals for Frances Lake are only available for the duration of Campbell's and Hardisty's tenure. Therefore, it is assumed that the majority of the entries are authored by one of these two men.

Table 7: HBC post masters and journal authors for the southern Yukon Territory

	Frances Lake	Pelly Banks	Fort Selkirk
Journal author(s)	R. Campbell W.L. Hardisty	R. Campbell	R. Campbell J.G. Stewart
Post master	R. Campbell (1842-44) W.L. Hardisty (1844-45) J.G. Stewart (1847-48) P.C. Pambrum (1848-51)	R. Campbell W.L. Hardisty	R. Campbell J.G. Stewart
Signature at end of post volumes	Outfit 1843/42 - RC Outfit 1843/44 – RC Outfit 1844/45 – N/A Outfit 1845/46 - WLH	Outfit 1845/46 – n/a Outfit 1846/46- n/a	n/a

RC = Robert Campbell WLH = William Lucas Hardisty

The author of the Pelly Banks journal (1845-47) is Robert Campbell. The journal is housed within Campbell's private papers and not within the HBC archives (NA MG19-A25). No record of the post's journal exists following Campbell's departure from Pelly Banks in the spring of 1847, despite the fact that the post operated until 1849. Thus, the Pelly Banks journal is likely an unofficial post journal not sanctioned by the HBC, but rather a personal account of the activities at the post during Campbell's tenure. In his memoirs, Campbell indicates that he lost all his papers and journals in Lake Finlayson in September 1850 (Campbell 1958). Obviously, the Pelly Banks journal must have been stored elsewhere at the time. Pelly Banks may have been considered an offshoot of Frances Lake and not a full-post in its own right. Pelly Banks is not listed as an HBC post in the HBC archives. The fact that Pambrum was left in charge of both posts for 1848 supports the theory that Pelly Banks was not a large enough operation to have required separate leadership. Regardless of whether the Pelly Banks journal is official or not, it is likely that Campbell employed much of the same rules when recording information as he did in official HBC post journals.

To a certain degree, we have already established who the authors were for a majority of the journals. Most senior servants were from the United Kingdom, although the majority of the men under discussion here were from Lower Canada (i.e. Quebec). Robert Campbell was Scottish and relocated to Canada in 1830 at the age of 22. James Green Stewart was Canadian, born in Quebec City in 1825 and joined the HBC in 1844. William Lucas Hardisty, also from Quebec, was the son a HBC Chief Trader. Hardisty joined the HBC in 1842.

Victorian society had a great influence on people and institutions such as the HBC, invested in exploring and colonizing Canada. In Europe, the 17th century's Industrial Revolution and the 18th century's Enlightenment legacies led to a "firm belief in the deductive method of reasoning ... and emphasized the importance of collecting, cataloguing, and disseminating scientific information" (Zeller 1996). A better understanding of nature was believed to give society the power to predict and control it. The explorer David Thompson may have summarized the HBC's reasoning the best: "...the age of guessing is passed away, and the traveller is expected to give his reasons for what he asserts..." (Glover 1962).

Despite this desire for objectivity and analysis, one cannot deny that cultural perceptions and ideals will have influenced authors' viewpoints and what they recorded. This is evident when one considers the ethnocentric culture of the British during the nineteenth century. By and large, the British believed they were superior to the indigenous populations, as well as the local French-Canadian voyageurs that represented the past-threat of France. This attitude was often reflected both consciously and unconsciously, in the journals and narratives of early British explorers like John Franklin, Alexander Mackenzie and Samuel Hearne. An ethnocentric attitude was the downfall of many expeditions, such as Franklin's first Arctic land expedition (1819-1823). This ethnocentric attitude backfired on the British. Some native and voyageur guides deliberately sabotaged expeditions by breaking or losing equipment or giving false geographical information, as a passive form of resistance (Davis 1995).

It could be argued that ethnocentric attitudes were also present in the HBC journals from the Yukon. These ethnocentric attitudes would have differed depending on the HBC employee's relationship with the native population. Native hunters and guides may not have been subjected to as much discrimination because of their integral role in the HBC operations. Whereas native communities with which the HBC relied on for trade may have suffered from greater discrimination since their ties to the company were less strong. As well, some native communities were viewed as negatively since they refused to trade with the HBC.

Robert Campbell worked closely with many natives, including his interpreter Francis Hoole and his "faithful" hunters, Lapie and Kitza (or Kitsah). Campbell called them "his inseparables" and all three natives figured prominently in the establishment of Frances Lake, Pelly Banks, and Fort Selkirk (Campbell 1958). There are a few negative comments concerning the native population present in the journal. Two of the comments come from Campbell: "Many useless Indians about" (NA MG19-D13) and "...Three Indians arrived starving and nothing to trade. It's an excuse for their incapability to kill, they say there are no animals. This we know to be false" (NA MG19-A25). These comments may reflect an ethnocentric viewpoint or they may truly reflect the reality of the situation. Overall, Campbell appears to have respect for the indigenous population. In his personal journal, he wrote a glowing tribute:

> During the last winter [1850/51], a party of Indians came to Pelly Banks with furs to barter, but finding no one there with whom to trade, & seeing a few pieces of goods in the only house left standing by the fire, they opened up some of the goods themselves … & took such of the things they required or wanted, leaving in their place furs more than equivalent to pay for all. Many a civilized & christianized white man might take a lesson in honesty from these poor Indians in their natural state. The temptation to help themselves to many things, such as clothing & Blankets, was no doubt very strong in their destitute condition, but their self-denial & integrity enabled them to resist.
>
> (Campbell 1958, p. 95)

However, this quote could have many meanings. The natives may have left "more than equivalent" pay for the goods they took because they respected the trading relationship they had with the HBC and wanted to maintain it. Also, Campbell's comments on the "destitute condition" of the natives may be biased. What appeared to be "destitute" to a white man may have been normal living conditions to the native population. On the other hand, it could be argued that Campbell's broad trading experience with the native communities allowed him to make a fair judgement concerning their living conditions.

So how would an ethnocentric attitude affect the weather information recorded within the Yukon's post journals? Overall, there should be no direct influence, since references to the weather were separate from references to Indians. However, care must be taken when considering indirect data, such as references to starving Indians, as a possible indicator of weather conditions. If an author referred to starving natives and implied their condition was the result of inadequacy or laziness, then ethnocentricity may play a role and mask possible climatic influences. In the case of the post journals, only one of the references makes this link (see paragraph above). The remaining references to starving natives either imply poor weather conditions as a causation factor or supply no reason at all. Often, references to starving natives were also accompanied by references to starvation at the post.

What?

The final question that must be addressed when assessing reliability is what type of information was recorded. Both direct and indirect references to weather were recorded in the post journals. Developing a connection between indirect references and weather can be difficult at times, since numerous factors besides weather may be at play (e.g. starvation). However, some indirect references, such as ice activity, provide a strong link to weather conditions (Magnuson et al. 2000). Miscellaneous comments on the weather are also viewed as indirect references. These include descriptive terms such as fine, fair, beautiful, boisterous, delightful and charming. These terms are much harder to link to direct weather conditions and could be considered subjective.

The majority of weather references for the three HBC posts were direct, qualitative references. These include information on temperature, precipitation, cloud cover and wind conditions. Direct, qualitative references were recorded almost daily at Fort Selkirk and Frances Lake throughout all volumes. The Frances Lake record is missing one entire month (June 1843), when Campbell left the post to further explore the Pelly River. Overall, the journals were kept daily, but months with only partial entries do exist. The daily journals were not meteorological registers or weather journals specifically, as was the case with historical climatology studies based on other HBC records (Wilson 1982; Ball 1995). Missing entries are common during the transition period of late spring/early summer (or early fall in the case of Fort Selkirk) when the furs procured at the post were packaged and returned to Fort Simpson.

However, daily journal entries do not necessarily translate into daily weather references. Table 8 outlines the average annual percent of direct and indirect weather references per year by post. These averages are weighted by the number of days with entries per journal to take into account missing days or months due to absence from the post rather than a lack of entries due to record keeping. The average number of daily entries for Frances Lake and Fort Selkirk is high. Over 75% of the days available are recorded in the journals. Direct weather references account for the majority of the indicators of weather and are at least double the indirect references. Fort Selkirk has the highest number of daily direct weather references (63.43%), indicating on average 210 days of the year the weather was mentioned directly. Pelly Banks has the lowest number of yearly direct weather references at 39.13%. Figure 4 illustrates the average monthly breakdown of the direct weather references. Overall, March-May represents the lowest number of direct weather references.

Table 8: Average percent of annual references by post

Post name	Percent of Direct weather references	Percent Indirect weather references	Percent of all annual references
Frances Lake	57.61%	19.02%	76.63%
Pelly Banks	39.13%	18.54%	48.91%
Fort Selkirk	63.43%	15.77%	79.20%

The quantity of information recorded at the three posts varies. Pelly Banks has the sparsest journals. The average number of days with direct or indirect weather references per month is 15, which is considerably lower than Frances Lake (23 days) and Fort Selkirk (24 days). For the first outfit year (October 1845 to April 1846) only eight weather references per month at most were recorded. March 1846 only has one reference. The low number of daily entries in the first volume is due to the fact that the post had yet to be fully established. Campbell's references likely reflected his time spent visiting the site. The second volume, from May 1846 to April 1847, is more complete. Weather references range from 14 to 22 per month, except for November 1846, which has only eight references. The lack of information in the Pelly Banks journal may reflect the nature of the journal. Since is it likely that the post's journal was not an official HBC journal, but rather a personal journal by Robert Campbell, the attention given to it might have been less. Also, activities at the post and Campbell's continued exploration of the region interrupted his journal taking. Regardless, the Pelly Banks journals provide a vital overlap period with Frances Lake and partially bridges the gap with the Fort Selkirk record.

The Fort Selkirk journals are the most detailed of the three posts (in terms of entry length). Missing days are rare and occur only when neither Campbell nor Stewart were at the post. As indicated before, the journals were co-written, except for the year 1852, which is comprised by Stewart's own Volume Three. Compared to the earlier co-written volumes, Stewart's individual references to daily

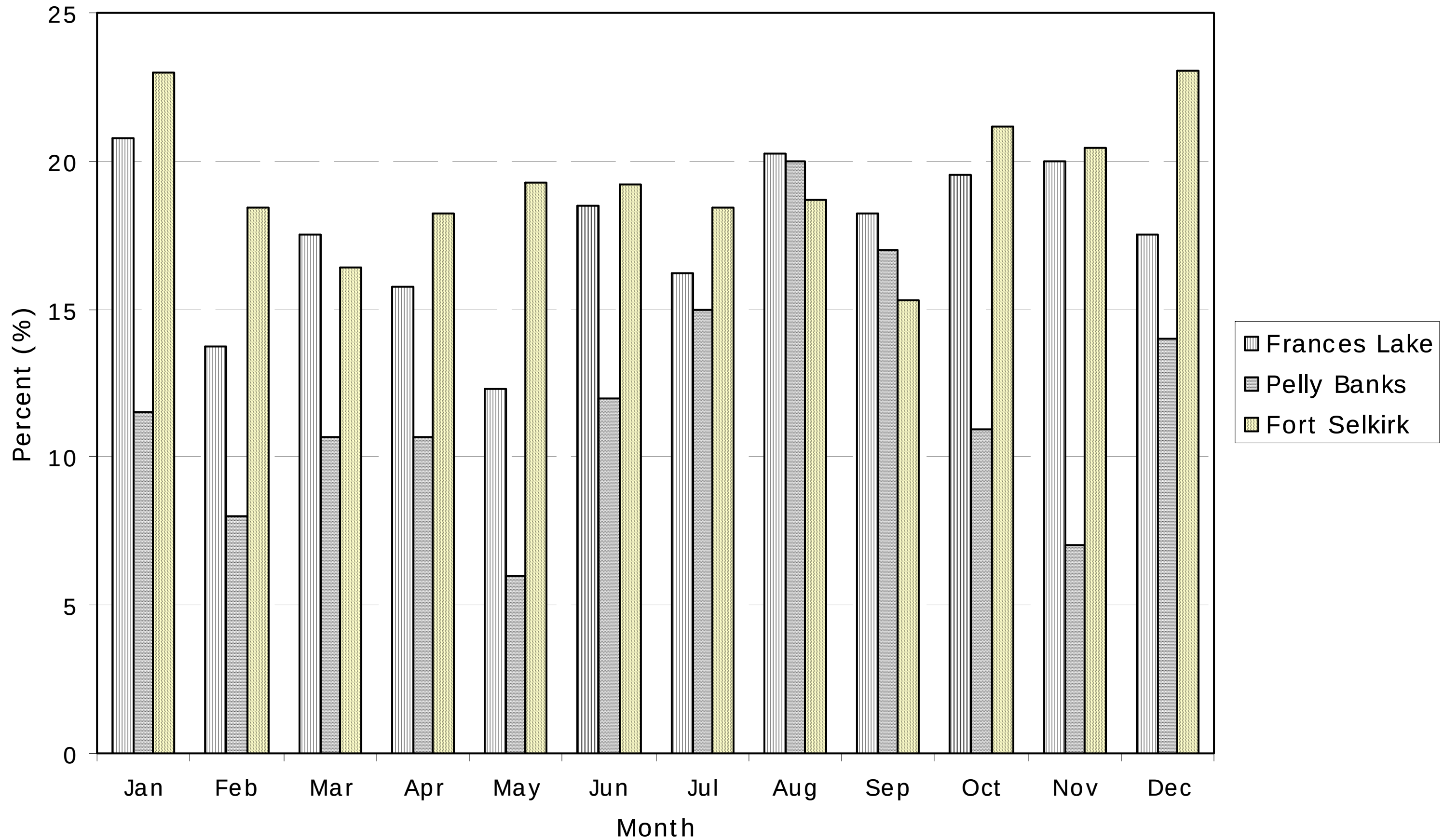


Figure 4: Average percent of direct weather references by month for Frances Lake (1842-1846), Pelly Banks (1845-1847) and Fort Selkirk (1848-1852). The averages are weighted by the total number of days per month with daily entries.

weather for 1852 were much lower. On average, Stewart's entries contain four days fewer references per month compared to the co-written volumes.

The Frances Lake journals fall between the Pelly Banks and Fort Selkirk journals in terms of detail. The entry lengths may not be as long as Fort Selkirk, but it does contain almost as many daily references to weather as Fort Selkirk. These journals have one significant advantage over the other posts. Temperature measurements from December 1842 to May 1844 were recorded along with the qualitative weather description. Often temperature measurements were taken three times a day and there are indications that the three measurements represented morning, noon and night readings. The Royal Society provided meteorological instruments (e.g. thermometers and barometers) to earlier HBC posts, such as York Factory and Churchill (Ball 1995). Journals from those posts as well as others situated at or near Hudson Bay recorded the brand of instrument used and usually the location of the instruments. These temperature and pressure measurements were recorded in meteorological journals, not the post journals. In these cases, the head officer usually kept the post journals while the instrumental journal was maintained by surgeons. However, no surgeons were ever present at the three HBC posts under consideration and there is no indication that a separate meteorological journal was maintained for temperature measurements. The Frances Lake temperature observations are embedded within the normal text of the journals, either preceding or appearing after the text entries (Figure 5).

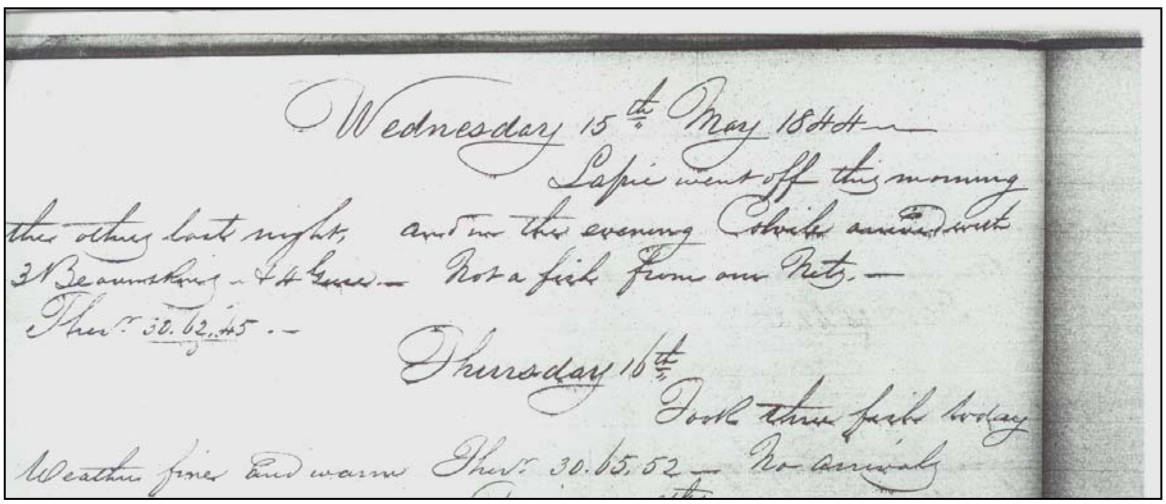


Figure 5: Example of temperature readings from Frances Lake post journal, May 15 and 16, 1844. The first entry has the temperature readings at the end of the written entry, while the next day has the readings embedded within the text.

Part 2: Coding Scheme

In order to quantify and analyze the textual weather information in the journals, a hierarchical coding scheme was developed using a software program called MaxQDA (Qualitative Data Analysis) (VERBI Software 2005). The coding scheme is used to separate weather references into categories, which are unique, exclusive and representative of the weather information stored within the journals. The codes represent the main weather conditions as well as more extreme conditions. In order to represent differences in the intensity and type of weather, the codes are divided into subcodes. One of the challenges with coding is creating a coding hierarchy that balances the total number of subcodes and the uniqueness of the subcode. Numerous descriptors may be used when referencing a weather condition, each implying some distinctiveness through the use of different terminology. However, if every unique descriptor is given a unique subcode, the total number of subcode may be very large and the total number of references within each subcode may be very low. Trends within the data may be lost and the effectiveness of the coding scheme could be questioned.

Generally, studies that involve a large number of documents covering an extended period of time (i.e. 50+ years) have more diversity in the type and number of subcodes. This is because the subcodes tend to be better represented within a longer time period. For example, Moodie and Catchpole's (1978) study on ice freeze-up and break-up activity of Hudson Bay estuaries using HBC journals from 1715-1871 first developed 16 ice subcodes, which were eventually combined into four ice activity subcodes.

This study is based on documentary records that cover a considerably shorter period than most studies. Only one study consulted for this project attempted to reconstruct climate conditions for a period less than 50 years (Rodrigo et al. 1998). Therefore the breadth and depth of information provided by the Yukon's posts has to be considered differently. Multiple subcodes are not necessarily mandated by the weather information in the text and at times, only a few levels of intensity for weather conditions can be identified reliably.

The text analysis program, MaxQDA, allows text documents to be imported and coded by a user-defined hierarchical coding scheme. The smallest textual unit that can be coded is a word. For the purpose of this study, the smallest coding unit was a day. Figure 6 shows a screen capture of the program. Since digital versions of the three journals did not exist, the weather information was digitized as Rich Text Format (RTF). Each file represented all the references to weather (both direct and indirect) for a given month of a given year. Due to time constraints, it was not feasible to transcribe the entire texts. Any information that could remotely indicate weather or environmental conditions was recorded. Each month from the journals was transcribed into a separate RTF file with the appropriate header information describing the text, author, and location. Appendix 2a-c contains an example from each post. To view all the transcribed journal entries, please refer to Appendix 2a-c on the CD available with this study. Transcription proved challenging due to the delicate nature of the original text and required multiple readings in order to become familiar with handwriting styles and phraseology. Figure 7 shows some examples of entries from the journals. However, the interpretation of the texts was not greatly hindered by the delicate nature and difference in handwriting styles. An edited, typed version of the Fort Selkirk journals existed for consultation (Johnson and Legros 2000). The loss of information due to illegible text in the Frances Lake and Pelly Banks journal is estimated as low. Illegible text was generally confined to a single word. Also, information preceding and following "problematic" text contributed greatly to interpretation and often suggested possible spelling.

Some of the categories and subcodes were predetermined from the outset. It was assumed that a category for temperature, precipitation and wind conditions would be needed. Additional categories and sub-categories were based on the unique information from each of the post journals and took into account differences in terminology. Coding and categorization schemes used by other researchers were also considered. Bartholy et al. (2004), in their massive study using 15,000 records from the Carpathian Basin, employed only three categories: temperature, precipitation, and wind. They also included a "consequence" code, which took into account the impact of weather. Other studies have focused on single weather events, such as floods, droughts or storms, developing the classification scheme

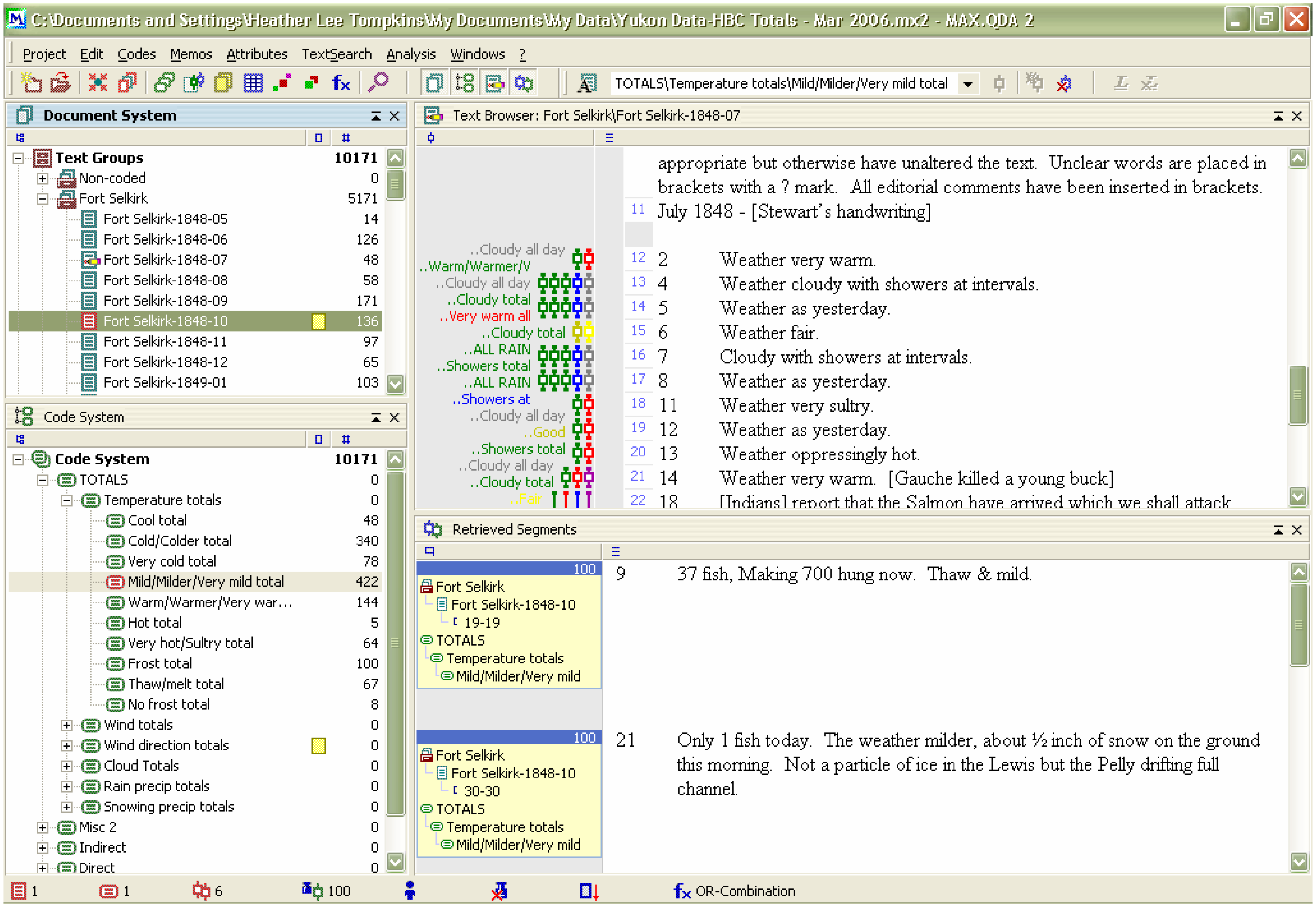
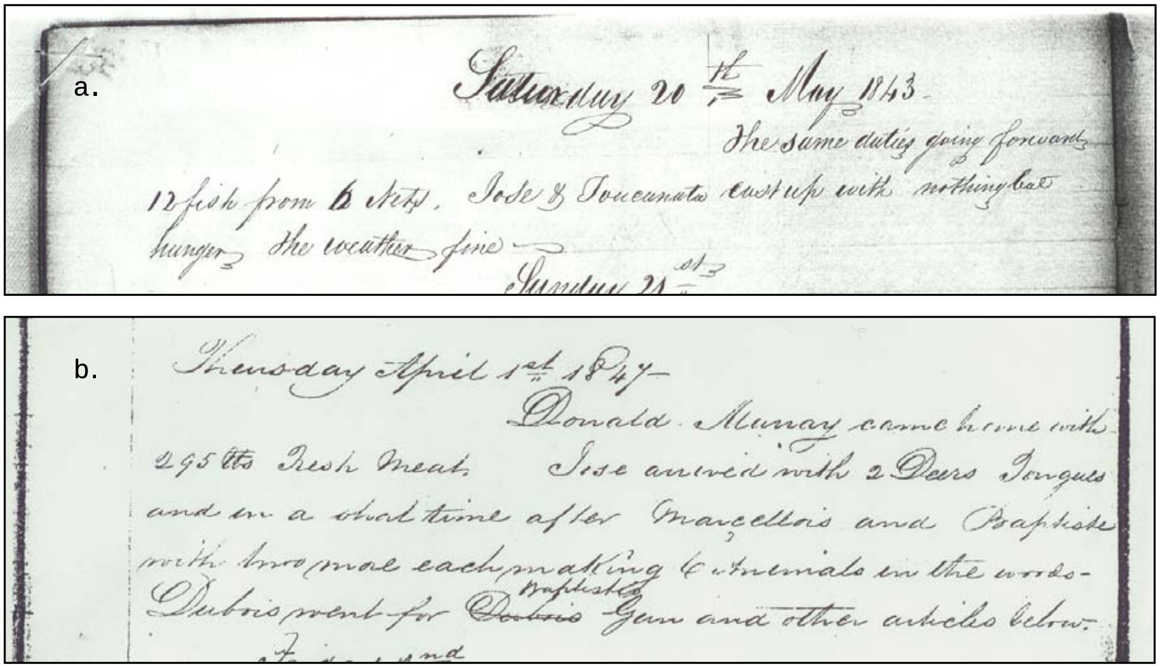


Figure 6: Screenshot of MaxQDA Program. The program is divided into four main windows. The Document System window imports and organizes the texts that will be coded. The Text Browser window allows viewing, editing and coding of texts. The Code System window allows the manipulation and viewing of the hierarchical coding scheme. The Retrieved Segments window shows the coded segments for one or multiple texts.


a.

Saturday 20th May 1843.
The same duties going forward
12 fish from 6 Nets. Jose & Toucanata cast up with nothing but
hunger the weather fine.
Sunday 21st

b.

Thursday April 1st 1847
Donald Murray came home with
295 lbs Fresh Meat. Jose arrived with 2 Deers Tongues
and in a short time after Marcellois and Baptiste
with two more each making 6 Animals in the woods.
Dubois went for Baptiste's Gun and other articles below.

Figure 7: Examples of HBC journal entries. Figure 6a is from “Journal of daily Occurrences on the way to and at Frances Lake: Mackenzies River District Outfit 1842.” Figure 6b is from Volume 2 of “Pelly Banks Journal of Occurrence 1845-1847”.

around the level of magnitude and frequency (Brazdil et al. 1999; Kraker 1999). Nash and Endfield (2002) split their historical drought data for Africa into three categories:

- details of catastrophic or unusual events,
- general anecdotal comments on the weather, including observations on the rainy season, and
- indirect evidence of climatic variability (e.g. harvest loss).

Ge et al. (2003) divided their classification scheme for China into ‘natural evidence’, which provided information on temperature directly (e.g. phenological and cryosphere data), and ‘impact evidence’, which referred to the impact of cold/warm events on man and society. Walsh et al. (1999) used the categories rainfall days, wind direction and cloud cover to reconstruct the eighteenth century climate of Madras from detailed weather diaries. Ball (1995) developed 14 categories for his treatment of HBC data for the Hudson Bay region: instrumental temperature, wind direction, wind strength and type, precipitation, cloud cover, thunder, non-instrumental temperature, general weather, melting, frost, drift, and remarks. Some of his categories were further sub-divided.

The coding scheme used in this study is the result of extensive examination of the weather references in the HBC post journals. Initially, a number of years of texts were reviewed in their entirety and coded. Any reference to weather was coded using keywords. For example, a reference to warm weather was automatically coded as “warm”. A reference to a strong wind was coded as “strong wind”. Once the first stage of a comprehensive coding hierarchy was developed, the remaining texts were automatically coded by MaxQDA using string searches. To ensure that the daily entries were not miscoded or un-coded by the automatic coding, each monthly text was reviewed from each post. Subcodes were constantly revised in order to reduce redundancy and maximize the effectiveness of the coding structure. The coding scheme used in this study represents the two groups' documentary proxy data reviewed in Chapter 1: direct and indirect data. Direct references referred to actual weather conditions and were split into six categories: Temperature, Rainfall, Snowfall, Cloud cover, Wind strength, and Wind direction. Each category was further sub-divided to highlight the main weather conditions. For example, Temperatures was divided into nine subcodes: Cool, Cold, Very cold, Mild, Warm, Hot, Frost, Thaw, and No frost. Indirect codes referred to the impact of the weather on the environment and human activity. It is represented by four sub-categories: Biological, Ice activity, Human impacts, and Miscellaneous remarks. Figure 8 shows the breakdown of the direct and indirect coding schemes by category and subcodes. The following section provides definitions and examples of the subcodes.

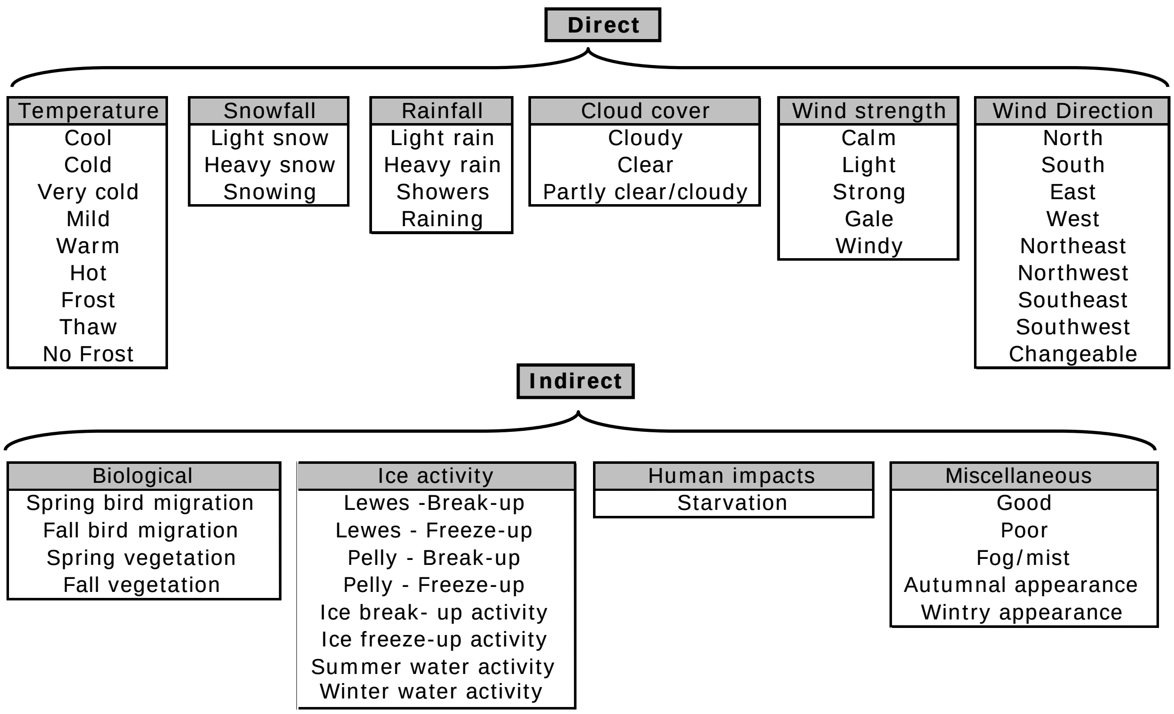


Figure 8: Classification scheme used in study. Daily references are divided in direct or indirect categories and further sub-divided into exclusive codes.

Direct Code Definitions

Temperature

The temperature subcategory is one of the most difficult to code. Temperature is a subjective code because authors may be referring to temperature conditions in either a relative or an absolute sense. Early on in the coding exercise, the decision was made that the temperature coding would be based on a relative rather than an absolute coding system. An absolute coding system would attempt to place temperature references in subcodes that reflect actual temperature values. For example, a reference to “a warm day” in December could be coded as “mild” and not “warm” since warm temperatures (e.g. those above zero degrees Celsius) would be very unlikely. This line of reasoning would also require the coder to assign somewhat arbitrary temperature ranges to qualitative terms, such as warm temperatures are greater than 0ºC. In contrast, in a relative coding scheme, a reference to “warm” conditions would be coded as “warm” since the temperature would be interpreted by the journal author to be warm relative to normal conditions.

An absolute coding system for temperature is problematic since it can be very difficult to determine what the authors truly mean without additional information, such as references to ice conditions in the winter, or frost/thaw activity, or actual temperature values. More likely, the author’s previous experience with weather both abroad and in situ, as well as his health and living conditions, will influence his references to weather, especially temperature. Food supplies for the HBC were always less than needed and almost every winter there were references to inadequate food supplies and starvation. A malnourished, under-dressed author was likely to feel the cold more significantly than an author who was well fed and dressed. None of the historical climatology studies reviewed for this project relied on an absolute coding scheme, since it requires a large amount of interpretation and speculation on the part of the researcher. Regardless, a certain amount of interpretation on the part of the researcher is required and clear descriptions of the coding schemes are necessary. Therefore, it was decided that a relative coding scheme would be a truer reflection of the temperature information recorded by the author. For example, references to “cool” weather in either June or December were both coded as <u>Cool</u>. Some exceptions to the relative coding scheme do apply to the temperature codes and are described for each subcode in a later section.

Initial coding of temperature references resulted in 21 subcodes based on terminology:

- below freezing
- cool
- cooler
- cold
- colder
- very cold
- mild
- milder
- very mild
- warm
- warm sun
- warmer
- very warm sun
- very warm
- hot
- very hot
- sultry
- thaw/melt
- frost
- frosty
- no frost

It was decided to include four indirect measures of temperature (thaw, frost, frosty, and no frost) in the Temperature category rather than in another indirect category, as was done with ice activity. The formation of frost is strongly linked to local ground temperature values near or below freezing. Forty per cent of the frost references were associated with qualitative temperature descriptions. Temperature codes were revised into nine subcodes (Figure 8):

<u>Cool</u> – Includes references to “cool” weather and allows for the categorization of less extreme temperature conditions (not just hot or cold). References to "not cold", or "not warm" weather are coded as <u>Cool</u>. References such as "not so cool" made during winter (November-March) are coded as <u>Cold</u> not <u>Cool</u> since the reference indicates a negative departure from cool conditions. References to chilly weather were also coded as <u>Cool</u> because 9 of the 11 references to chilly weather occurred in May or September and indicated ice activity and

frost conditions. References to frost or thawing for May-September in conjunction with the term "cold" was coded as Cool.

Cold – Cold represents the second largest temperature subcode for each HBC post. References to "cold" weather in conjunction with snow from May-September were coded as Cold and not recoded to Cool, because the temperature conditions required for snow versus frost are different. Cold also includes references to "colder" and "more cold" weather. Over 50% of the references to "colder" weather were made in the winter season (December-February), implying traditionally cold conditions.

Very cold – This subcode takes into account extreme cold and includes references such as "desperately cold", "fearfully cold", "intensely cold", "bitterly cold", "awfully cold", and "most cold".

Mild – Includes references to "mild", "milder" and "very mild" weather. Most comments on mild weather seem to reflect overall weather conditions. The term "milder" does not necessarily imply mild temperatures per se, but rather a break from conditions before, whether it be hot or cold weather. The same would apply to references such as "cooler", "colder", "warmer" etc. However, in order to reduce the amount of subjective interpretation on the part of the researcher, the references were coded according to the relative coding scheme.

Warm - This code refers to warm weather conditions and includes references to "warm", "warmer", "very warm", "warm sun" (one reference), and "very warm sun" (one reference). References to "warm sun" appear to reflect warmer conditions during days that are generally during a cooler season.

Hot - This code refers to "hot", "very hot", "humid", "muggy", and "sultry" weather. Direct references to "hot" weather only totalled five, so it was combined with "very hot" references in order to maximize impact. It also includes references to "oppressingly hot", "fearfully hot", "remarkably hot", and "boiling hot".

Thaw – This code includes references to thaw (e.g. "general thaw", "thaw all day" or "thawing all day") and snow melt (e.g. "snow disappearing").

Frost – This code includes references to "frost" on the ground and "frosty" weather. It also includes references such as "froze hard at night" which is interpreted to mean that it was cold enough to freeze and thus have frost. The majority of references to "froze" are in the spring (March-May) and fall (September-November).

No frost – This code is used when authors noted the lack of frost or freezing at night.

Cloud conditions

Cloud conditions were the most straightforward subcode scheme to create and represent the second highest number of weather references. HBC authors were generally consistent in their usage of terms and stuck to descriptors that indicated three main conditions:

Partly clear/cloudy – This code includes references to "partly clear", "partly cloudy", and "partly sunny skies". All of the HBC coded segments are for "all day" conditions. Partly sunny/clear/cloudy implies "two sides of the same coin" (i.e. if it is partly cloudy, than it must be partly sunny as well). However, since the authors do choose to use one of two phrases, it implies that there might be a difference. The use of partly cloudy over partly sunny could imply that it was more cloudy that sunny that day (e.g. 60% cloud cover). But the use of the term "partly" or "somewhat" indicates that there was at least some cloud cover.

Cloudy – This code refers to "cloudy", "overcast" and "dull" skies. According to Environment Canada (2006), "Cloudy means that clouds cover more than 60 per cent of the sky….. [while]… Overcast means grey and dull skies, with extensive cloud cover." However, it cannot be confirmed if the journals' authors also adhere to that definition, so it is assumed that references to cloudy and overcast indicates the majority of the sky is covered by clouds. Linguistically *cloudy* and *overcast* are synonyms.

Clear - Clear conditions represent the largest set of main codes for each HBC post. It includes references to "clear" and "sunny" skies.

Snowfall

Snowfall nearly ties with rainfall as amounting to the lowest number of references and is roughly one-fourth in number of the temperature references. Additional references to snowfall were found within the texts but are not considered subcodes of snowfall since they do not directly imply snowfall. These references include: amount of snow on the ground, snow on the mountains, and appearance of snow. These references may be useful when considering overall conditions. Three subcodes comprise the snowfall category:

Light snow – This code takes into account snowfall intensity and is applied when authors mention "snowing lightly", "a little snow", "snowed a little" or "gently snowing".

Heavy snow – This code is not well represented in the HBC texts (there are only 14 references in total). However, it does highlight heavier snowfall conditions from snowstorms, blizzards and squalls. It is also used to represent references to "fast snow" and "snowing hard".

Snowing – This is a general subcode applied to all other references of snowfall where intensity is not indicated. It accounts for two-thirds of the snowfall references.

Rainfall

Rainfall was the least represented code for the HBC posts and is divided into four categories depending on intensity. Often, references to rainfall also included references to lightning and thunder, which were recorded.

Light rain – Includes references to "light rain", "drizzle", "slight showers", "raining lightly", "raining slightly" and "raining a little".

Showers – This code is used to categorize rainfall of medium intensity. Many of the references to "showers" indicate that they occurred at intervals and did not last long.

Heavy rain – Heavy rain is used to describe rainfall of the highest intensity. It includes descriptors such as "heavy", "hard", "fast", and "pouring".

Raining – This code includes references to rainfall that are associated with an intensity descriptor. It accounts for just over 50% of the rainfall references.

Wind strength

Wind strength composes the second largest direct weather category and offers perhaps the most variation. Approximately half of all references to wind were accompanied by an intensity descriptor and indication of direction. Wind strength provides a coding challenge, since many different descriptors were used by the authors with no clear definition of what they thought each term encompassed. HBC ship's logbooks were known to have applied the Beaufort wind scale to entries; however, the application of the scale to land-based posts has not been found. Table 9 shows the total number of wind references that apply to each Beaufort category.

Table 9: Number of wind references that apply to the Beaufort scale

Beautfort value	Beaufort term	Fort Selkirk	Pelly Banks	Frances Lakes	HBC Total
0	Calm	34	15	123	172
1	Light airs				
2	Light breeze	4	1	4	9
3	Gentle breeze				
4	Moderate breeze				
5	Fresh breeze	1		7	8
6	Strong breeze	6		13	19
7	Moderate gale				
8	Fresh gale				
9	Strong gale			22	22
10	Whole gale				
1	Storm				
12	Hurricane			1	1

Only 35% of the HBC wind strength references fell within the Beaufort scale terminology and 75% of those codes were from the Calm category. Therefore, it could not be substantiated that the wind strength terminology used by the three Yukon HBC posts employed the Beaufort Scale. Also, it was unlikely that a marine-based wind index would be applied to a non-marine setting. Five subcodes comprise wind strength:

Calm – This code includes references to "calm", "still", "no wind" or "hardly a breath of wind".

Light wind– This code encompasses descriptors such as "light", "slight" and "breeze". If references included the term "light" or "slight" in conjunction with another descriptor such as "blowing lightly" the term "light" took precedence and the reference was coded as Light. It also contains references to "fresh" wind, since the majority of "fresh" references were paired with "breeze", such as "fresh breeze".

Strong wind – Includes references to "strong wind", "strong breeze", "blowing", "high wind", and "gusts".

Gale – References to "gale wind" or wind "blowing a gale" were primarily found in the Frances Lake journals. Since the term implies a particularly strong wind and is represented by the Beaufort Scale, the term gale was not combined with another code of wind intensity.

Windy – This code includes all references to wind strength without a descriptor of intensity. For example, "Northerly wind" or "wind variable".

Wind direction

Wind direction was one of the simpler categories to code and is based on the eight-point compass. It consists of 10 subcodes, including North, South, East, West, Northeast, Northwest, Southeast, and Southwest. A few references to wind initially referred to "head wind" conditions with regards to boat navigation. Further investigation of these references allowed actual wind direction to be established. This category also includes the subcode Changeable, which refers to conditions where the wind was blowing from "every point of the compass". Only two references are in the Changeable category.

Indirect Code Definitions

Indirect subcodes are the companion category for direct references. An indirect reference can be used to either establish a relationship between the indirect subcode and actual weather condition (e.g. ice activity and temperature) or it can be used to qualitatively support the emerging picture of weather put forth by direct subcodes (e.g. starvation references). In this study indirect references account for approximately one-third of the overall coded references and are divided into four main categories: Biological, Human impacts, Ice activity, and Miscellaneous remarks.

Biological

Biological references encompass the response of the flora and fauna to changing weather conditions. In particular, it includes references to bird migration and vegetation activity. Research has shown significant correlations to changes in temperature with regards to vegetation maturation (e.g. wine harvests) and waterfowl spring migration (Le Roy Ladurie 1971; Ball 1983). Four subcodes comprise this category:

Spring migration – This code includes sighting of birds and ducks during spring migration (March-May). Specific references mention snow geese, cranes and swans, while more generic terms such as geese, wildfowl and ducks were also included. References to birds or ducks being killed, which implied migration, are coded as Spring migration as well.

Fall migration – Fall migration is coded in a similar manner to Spring migration but it covers the fall period (August-October) to take into account the fact that fall migration in the Yukon can occur as early as August.

Spring vegetation – Spring vegetation includes all references to crops and vegetation growing as well as planting small experimental farms at the post. It covers the period May-July.

Fall vegetation – Fall vegetation includes all references to "leaves turning colour", "harvesting" and "frost damage" to the crops. It covers the period August-October. References to "frost damage" to the crops in early spring or summer were recorded and are taken into consideration.

Ice activity

Ice activity is one of the most relevant indirect categories for this study. Previous work has shown that ice break-up and freeze-up activity can be used as a proxy for temperatures. Moodie and Catchpole (1978) developed a stringent coding index for break-up and freeze-up based on long-term HBC records. References to ice activity were common in the Yukon's HBC journals, particularly Fort Selkirk, which was relocated in 1852 due to regular flooding by spring ice. However, the total number of ice activity references is substantially lower than those used by Moodie and Catchpole. Therefore, a simpler scheme has been employed. Eight subcodes comprise this category, although two are only applicable to Fort Selkirk.

Ice break-up activity– This code covers the March-May ice break-up period. It includes references to "unsafe ice", "falling through the ice", "ice break-up", "ice moving/running", "ice jammed", "water on ice", "ice thickness", "full channel", "ice in lake/river", "open water/leads", and "flooding by ice". It also includes references to "water high", "water rising", "water low" and "water falling". This code is used for all three posts, except in the case of Fort Selkirk, when the Pelly or Lewes (Yukon) rivers were specifically mentioned.

Pelly break-up – This code refers explicitly to spring break-up conditions on the Pelly River at Fort Selkirk.

Lewes break-up – This code refers explicitly to spring break-up conditions on the Lewes River at Fort Selkirk.

Ice freeze-up activity – Similar to Ice break-up activity, although it covers the fall freeze-up period, September to November. This code includes references to "ice thickening", "ice freeze-up", "ice set fast", "unsafe ice", "falling through the ice", "ice moving/ running", "ice jammed", "water on ice", "full channel", "ice in lake/river", and "open water/leads". It also includes references to "water high", "water rising", "water low" and "water falling". This code is used for all three posts, except in the case of Fort Selkirk, when the Pelly or Lewes rivers were specifically mentioned.

Pelly freeze-up – This code refers explicitly to fall freeze-up conditions on the Pelly River at Fort Selkirk.

Lewes freeze-up – This code refers explicitly to fall freeze-up conditions on the Lewes River at Fort Selkirk.

Summer water activity – This subcode refers to lake and river activity at the post and includes references to “water high”, “water rising”, “water low” and “water falling”. It takes into consideration changes in water elevation that may be a result of late ice-break up activity and heavy precipitation. It covers the summer season from June to August.

Winter water activity – Similar to Summer water activity, except that it covers the period December-February. References to changes in water elevation in winter may signal delayed ice freeze-up or mild temperatures.

Human impacts

Only one subcode is contained within the Human impacts category: Starvation. Starvation at the HBC posts in the Yukon was common, although it cannot all be attributed to poor weather conditions. Often inadequate supplies were the culprit. Over exploitation of resources is another possible factor. This code includes references to “starvation at the post”, “starving Indians”, “starving hunters”, “starving dogs”, “poor hunting”, and “poor food supplies”.

Miscellaneous

Miscellaneous remarks include very qualitative descriptors of the weather that cannot be attributed to any direct weather subcode. It is split into five subcodes:

Good – This subcode includes all qualitative references to favourable weather conditions. This includes the terms “fine”, “fair”, “beautiful”, “charming”, and “delightful”. This code accounts for over 600 references and was widely used in all the journals.

Poor – This subcode is the opposite of the Good subcode and represents unfavourable weather conditions. Terms included in this code are “boisterous”, “doubtful”, “gloomy”, “unsettled”, and “raw”.

Fog/mist – This code includes references to fog or mist, which may indicate temperature and precipitation conditions.

Autumnal appearance – References to the surroundings “assuming an autumnal appearance” or the weather “fall-like” were grouped into this category because they give an indication of the timing of seasonal changes.

Wintry appearance – This code is similar to Autumnal appearance, except that it includes references to “wintry weather” or “winter-like”.

Coding Resolution

The smallest unit of times used in the study is a day. However, the use of time-sensitive codes was initially investigated. Previous work with HBC data had indicated that strong attention to detail was present in the journals (Moodie and Catchpole 1975; Catchpole and Halpin 1987). For example, posts from the Hudson Bay region made a distinction between snow melting in the sun versus the shade

(Ball 1995). Subcodes for the Yukon journals were initially divided up into four time intervals: morning, afternoon, night, and all day. For example:

> Weather clear in the morning but cloudy & threatening rain at night.
>
> (Fort Selkirk- August 9, 1851)
> (NA MG19-D13)

> The weather suddenly changed last night to cold... before sunrise -23 at noon -26 [ºF] but beautifully clear and calm.
>
> (Frances Lake- December 18, 1842)
> (HBCA B.73/a/1)

> Heavy showers of rain in the afternoon.
>
> (Pelly Banks- August 29, 1846)
> (NA MG19-A25)

In general, time-associated weather references were not common. Table 10 outlines the percentage of direct codes associated with any of the four time intervals. The mean percentage of all the codes associated with a time interval is 14.20%. The highest mean percentages were from Snowfall and Rainfall codes, 43.70% and 28.50% respectively. The percentage of the other three direct codes, Temperature (2.88%), Cloud conditions (4.88%) and Wind strength (5.85%), were significantly lower. Also, Rainfall and Snowfall account for the lowest number of daily references overall (Table 10). Both categories account for fewer than 300 references, while the next lowest category, Wind strength, accounts for double the amount. Since rainfall and snowfall appear to be less frequently cited weather conditions, the occurrence of such conditions may have been considered more noteworthy compared to other conditions, such as temperature and wind, which were daily events. Consequently, the authors may have been biased towards recording more detail on precipitation events. Since only two of the direct categories, representing 16% of all the coded segments, were associated with time, it was deemed inappropriate to apply time interval coding to all the categories. Instead, the smallest unit of time used in the study is a day.

Table 10: Percentage of total direct codes associated with a time interval (averaged for all Frances Lake, Pelly Banks and Fork Selkirk data)

Direct Category	Minimum Percentage	Maximum Percentage	Mean Percentage	Total number of coded segments
Temperature	0.07	7.46	2.88	1285
Rainfall	22.22	57.14	43.79	272
Snowfall	24.14	32.86	28.50	285
Wind strength*	1.60	8.57	5.85	664
Cloud conditions	2.08	8.33	4.88	707
All codes	0.07	60.71	14.20	3569

* Wind direction is not included because no time period was specified in conjunction with direction.

Part 3: Quantification

Once all the daily entries had been coded according to the coding scheme, monthly subcode totals were calculated for each month of each year by post. These totals can be used for frequency counts (i.e. content analysis). Table 11 provides an example of the monthly subcode totals for Fort Selkirk. Appendix 3 provides an example of the monthly code totals for all posts and subcodes. To review the monthly subcode totals for the three posts, please refer to Appendix 3a-c on the attached CD. In order to highlight trends, the daily subcode data were summed or averaged to a monthly or seasonal level. Viewing the data in seasonal formats is particularly useful for the identification of normal versus extreme conditions. The seasonal divisions used for the index are as follows:

Spring = April – May	Summer = June – August
Fall = September – October	Winter = November – March

Traditionally, many paleoclimatic studies have used a three month division to represent seasons where Winter = December-February, Spring = March-May, Summer = June-August, and Fall = September-October. However, this seasonal division is not appropriate for a northern latitude study site where the winter season is more prolonged and not adequately represented by only three months. Generally, the winter season is defined as the period when the mean daily temperature is below freezing. Summer is defined as the period where the mean daily temperature is above 10°C. Wahl et al. (1987) suggest that the winter season in the Yukon lasts from mid-October to mid-April and the summer lasts from July-August. For the purpose of this study, the winter season is defined as November to March in order to have spring and fall seasons that are represented by two complete months. Figure 9 compares average monthly temperature and precipitation for the modern period between the three climate normal stations used in this study. The largest temperature difference (4.5°C to 6°C) between the three sites occurs in winter (mainly December-February). Precipitation varies more then temperature, on account of the Watson Lake A record which represents one of the wetter areas in the Yukon. Its precipitation values are consistently higher, particularly in May and June.

Average Calculations

Totals and averages for the month, year and season were calculated. Two different averages were calculated depending on the subcode. Average 1 represents the number of monthly or seasonal references for a subcode while Average 2 indicates the average number of occurrences of a subcode. Average 1 was applied to <u>Temperature</u>, <u>Wind strength</u>, <u>Wind direction</u> and <u>Cloud conditions</u> and is based on the total number of subcode references per year divided by the total number of years that contain references to the subcode. This average does not consider a lack of reference to a subcode as an indication of a lack of the subcode's conditions. For example, references to wind strength were noted often but not every single day. To assume that a lack of wind reference meant a lack of wind would be improper, since the authors did record calm condition. Average 2 was specifically applied to the <u>Snowfall</u> and <u>Rainfall</u> subcodes. Average 2 is based on the total number of references per year divided by the total number of years with entries regardless of whether references to snowfall or rainfall were made. This average takes into account that a month with no reference to precipitation may actually indicate that

Category	1849 Apr	1850 Apr	1851 Apr	1852 Apr	Ave 2	Total	1848 May	1849 May	1850 May	1851 May	1852 May	Ave 2	Total	1848 Jun	1849 Jun	1850 Jun	1851 Jun	1852 Jun	Ave 2	Total
Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0.4	2
Heavy	0	0	0	0	0	0	0	0	1	1	1	0.6	3	1	0	0	0	1	0.4	2
Showers	0	0	0	0	0	0	0	1	1	1	0	0.6	3	7	2	3	5	0	3.4	17
Raining	0	2	1	0	0.75	3	1	0	1	3	4	1.8	9	1	3	1	3	3	2.2	11
All rain total	0	2	1	0	0.75	3	1	1	3	5	5	3.00	15	9	5	5	9	4	6.4	32

Category	1848 Oct	1849 Oct	1850 Oct	1851 Oct	Ave 2	Total	1848 Nov	1849 Nov	1850 Nov	1851 Nov	Ave 2	Total	1848 Dec	1849 Dec	1850 Dec	1851 Dec	Ave 2	Total
Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Showers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raining	1	0	0	2	0.75	3	0	0	0	1	0.25	1	0	0	1	0	0.25	1
All rain total	1	0	0	2	0.75	3	0	0	0	1	0.25	1	0	0	1	0	0.25	1

	Spring* - March – May							Summer – June – August						
Category	1848	1849	1850	1851	1852	Ave 2	Total	1848	1849	1850	1851	1852	Ave 2	Total
Light	0	0	0	0	0	0	0	1	6	5	3	0	3	15
Heavy	0	0	1	1	1	0.6	3	3	4	3	1	4	3	15
Showers	0	1	1	1	0	0.6	3	11	4	10	8	0	6.6	33
Raining	1	0	3	4	4	2.4	12	7	12	6	13	12	10	50
All rain total	1	1	5	6	5	3.6	18	22	26	24	25	16	22.6	113

Note: Spring 1848 data based on May data only (no data 1848 for March or April)

	Fall - October - November						Winter *- December - February						**Total**
Category	1848	1849	1850	1852	Ave 1	Total	1848	1849	1850	1851	Ave 2	Total	**all years**
Light	1	1	0	0	0.5	2	0	0	0	0	0	0	17
Heavy	1	2	0	0	0.75	3	0	0	0	0	0	0	21
Showers	0	0	0	0	0	0	0	0	0	0	0	0	36
Raining	3	0	0	7	2.5	10	0	0	1	0	0	1	73
All rain total	5	3	0	7	3.75	15	0	0	1	0	0	1	147

*Note: Winter rainfall data based on December only (no rainfall recorded in January or February).

Table 11: Example of monthly code total for Rainfall – Fort Selkirk
Note that there is no rainfall mentioned for the months January-March so no table data are shown.
Average calculation is based on the "Number of Rainfall Days/Number of Years". Months with no rainfall data are assumed to indicate months with no rainfall.

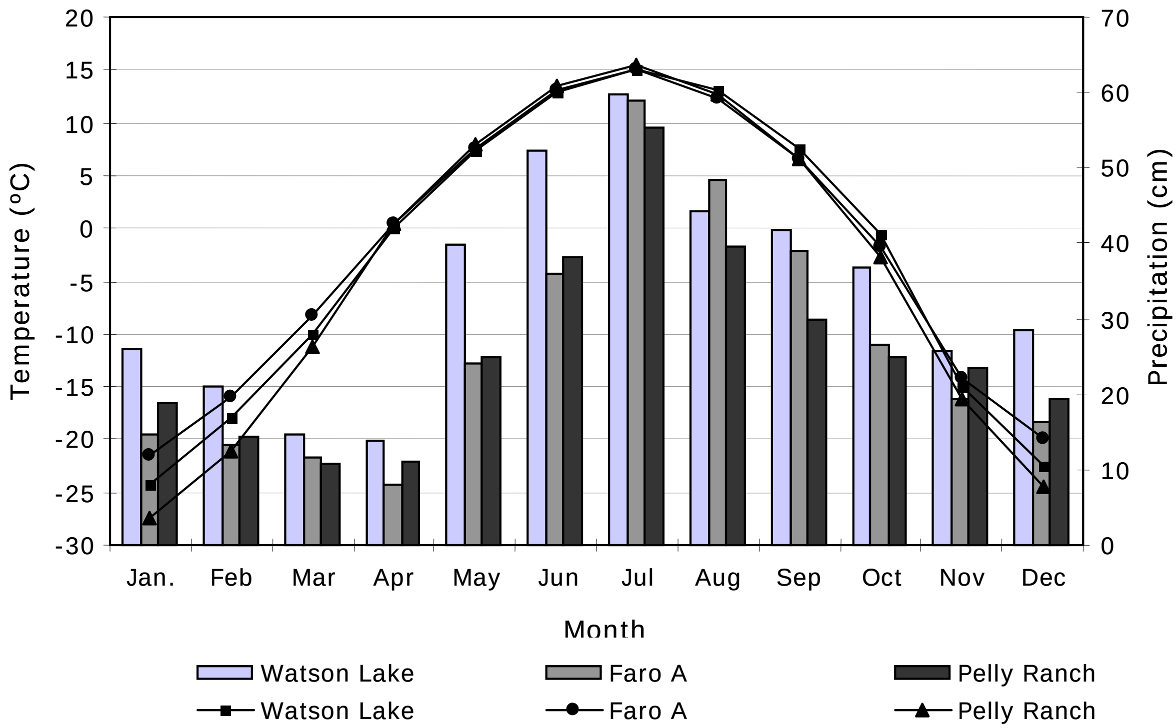


Figure 9: Comparison of the climate normal records for three climate normal (1971-2000) stations from the southern Yukon.

there was no precipitation. Table 12 (following page) gives an example of the difference between the two averages. Table 11 shows the application of Average 2 to rainfall data.

In Table 12, Average 2 indicates that there were 0.25 Cool days a month in September at Frances Lake. However, Average 2 assumes that the authors recorded qualitative temperature conditions every day, which is not the case. As indicated in Part 1, the resolution of the historical texts is high with daily entries the majority of the time. But in the case of Frances Lake, there were only 8 days in September with temperature references on average per year. Therefore, Average 1 is more appropriate since it only takes into consideration the average number of references. Average 1 shows that there was only 1 day per month with cool conditions at Frances Lake.

Category	1842 Sep	1843 Sep	1844 Sep	1845 Sep	Ave 1	Ave 2	Total
Cool		1			1	0.25	1
Cold		1	3	2	2	1.5	6
Very cold							
Mild	1	1			1	0.5	2
Warm	2			2	2	1	4
Hot							
Frost	4	1	2		2.33	1.75	7
Thaw							
Total	7	4	5	4	8.33	5	20

Average 1 = (Total # of subcode refs.) / (Total # of years with journal entries referencing subcode)

Average 2 = (Total # of subcode refs.) / (Total # of years with journal entries)

Table 12: Example of difference between Average 1 and Average 2 calculations for Frances Lake using the September Temperature subcodes

Part 4: Identification of Normal vs. Extreme Years

One of the major concerns with historical documents is a bias towards extreme events. Authors may be more likely to notice and note abnormal conditions instead of recording the weather regularly and unconditionally. The purpose of the historical document can influence whether or not this bias will occur. Personal diaries and letters are more likely to exhibit this bias than government reports or official documents because of the difference in intent. The HBC journals, as discussed previously, were created for specific purposes and the authors were expected to record events, such as the weather, daily and accurately. Consequently, a bias towards extreme events is unlikely; both normal and extreme conditions should be adequately represented in the journals.

There are a number of ways to identify extreme conditions from historical documents. Sometimes the description of the event itself is enough to indicate abnormal conditions. For example:

> Never saw such continuation of mild weather at this season. Snow soft all day & no frost at night.
> (James Stewart - Fort Selkirk, December 28, 1850)
> (NA MG19-D13)

> The weather has been throughout the month the mildest & most lovely that mortal ever saw in this part of the savage world.
> (Robert Campbell - Fort Selkirk, February 28, 1850)
> (NA MG19-D13)

References such as these must take into consideration the author's situation and extenuating circumstances. An author with little experience with the winter in the Yukon might have very different expectations than a seasoned employee of the HBC. However, both the above quotations are by HBC employees with considerable experience in northern regions, especially Campbell. As well, Stewart had spent two winters at Fort Selkirk by the time he referenced the December mild spell. Overall, the authors of the three HBC journals were seasoned employees and refrained from using exaggerated language when referring to the weather. The above quotations illustrate the strongest language used in the journals describing weather. Adjectives such as "very", "remarkably", "exceedingly", "intensely", "most" and "for the season" were the strongest qualifiers used to explain the intensity of weather conditions. When the authors indicated the day was the "coldest" or "hottest" they always qualified their statement with a time frame, such as:

> The weather clear and the coldest day we have had yet. -3 and 2.
>
> (Frances Lake – November 20, 1843)
> (HBCA B.73/a/1)

> One of the coldest days we have had this winter.
>
> (Fort Selkirk - February 23, 1849)
> (NA MG19-D13)

> Extraordinary Weather for the season. We had a regular snowstorm this morning.... This is the latest season I have known in the North.
>
> (Fort Selkirk - May 27, 1849)
> (NA MG19-D13)

There are no instances in the journals that state the weather conditions were the worst or best ever. The most extreme language appears to be reserved for descriptions of boredom and lack of food supplies. For example:

> ... our situation is becoming more and more forlorne and dreary, how are we to get through the winter in this back region God only knows. The weather is so mild that all the detriots of the lake are broke up the ice having decayed. Dawn 0. Close 7.
>
> (Frances Lake – January 12, 1843)
> (HBCA B.73/a/1)

> Our bag of Flour is now emptying and we look forward now in despair to a most dishonourable death, that by starvation. Our dogs are dying having not had anything this month. 16, 29 and 26.
>
> (Frances Lake – February 22 1844)
> (NA MG19-D13)

References to poor food supplies were common at the posts and it is unlikely that the authors were exaggerating in hopes that false information would allow for better conditions in later years. Campbell repeatedly sent letters requesting a larger outfit for his posts but the appeals often went unnoticed (Campbell 1958).

Some historical climatology studies have developed subcodes that take into account normal versus extreme weather conditions. Bartholy et al. (2004) separated their coding scheme for the Carpathian basin into moderate (i.e. normal conditions) and extreme conditions based on the month or season that the code is present. For example, Bartholy et al. (2004) determined their codes "cold", "cool", "frost", and "cold year" indicated normal conditions for the winter, while the codes "very cold", "severe winter" and "long winter" implied extreme conditions for the winter. This type of coding is particularly useful for the temperature subcodes, since words such as "cool" and "mild" can imply different conditions in different seasons.

It is also possible to avoid misinterpretation of the same subcodes in different seasons by creating different subcodes – for example, a "cool in summer", "frost in summer", or "warm in winter" subcode. These codes would represent extreme conditions, while codes called "cool in fall" or "warm in summer" would indicate normal conditions. However, the creation of the seasonally sensitive codes often creates unneeded duplication of subcodes.

Thermal (i.e. warm/cold) and wetness (i.e. wet/dry) indices are the most common method in historical climatology for determining normal and extreme conditions. Indices represent deviations from normal conditions and range from monthly and seasonally to annual and decadal in scale. Units of time, such as months, that have predominantly normal thermal or precipitation conditions are assigned a value of 0. Months that are extreme are assigned either positive (e.g. +1 for abnormally warm) or negative (e.g. -1 for abnormally cold) values.

Indices can be expressed either in excess or ratio format. Excess indices represent the excess of extreme months or years over a certain time period. These indices are appropriate for long-term, continuous records from multiple sources, which offer the opportunity to view both normal and extreme conditions. Generally, the longer time period coverage results in more information available to gauge the true range of conditions. Brooks (1926) was the first to apply indices to documentary data, resulting in winter wetness and severity annual indices for Europe for over 50 years of data. Lamb (1977) further refined the work and created a decadal winter severity index that was expressed by subtracting the number of unmistakably mild months from the number of unmistakably cold months per decade.

Excess indices are inappropriate for short-term records (i.e. less than 50 years) since the indices are sensitive to missing data and uncertainties in the perception of events (Ingram et al. 1981). Also, shorter records are more likely to have the entire coverage period fall within only a normal or extreme period; therefore, it may be difficult to gauge the true range of data. Ratio indices are more robust and are not sensitive to missing data or changes in perception. These indices are used for shorter time series or when data are not available from multiple sources, as is the case with the HBC data. Ratio indices present the total number of extreme references compared to the total number of references for a time period.

HBC Seasonal Warm/Cold Index

A seasonal warm/cold index was developed for HBC data from the southern Yukon posts and covers 117 months from 1842-1852 (with one year of missing data from May 1847-1848). The index is seasonally based to minimize the influence of individual months and highlight the impact of longer-term extreme conditions. The index is presented as an index for the entire southern Yukon Territory region. It is assumed that the local extremes experienced at a site are reflective of a regional signal. Eight months of overlap occur in the index between Frances Lake and Pelly Banks (October 1845 to May 1846). The Pelly Banks record from October 1845 to April 1846 is very limited and therefore, the Frances Lake record takes precedence. Agreement between the two index records for the overlap period confirms the reliability of the index and the common signal between the two sites.

The thermal index is based mainly on the temperature subcodes. Therefore, prior to constructing the index, it was important to examine the distribution of the temperature subcodes over the months before assigning a code as normal or extreme for a month. A consistently high relative frequency for a specific month over all years should imply that the code is likely representative of normal conditions. Conversely, the month with the lowest frequency over all years should indicate that the condition is extreme. However, this assumption is not absolute because if extreme conditions did occur during a season or more over a number of years, the frequency values would be artificially higher. Therefore, examination of the references in context was required as well. Table 13 outlines the seasonal divisions used to categorize the temperature subcodes into normal versus extreme conditions.

Table 13: Seasonal division of normal vs. extreme temperature subcodes

Subcode	Normal Season	Extreme Cold Season	Extreme Warm Season
Cool	Spring, Fall	Summer	Winter
Cold	Winter	Summer, Spring, Fall	
Very cold	Winter	Summer, Spring, Fall	
Mild	Spring, Fall	Summer	Winter
Warm	Spring, Summer, Fall		Winter
Hot	Summer		Spring, Fall, Winter
Thaw	Spring, Fall	Summer	Winter
Frost	Spring, Fall	Summer	Winter

Note: The subcode "No frost" was not included in this seasonal division since it indicates a lack of frost and should be represented inversely by the "Frost" code.

The warm/cold index does not capture extremely warm summers. References to "very hot" weather amounted to fewer than four days total for the period 1842-1852 and none of the references was from the same year. Therefore, a subcode called "very hot" was not created for this condition and no extremely warm summers are reflected in the index.

The construction of the warm/cold index is a multi-step process. Two separate index calculations were required in order to determine whether a month was extremely cold or warm, since different Temperature subcodes were applicable to different extreme conditions (Table 13). Ratios of normal to extreme conditions were calculated for each month and a two-thirds "rule" was applied to the ratios when determining the index value. The details of the index construction are as follows:

To determine if a month is extremely warm or cold, calculate:

1) the total number of references to each Temperature subcode (Appendix 3),
2) the sum of all the normal Temperature subcode references (Table 13). This value will be the same for both the extreme warm and extreme cold month index calculation,
3) the sum of all the extreme Temperature subcode references. This value will differ for the extreme warm and extreme cold month index calculation. For example, for January the number of normal subcode references would be calculated from the subcode Cold. The number of extreme warm subcode references are calculated from the subcodes Mild, Warm, Hot, Frost and Thaw. The number of extreme cold subcode references would be calculated from the subcode Very cold,
4) the sum of normal and extreme Temperature subcodes. This value will differ for the extreme warm and extreme cold month index calculation,
5) the ratio of normal and extreme references to the total number of codes:

$$\frac{\textit{Total number of extreme references for Month X}}{\textit{Total number of normal + extreme references for Month X}}$$

6) A 2/3 rule was applied to the normal and extreme ratios to determine whether the month was extremely warm, extremely cold or normal. Two-thirds of the total temperature references per month must be extreme in order for the month to be assigned an extreme value based solely on the temperature subcodes. The index values were 1 (extremely warm), 0 (normal) and –1 (extremely cold). This index does not account for extremely warm conditions in summer, as previously discussed.

7) The monthly index values were examined closely to establish reliability. Months with fewer than five qualitative temperature references were re-evaluated. At least two additional direct or indirect references were required in order to support the index value. If additional evidence was unavailable, the month was assigned a default index value of 0, since the month could not be satisfactorily confirmed as extreme. Months with extreme index ratios that almost satisfied the 2/3 rule were also examined for further direct and indirect evidence. Indirect references that indicate extreme conditions are:

    - Winter – Rainfall, Winter water activity
    - Summer – Snowfall, Frost, Ice activity, Migration

8) The monthly subcodes were averaged to create seasonal totals, resulting in an index that had a possible range from –1 to +1. The averages of the monthly values were used since the seasons were based on different numbers of months. However, this averaging has created exaggeration of index values for the spring and fall seasons, which are based on the lowest number of months. For example, a spring season with one abnormally warm month will yield an index value of 0.50 while a winter season with two abnormally warm months will result in a value of 0.40. These values imply that the extreme warmth of the spring season is more notable than the extreme warmth of the winter season.

Table 14 gives an example of the monthly index calculation for Fort Selkirk. The first section of the table gives the total number of Temperature subcodes by month and year. The second section of the table contains the index calculation for extreme cold months, while the third section gives the calculation for extreme warm months. The last row in the table gives the final index value based on both the extreme cold and extreme warm index values and also taking into account additional indirect evidence. The warm/cold index construction is exclusive, meaning that a month cannot have both an extreme warm index value of +1 and an extreme cold index value of -1. The extreme ratio values for January and February 1850 were nearly at the 2/3-threshold limit for an extreme index value. However, there was no other direct or indirect evidence that indicated January was colder than normal. In fact, there is even one reference on January 6th indicating "Most beautiful weather for the season" (NA MG19-D13). There are two additional indirect references of the same nature for February 1850 that confirms the month was warmer than normal. Therefore, the index value assigned was +1. The extreme warm index value for February 1852 was originally +1 but the final index value was revised to 0 because there were fewer than five qualitative temperature references and no additional supporting evidence. The calculations for the warm/cold index are located in Appendix 3.

It should be noted that the Miscellaneous references Good and Poor were not included in the index calculation as indicators of normal and extreme conditions. References to "fine", "fair" and "good" weather were common, but it cannot be assumed that these are indicators of normal conditions. At times, Good references were used in conjunction with extreme temperature subcodes (i.e. “Fine and mild” in January). Also, the high number of miscellaneous subcodes would in many cases outweigh the number of qualitative thermal descriptors and result in the false impression that a month was normal.

Wet/Dry Index

A wetness index was not constructed for the HBC data because there was little indication of periods of drought or floods. Wetness indices are more relevant to regions where precipitation plays a major role in climate, such as India and Sub-Saharan Africa (Nicholson 2001). However, the snowfall and rainfall data were used to determine the number of snow and rain days per month, which are compared to the modern records.

Part 5: Comparison to the Modern Record

In order to determine how the historical records differ from the modern record, the monthly and seasonal averages and totals of the subcodes are compared to the records of climate normal stations located near the three posts. As indicated previously, there are only 17 stations in the Yukon Territory that meet the criteria for a climate normal station. Figure 10 shows the location of the Environment Canada climate normal stations at increments of 50km buffer distances from the posts. Only one of the HBC posts, Fort Selkirk, has a climate normal station within 50 km of it: Pelly Ranch. The closest climate normal stations for Frances Lake and Pelly Banks are Watson Lake A and Faro A at approximately 150 km distance.

The lack of a nearby climate normal station for Pelly Banks and Frances Lake is problematic. There are three additional meteorological stations within 50 km of the Frances Lake post (Figure 3): Frances Lake, Hour Lake and Simpson Tower. The records of Frances Lake and Simpson Tower cover only two years from 1976-1978, while the Hour Lake record (1982-2002) has 50% of the data from 1980s missing and only one complete year in the 1990s. The station Tutichua is within 100 km of Frances Lake but has patchy coverage from 1967-2002. There are four additional meteorological stations within 100 km of Pelly Banks (Sheldon Lake, Ketza River Mine, Ross River A, and Ross River YTG). The Ross River A station (1961-1994) offers the least problematic record but continuous data are only available from 1984-1994. Table 15 lists the modern stations used for comparison for each post.

Verification of the Seasonal Warm/Cold Index

The warm/cold Index was verified by comparing the seasonal index values with the temperature anomaly between the historical Frances Lake temperature record (December 1842 – May 1844) and the modern temperature record from Watson Lake A. The Frances Lake temperature record contains the earliest available continuous temperature readings for the southern Yukon. The following section details the nature and treatment of the historical readings.

Table 14: Example index calculation for extreme cold and extreme warm month: Fort Selkirk

Step	Subcode	1849 Jan	1850 Jan	1851 Jan	1852 Jan	1849 Feb	1850 Feb	1851 Feb	1852 Feb	1849 Mar	1850 Mar	1851 Mar	1852 Mar
1	Cool										1		
1	Cold	6	7	15	1	7	5	6	1	7	8	2	3
1	Very cold	5	11	5		8					1		
1	Mild	15	7	11	7	4	5	14	2	9	5	6	2
1	Warm						1						
1	Hot												
1	Frost												
1	Thaw				1		3					2	1
2	Normal	6	6	15	1	7	5	6	1	7	8	2	3
3	Extreme cold	5	12	5	0	8	0	0	0	0	1	0	0
4	Total	11	18	20	1	15	5	6	1	7	9	2	3
5	2/3 Normal	0.55	0.39	0.75	1.00	0.47	1.00	1.00	1.00	1.00	0.89	1.00	1.00
5	2/3 Extreme cold	0.45	0.61	0.25	0.00	0.53	0.00	0.00	0.00	0.00	0.11	0.00	0.00
6-7	Index value	0	0	0	0	0	0	0	0	0	0	0	0
2	Normal	6	7	15	1	7	5	6	1	7	8	2	3
3	Extreme warm	15	7	11	8	4	9	14	2	9	6	8	3
4	Total	21	14	26	9	11	14	20	3	16	14	10	6
5	2/3 Normal	0.29	0.50	0.58	0.11	0.64	0.36	0.30	0.33	0.44	0.57	0.20	0.50
5	2/3 Extreme warm	0.71	0.50	0.42	0.89	0.36	0.64	0.70	0.67	0.56	0.43	0.80	0.50
6-7	Index value	1	0	0	1	0	0	1	1	0	0	1	0
	Final index value	1	-1	0	1	0	1	1	0	0	0	1	0

Table 15: Modern climate stations used for each post

HBC Post	Modern Station	Distance
Frances Lake	Watson Lake A	150 southeast
Pelly Banks	Faro A	120 km northwest
Fort Selkirk	Pelly Ranch	35 km southeast

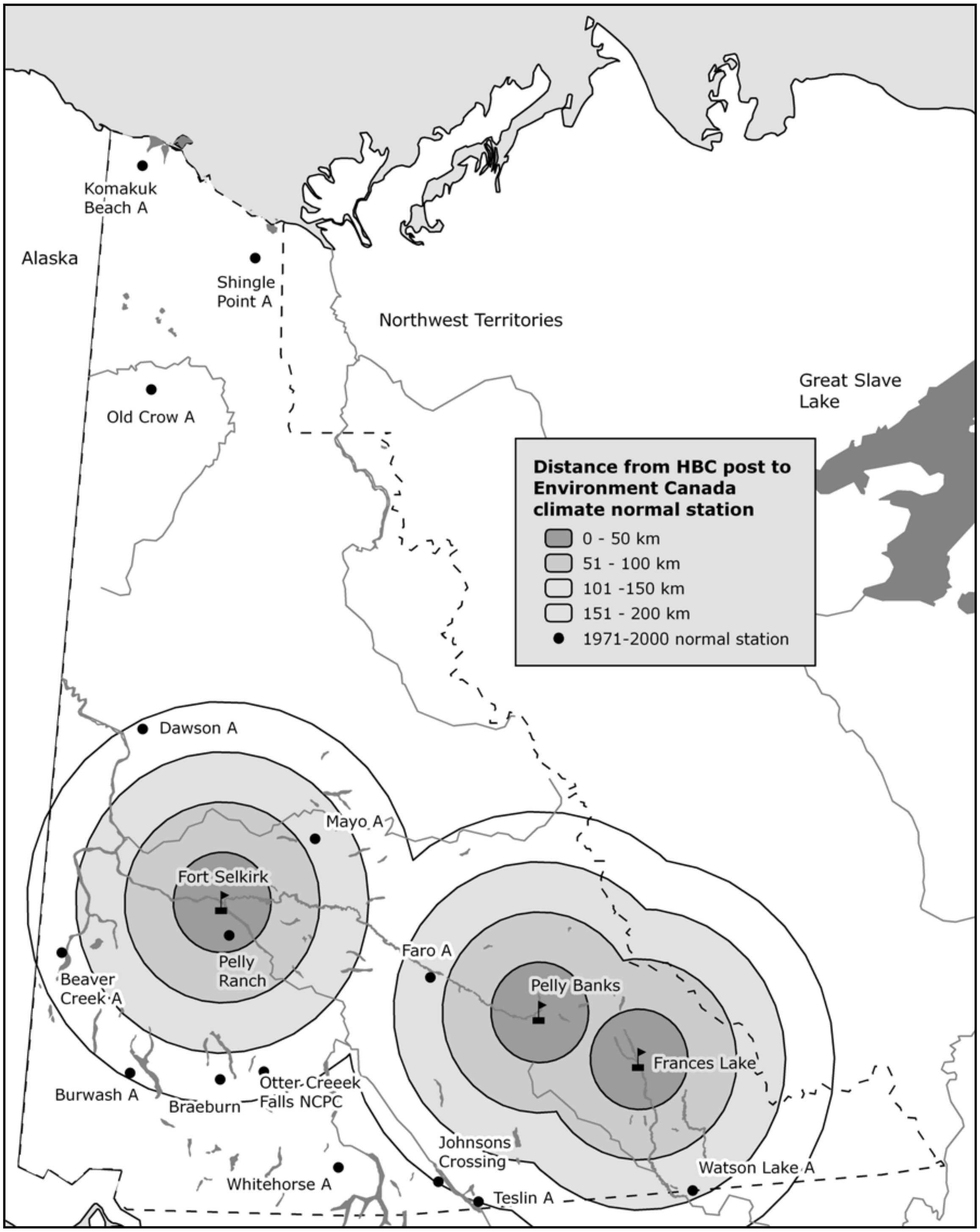


Figure 10: Distance from each post to Environment Canada's climate normal stations.

Frances Lake Temperature Record

Temperatures readings, in Fahrenheit, were taken up to three times a day at Frances Lake for the period December 1842 – May 1844 and were included within the qualitative journal entries. From December 1842 and January 1843 additional notations in the journal entries indicated if a reading was from the morning, noon or night. After this period, this information was not often given. However, it was assumed that three temperature readings likely represented the morning, noon and night. After May 17, 1845, the number of temperature readings per month dropped dramatically and account for fewer than half a dozen days. Table 16 outlines the missing data in the December 1842 to May 1844 record.

When calculating monthly mean temperatures from the climate normal period the World Meteorological Organization's "3/5" rule is usually applied (Environment Canada 2004). Monthly means are not computed if more than three consecutive daily temperature readings are missing or if more then five daily temperatures readings in total for a given month are missing. Only 10 of the 16 months represented in the Frances Lake historical temperature record meet the 3/5 rule. However, the majority of the remaining months are represented by days with at least two temperature measurements. Therefore, monthly averages, as well as the average minimum and maximum for all months, were calculated for the Frances Lake data for comparison to the modern Watson Lake A record.

Table 16: Missing Frances Lake temperature readings by month

Month	1842	1843	1844
January		2 days	2 days
February		1day	4 days
March		1 day	2 days
April		8 days	1 day
May			14 days
June			
July		19 days	
August		16 days	
September		11 days	
October		12 days	
November		4 days	
December	11 days	1 day	

Note: Blank cells indicate months with no historical temperature readings.

Very little is known about the thermometers used at the Yukon posts. The journals make no reference to the manufacturer or placement of the instruments, or whether more than one instrument was used for the readings. By the mid-1800s thermometer construction was relatively reliable, so it is unlikely that adjustments needed to be made to the readings due to instrumentation (Ball 1995). However, the location, calibration, exposure and recording schedule are all issues that must be addressed before establishing the reliability and comparability of an early instrumental record. Edward Parry's meteorological records, from his over-wintering in the eastern Canadian Arctic sea-ice during 1822-23, provide an excellent example of the questions that are raised when considering an early meteorological record (Kay 1995). Parry's expedition took temperature measurements from two locations: the ship's deck and over the ice. The location of the thermometer was changed during the winter to avoid the impact of the ship's warmth on the readings. Both spirit and mercury thermometers were used but the manufacturer was not indicated, which may have repercussions on the accuracy of the instruments. Readings were taken every two hours, but Parry did not indicate how the mean, minimum or maximum temperature values were calculated. Drawing on contemporary procedures, Kay (1995) determined that the values may be a compilation, such as a simple average, of all 12 thermometers in use. Unfortunately, all that can be determined from the Frances Lake journals is that multiple readings were taken daily and likely represented morning, noon and night readings.

The Pelly Banks journal contains one reference to a thermometer on July 25, 1846. Campbell notes, "On account of the exposure of the Thermometer to the sun by one of the men, it burst" (NA MG19-A25). However, the Pelly Banks journal does not contain any temperature readings and no reference is made to temperature being recorded elsewhere. The Fort Selkirk journal makes no reference to temperature readings.

Phenological Data

The use of phenological data, such as harvest dates, lacks application for the Yukon. Agriculture did not play a major role in the Yukon's economy in the past, due to its short growing season. The growing season in the Yukon is approximately 800 growing degree days, which is 100 degree days fewer than needed for barley to ripen and 200 degree days fewer than required to ripen wheat (Hill et al. 2002). However, the near 24-hour sunlight available from June to July provides a much extended growing day, which compensates for the shorter season. One of the tasks assigned to the HBC posts was to determine the usefulness of the landscape for agriculture. The establishment of small farm plots served two purposes: 1) to test the suitability of the land and climate for agriculture, and 2) if possible, to supply the posts with alternative and sustainable food sources. All three HBC posts used in this study had at least one reference to "experimental farms", which consisted mainly of barley and potatoes.

Unfortunately, none of the post's farming attempts met with much success. Early frost was the major culprit, although agricultural inexperience may have been partly to blame. The post journals show that at least some of the crops were planted too early or harvested too late:

> Barley in the upper field about an inch above ground. Here ends the month of May. Dreary and cold in the extreme, little or no vegetation & the banks of the river covered with Ice still...
>
> (Fort Selkirk, May 31, 1849)
> (NA MG19-D13)

> Hard frost overnight. Took up our Crop of Turnips which we ought to have done Saturday as the frost of last night has injured them. Ice on still water all day. 35 fish some of them very rusty.
>
> (Fort Selkirk, October 10, 1848)
> (NA MG19-D13)

Overall though, inhospitable conditions, such as unpredictable frost, appeared to be the major agricultural obstacle:

> Three nights ago the potatoe stalks were blackened by the Frost & tonight it is getting cold sufficiently so to put down all the Flies.
>
> (Fort Selkirk, July 7, 1849)
> (NA MG19-D13)

> The Barley was thrashed and cleaned which is nearly a keg and but for the above mentioned [frost] would have yield & good returns for about 1 ½ gallons sown.
>
> (Fort Selkirk, September 13, 1849)
> (NA MG19-D13)

> A hard frost this morning which was the unkindest of all to our Experimental farm.
>
> (Pelly Banks, August 17, 1846)
> (NA MG19-A25)

> About four inches of snow on the ground this morning and icicles hanging on the Houses. From such a wintery aspect, I began to take up the Potatoes and gathered about a quart from a large piece of ground, in size from a pea, to pigeon's egg the largest. Some of the seeds planted, appear as fresh as when put in the ground, and those which did not send a sprout or stem, through the ground, had generally most increase, all nestled in a cluster around the mother plant. Partially clear and sunshine occasionally, but snow still on ground.
>
> (Pelly Banks, September 12, 1846)
> (NA MG19-A25)

Phenological data relating to the migration of birds were available in the HBC journals. Previous work by Ball (1983) had indicated that dates of snow geese spring migration from post journals located in the Hudson Bay region indicated climate change. Ball's work, however, was based on over 100 years of data. The issue with the Yukon posts is that the time period is very short (<10 years) and the authors did not record references to migration every year. For years with migration references, the first and last date of migration for the spring and fall were noted. This information, as well as the harvest dates, is useful in a supplementary fashion only. Eley and Findlay (1977) identified very few suitable regions in the Yukon for subsistence agriculture. None of the regions identified were in the vicinity of Frances Lake, Pelly Banks and Fort Selkirk.

Chapter 4: Results

Weather information was available from the three Hudson's Bay Company (HBC) posts for the period July 1842 to August 1852 (HBCA B.73/a/1 -4; NA MG19-A25; NA MG19-D13). A total of 109 out of 122 months were covered by the journals. The majority of the missing months were from May 1847 to April 1848, which marks a gap in the Pelly Banks and Fort Selkirk journals. June 1843 is also absent in the Frances Lake journals. As indicated in Chapter 3, weather information was not recorded daily in the journals, but 76%, 49% and 79% of the daily entries referenced either direct or indirect weather for Frances Lake, Pelly Banks and Fort Selkirk, respectively. A total of 4739 weather references were coded. Direct weather references accounted for 75% (3570) of the weather references while indirect references accounted for 25% (1169), indicating that the authors were inclined to record actual weather conditions.

Monthly Category Averages

The breakdown of weather references varies by post and month. Part of this variability was due to differences in journal length. Pelly Banks represents the shortest journal coverage and hence the total number of weather references was lower than the journal of Fort Selkirk and Frances Lake. To increase comparability between the three post journals, a weighted average was applied to monthly, seasonal and yearly data. Table 17 outlines the weighted values applied to each post by month and year. The monthly averages are weighted by the number of years with data from that month. For example, June data for Frances Lake are weighted by a value of 2.00 since there are only two months of journal entries for June (June 1843 and 1844). Decimal weight values reflect months with missing daily entries. Pelly Banks has an October weight of 1.55 since the entire month of October 1845 is available but Oct 1846 is only available after the 17th of the month. Average annual data were weighted by the total number of years with references. Fort Selkirk represents the longest records and, therefore, the largest weight value (4.1 years), while Pelly Banks (1.5 years) represents the shortest record.

Table 17: Average monthly and annual weighted values

Month	Frances Lake	Pelly Banks	Fort Selkirk	All posts
January	4.00	2.00	4.00	3.33
February	4.00	2.00	3.64	3.21
March	4.00	1.50	3.84	3.11
April	4.00	1.87	4.00	3.29
May	3.00	1.00	4.26	2.75
June	2.00	1.00	5.00	2.67
July	3.52	1.00	5.00	3.17
August	4.00	1.00	4.71	3.24
September	4.00	1.00	3.07	2.69
October	4.00	1.55	3.55	3.03
November	3.80	2.00	3.77	3.19
December	4.00	2.00	3.77	3.26
Annual	3.7 years	1.5 years	4.1 years	9.24 years

The average number of days with weather references varies by month (Figure 11). Overall, September has the highest number of weather references with each post having its maximum from August – October. Months with the lowest number of weather references show a lack of trend and occur in May and July (Frances Lake), November (Pelly Banks), and April (Fort Selkirk). The lower number of weather references in spring and mid-summer may reflect time spent away from the posts when the men were transporting furs, exploring the region, and securing food supplies for the upcoming winter. Similar trends are seen when examining the overall average monthly references that are direct or indirect (Figure 12). The highest number of direct references occurs in August while the highest number of indirect references occurs in October (due to increased references to Fall vegetation, Fall migration and Freeze-up activity). The lowest number of direct references occurs in May, while the lowest number of indirect references occurs in January and from May - July. Figure 12 shows that the total number of direct references clearly outweighs indirect references over all months.

Figure 13 illustrates the breakdown of the direct and indirect weather categories. Overall, direct weather references account for 75% of the weather references but not all direct categories were represented equally in the journals. Figure 13b shows that the Temperature subcodes accounted for the largest number of references, 35%. Cloud conditions accounted for the next highest at 20%. Approximately half of the Wind strength references (19%) were also accompanied by Wind direction (10%) information. Understandably, Rainfall (8%) and Snowfall (8%) references account for the lowest percentages of direct references since precipitation events do not occur on a daily basis unlike temperature, wind and cloud cover. Miscellaneous references accounted for 15% of all weather references (Figure 13a) and 61% of indirect references (Figure 13c). The remaining indirect categories, Human impacts, Biological and Ice activity, represent only 9% of the total weather references when combined, indicating the lack of regular references to these conditions. However, this is expected because some of the indirect references, such as Biological and Ice activity, are seasonally based and are not referenced daily.

The type and number of references for each direct and indirect code category differs by post. Table 18 outlines the weighted annual average for each category. Fort Selkirk has the highest number of annual references in six of the ten categories, particularly in terms of Temperature and Ice activity. The higher number of references in the Fort Selkirk journals may reflect a more stable time in the HBC's stay in the Yukon. During the establishment of Frances Lake and Pelly Banks, Campbell and his men were still new to the region and were occupied with establishing fur-trading relationships, maintaining the posts and exploring the region. By the time Fort Selkirk was built, the priorities were slightly different. The main goal was to establish a permanent post that was supplied with furs steadily. Campbell and Stewart may have had more time on their hands for writing, resulting in a more detailed journal-writing regime.

Frances Lake has the highest annual average in two categories. On average Frances Lake had 103 miscellaneous references to weather each year, which include qualitative terms such as "fine" and good". This is 1.3 times the amount found in the Fort Selkirk journals and six times Pelly Banks. Frances Lake also had the highest annual average of Wind strength references, with almost 30 more references a year than Fort Selkirk. Pelly Banks, on the other hand, had the lowest annual averages for all categories except Human impacts. The low number of references is likely a reflection of the informal nature of the Pelly Banks journals. The post also has a particularly low number of Wind direction references compared to the other posts.

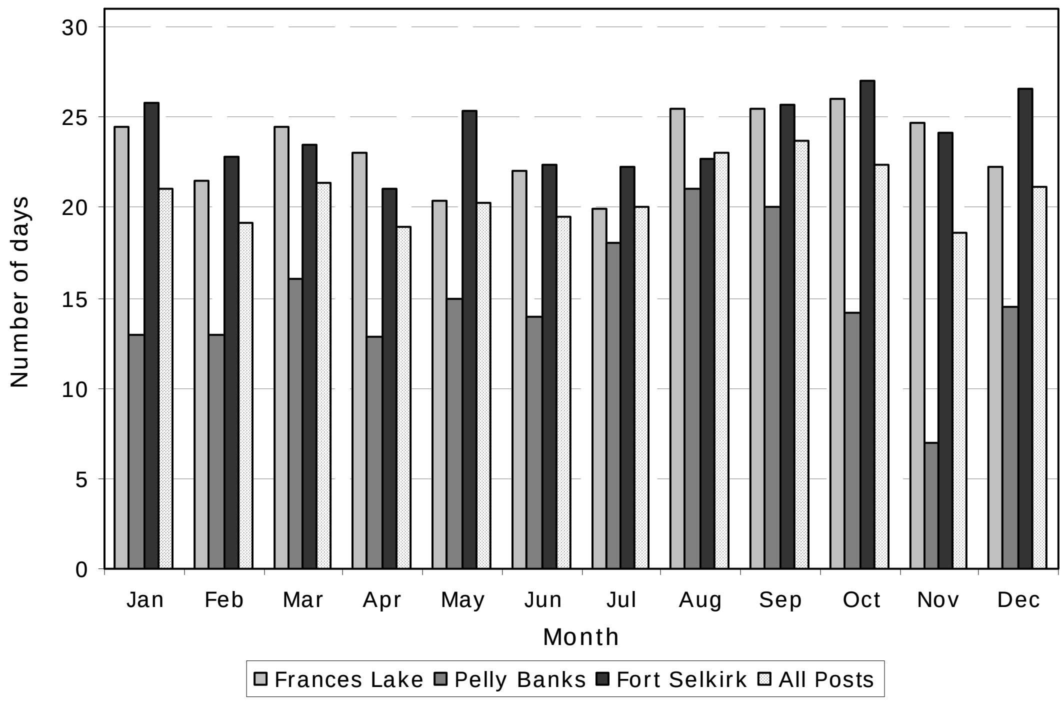


Figure 11: The average number of days per month with all weather references.

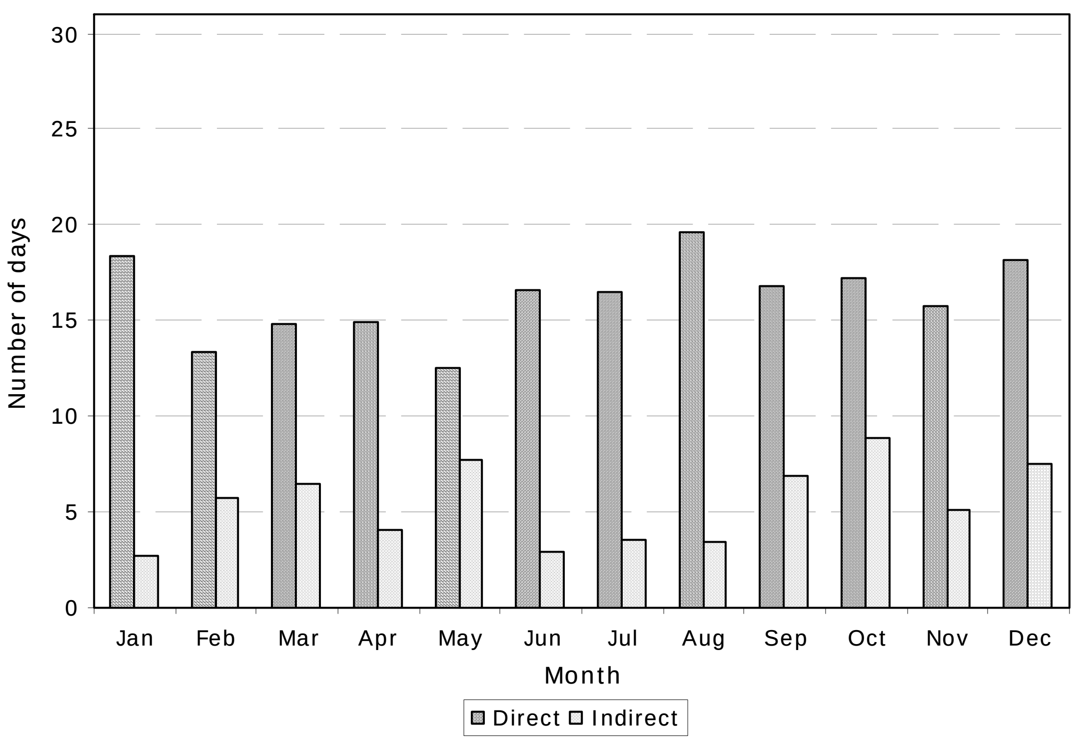


Figure 12: The average number of days per month with direct or indirect weather references (averaged over all three posts).

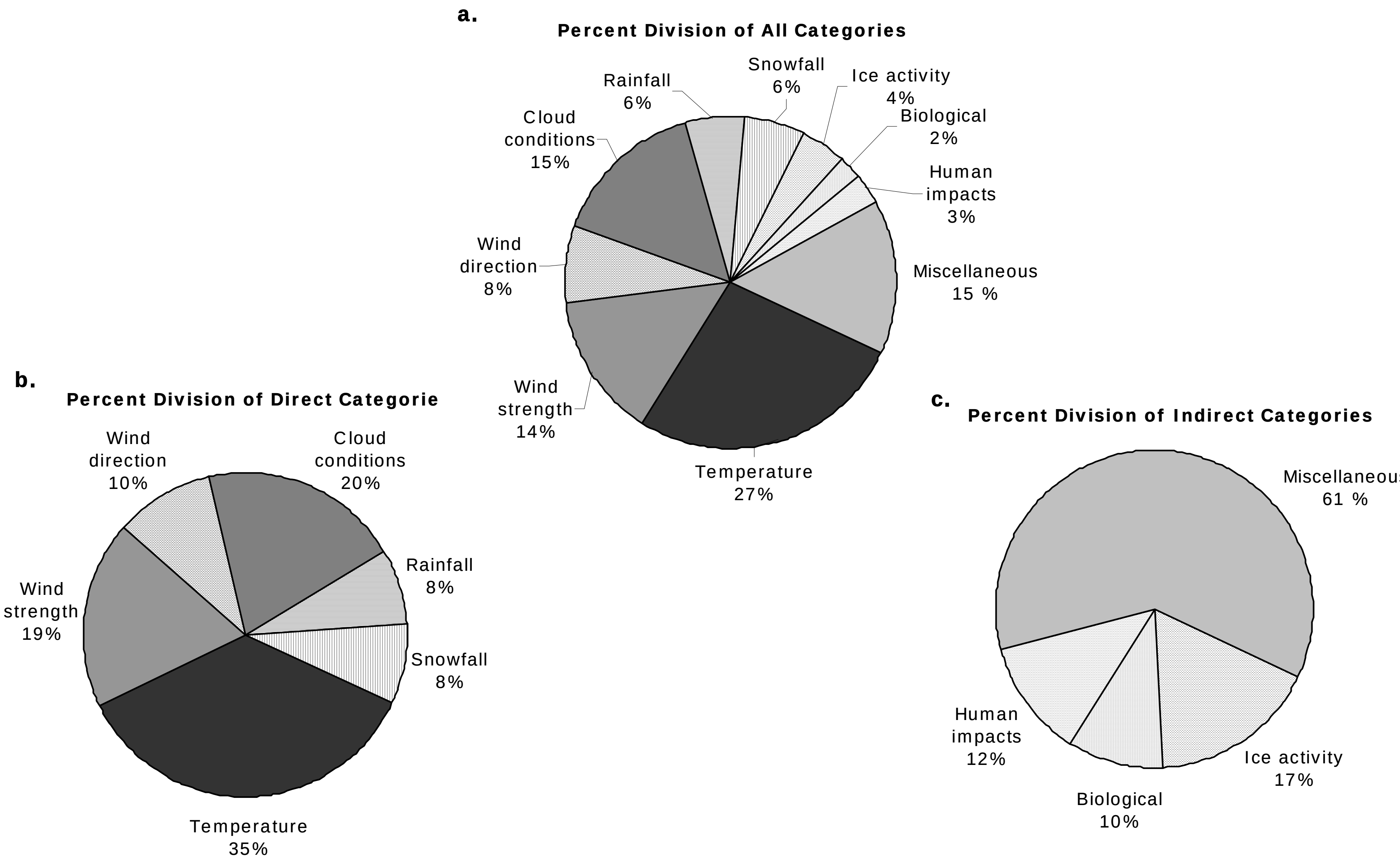


Figure 13: (a) The percent of total number or references for each direct and indirect category. (b) and (c) The percent division for the individual direct and indirect categories, respectively.

Table 18: Weighted annual average number of references by category and post

Category	Frances Lake	Pelly Banks	Fort Selkirk	All posts
Temperature	113.0	85.3	179.8	138.9
Cloud conditions	76.8	41.3	88.5	76.7
Wind strength	91.6	44.7	62.0	71.9
Wind direction	40.0	21.3	43.7	38.9
Rainfall	25.4	20.7	35.9	29.4
Snowfall	33.0	28.7	29.3	30.8
Miscellaneous	102.7	15.3	76.3	77.5
Ice activity	12.4	5.3	36.1	21.9
Biological	8.1	6.0	18.3	12.3
Human impacts	13.0	16.0	15.9	14.8

The average number of monthly weather categories is not evenly divided between months or posts. Some categories, such as Rainfall, Snowfall and Ice activity, are seasonally limited, while others, such as Temperature and Cloud conditions, could be evenly represented by all months. Figures 14-19 illustrate the average monthly number of references for all direct weather categories. Clear differences in the number of references per month and by post are evident. The winter months are especially important with regards to Temperature references (Figure 14). January has the highest number of temperature references for Fort Selkirk (23 references) and Frances Lake (15.5) while December is the highest for Pelly Banks (12.0). Spring and summer months have the lowest number of temperature descriptions (at least 10 days fewer). Cloud conditions, on the other hand, are more evenly distributed among months with a smaller range between the maximum and minimum number of references (Figure 15). All the posts exhibit approximately a six-day difference between the months with highest and lowest number of cloud references. Average monthly Wind strength references show a different trend when comparing Frances Lake to Pelly Banks and Fort Selkirk. Both Pelly Banks and Fort Selkirk experienced peaks in monthly references in spring and in late summer (Pelly Banks) and fall (Fort Selkirk). However, Frances Lake did not exhibit the spring increase or the corresponding summer low. Rather, monthly references to Wind strength began to increase in spring and peak in the fall. Wind direction references follow the same Wind strength pattern described above. The monthly distribution of Rainfall and Snowfall averages is as expected (Figures 18 and 19). The number of days with rainfall is the highest in July for Pelly Banks and in August for Frances Lake and Fort Selkirk. Fort Selkirk also exhibits an earlier decline in rainfall days in September, compared to October as seen in the other posts. None of the journal entries for the summer months (June-August) mentions snowfall at the posts. However, the month with the highest number of snow day differs widely between posts. Snow days are the greatest in January for Frances Lake, March for Pelly Banks and November for Fort Selkirk. The average monthly breakdown for indirect codes is not discussed in detail here since the references are often seasonally based (e.g. Ice activity, Biological). A discussion of the seasonal averages of the indirect subcodes is in the next section.

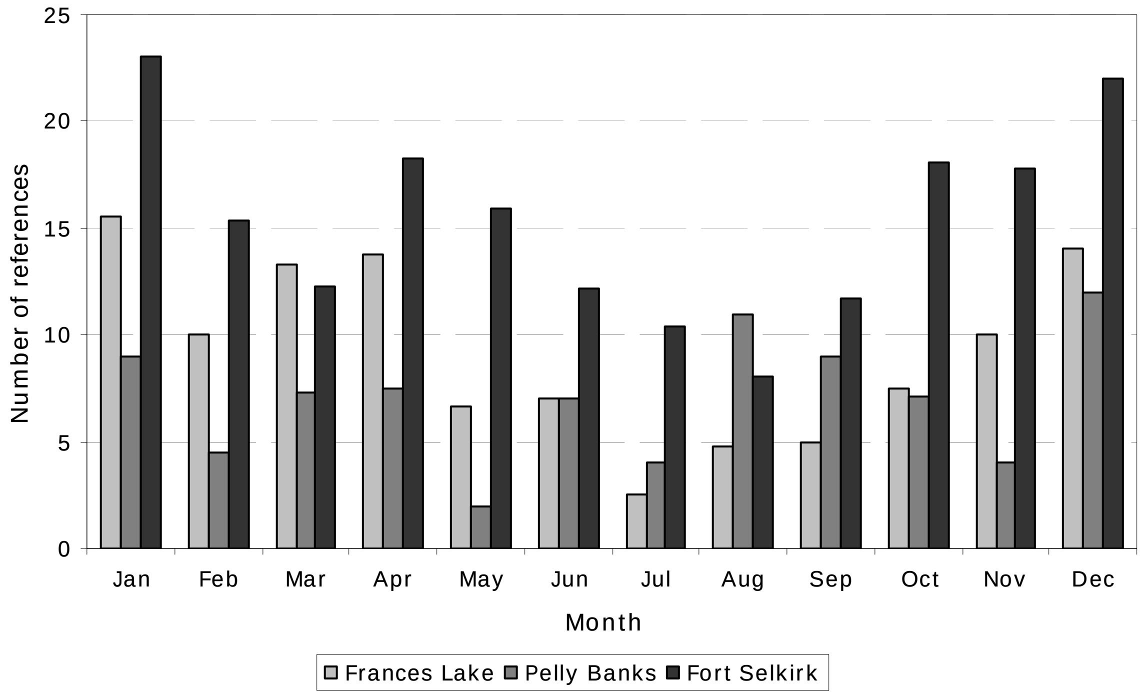


Figure 14: Weighted average number of monthly Temperature references by post.

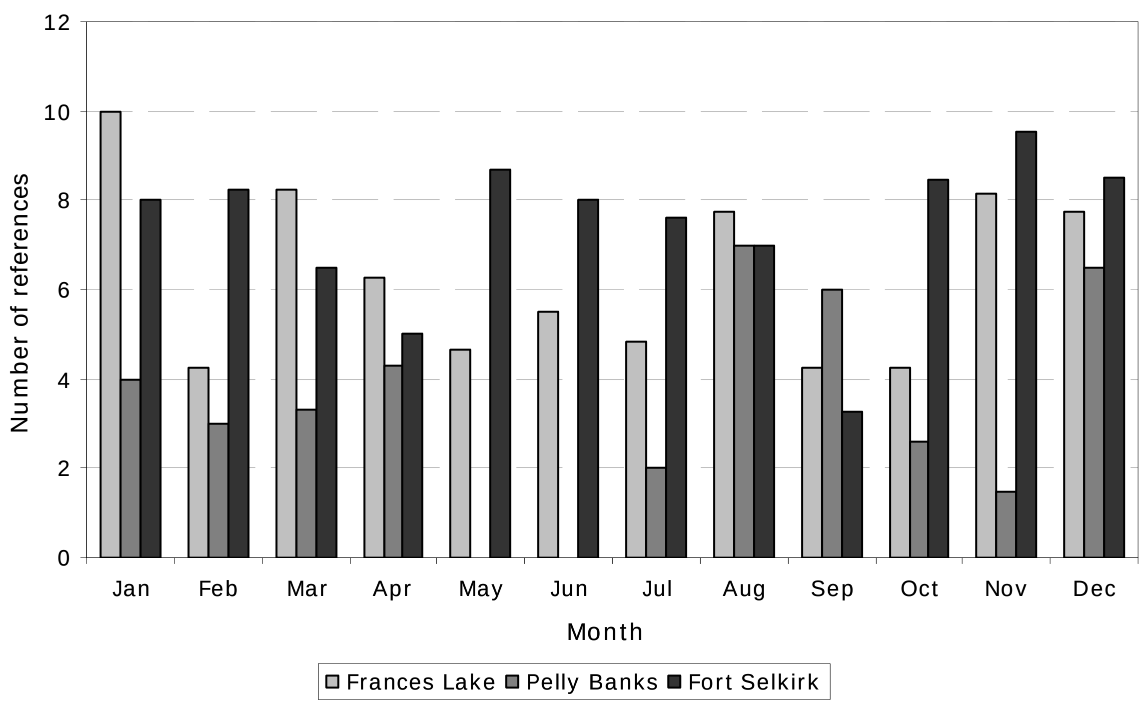


Figure 15: Weighted average number of monthly Cloud conditions references by post.

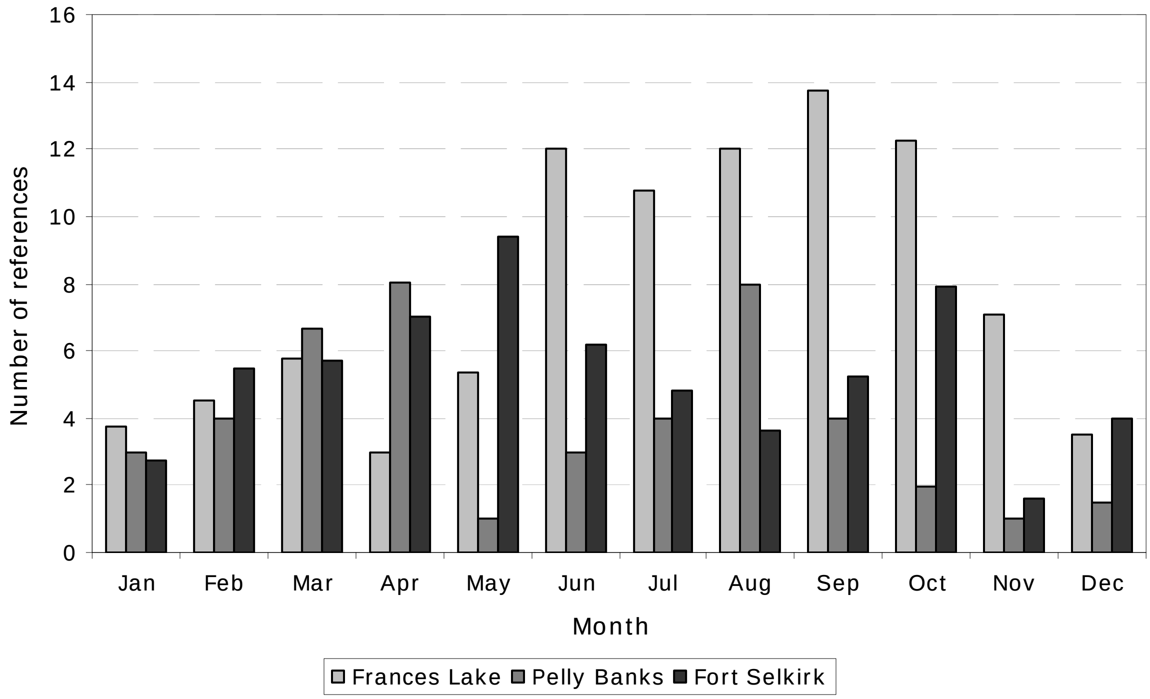


Figure 16: Weighted average number of monthly Wind strength references by post.

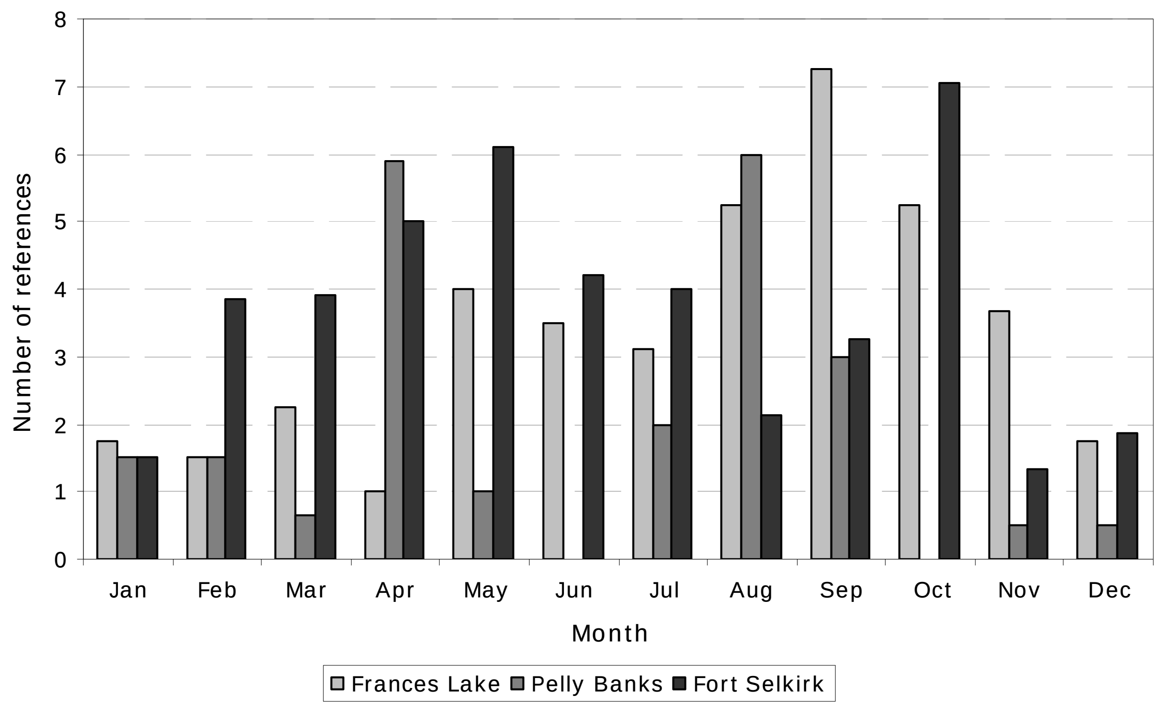


Figure 17: Weighted average number of monthly Wind direction references by post.

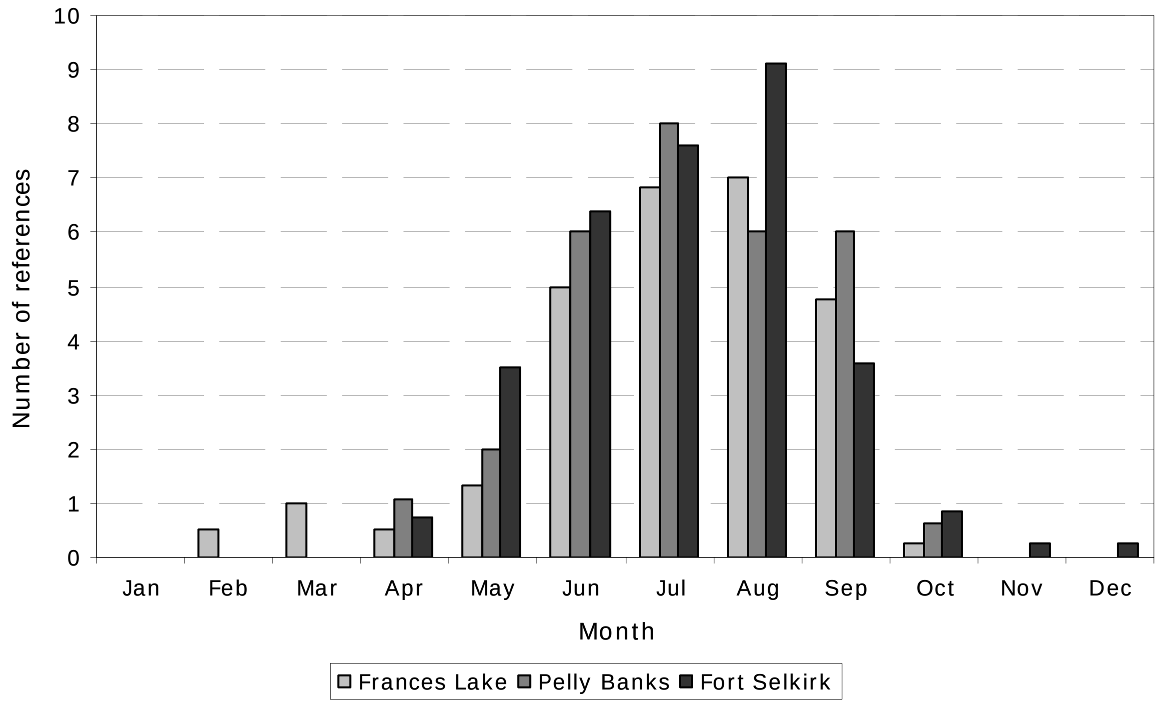


Figure 18: Weighted average number of monthly Rainfall references by post.

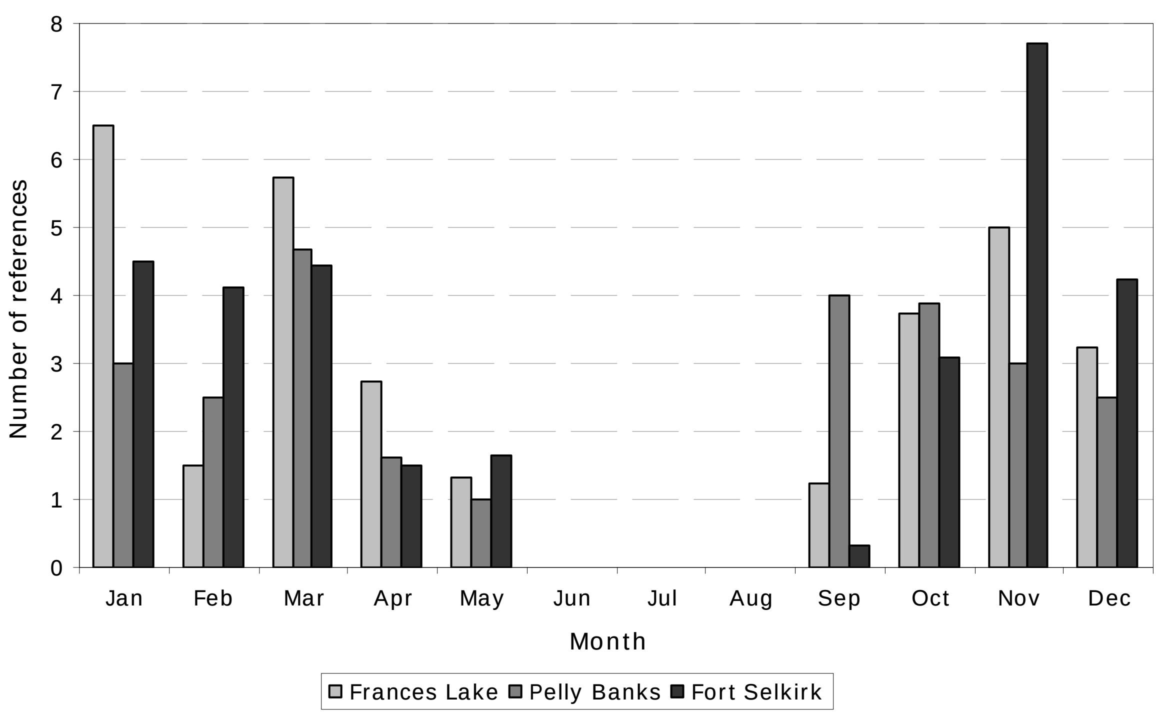


Figure 19: Weighted average number of monthly Snowfall references by post.

Seasonal Subcode Averages

The division of the subcodes varies by month, season and post. Appendix 4a-d lists the monthly, seasonal and annual average number of the subcode references for each direct category by post. These values are based on the data contained in Appendix 3. In order to highlight the importance of the subcodes, the seasonal averages were examined. The seasonal averages are calculated as the sum of the monthly averages for a season. The seasonal averages represent the number of days over the entire season with the subcode references. The seasonal averages are not weighted by the number of months in a season (as they are in the warm/cold index) because the resulting values can be misleading. For example, Pelly Banks has a total of 19.8 Mild references during winter and 10.8 during the fall (Appendix 4b). However, if the seasonal average were weighted by the number of months with data (both full and partial), the seasonal values would be 3.9 for winter and 5.5 for fall. These values indicate that on average each winter month has 3.9 Mild references while each fall month has 5.5. However, these weighted seasonal averages give the impression that Mild references are more notable in the fall than in the winter, which is not the case.

Rainfall and Snowfall subcode seasonal averages do not show any seasonal trend in the precipitation intensity (Appendix 4d). Rain or snow that ranged from light to heavy in intensity did not favour a particular season. Rather, rainfall and snowfall were the highest in summer and winter respectively. However, Temperature subcodes show a strong bias to Mild references in winter for all posts (Appendix 4a-d). Figure 20 shows the seasonal averages of the Temperature subcodes averaged for all posts over the time period 1842-1852. On average, there are 32 references during the winter season to Mild weather – five times as many references as the next highest season, spring. Overall, Temperature references are the highest during the winter season (Figure 20). A total of 68 references to temperature conditions were made from November to March, which is equal to all the temperature references made in the remaining seasons.

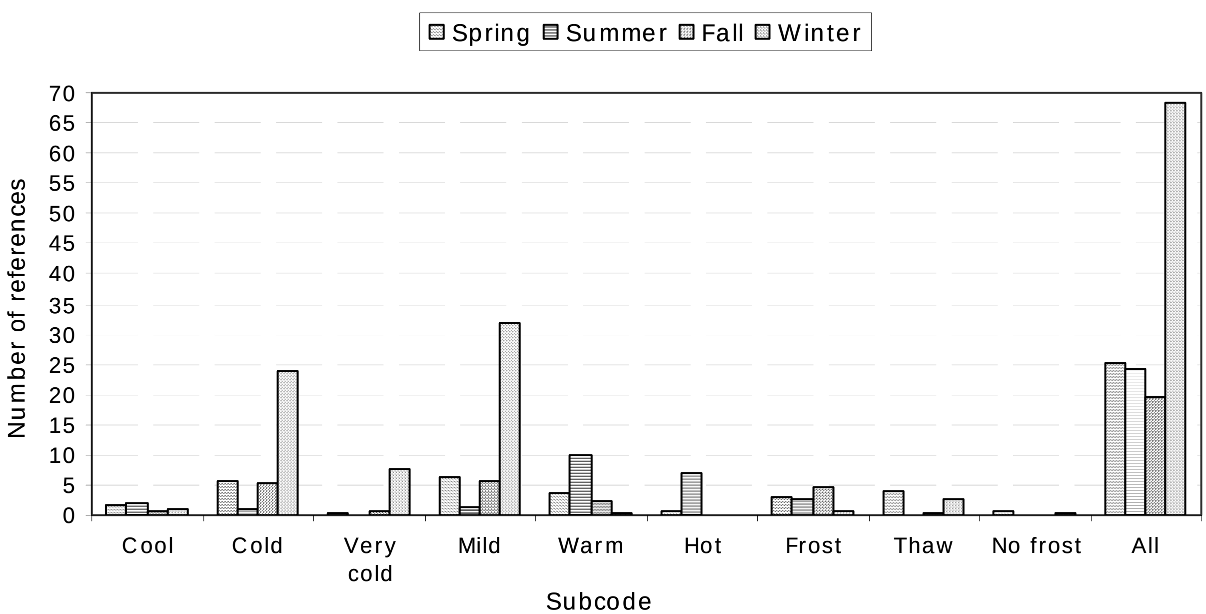


Figure 20: Seasonal averages for Temperature subcodes for all the posts. The group "All" refers to the sum of all the temperature subcode references.

Cloud conditions subcodes exhibit the same trend with winter references accounting for the highest number of references and summer accounting for the second highest (Appendix 4d). During the winter, clear conditions were reported the most at Frances Lake (24.8 days) and Pelly Banks (13.5 days), while clear and cloudy conditions prevailed almost equally at Fort Selkirk (19.7 and 18.7 days respectively).

No clear seasonal trend for all posts is apparent in the reporting of Wind strength. Frances Lake reported the highest number of wind strength references of all the posts (Appendix 4a). At Frances Lake, the references were highest in the summer (34.8 days) and considerably lower in spring (8.3 days). However, the wind strength subcodes (i.e. Calm, Light, Strong, Gale, Windy) were by and large evenly represented by all seasons, although calm conditions were reported the most. Gale winds, the greatest wind intensity subcode, were mainly recorded at Frances Lake, and occurred mostly in the summer and fall. At Fort Selkirk, Strong wind references were recorded the most often, except in the fall (Appendix 4c). Calm days were noted the most in the winter and spring, although overall, calm references accounted for only one-sixth of Wind strength references at Fort Selkirk. At Frances Lake, fall references to wind strength were the lowest for all posts (5.9 days). Calm, Strong and Windy references were divided relatively evenly throughout all seasons (i.e. less than a four-day difference) and accounted for 12-14 days each per year.

Averaged over all three posts, wind directions were reported for eight to ten days every season (Appendix 4d). Southeast winds represented the highest number of Wind direction references and Southwest represented the lowest. At Frances Lake, spring recorded the lowest number of references to direction (5 days) while the rest of the seasons were represented by 10.9 - 12.5 references. References to southwest winds accounted for 40% of all direction references at the post (16 days). However, at Fort Selkirk, the authors noted northwest winds almost 1.5 times as often as southeast winds. Wind direction references at Pelly Banks were approximately half that found at the other posts. Southeast winds were noted the most per year, particularly in winter. But spring references to wind direction overall were the highest.

The seasonal averages of the indirect subcodes reveal some interesting patterns. Appendices 5a-d gives the monthly, seasonal and annual averages for each post and overall. As indicated previously, Miscellaneous remarks accounted for 61% of all indirect categories, with references to Good weather amounting to 91% of all miscellaneous references. On average for all the posts, Miscellaneous references were made mainly in the winter (30.3 days) and the fall (26.6 days) (Appendix 5d). Frances Lake, which had the highest number of Miscellaneous references, has almost double the number of winter references than in the fall (Appendix 5a).

Fort Selkirk reported the highest number of ice freeze-up and break-up activity (approximately 17 and 13 days per year respectively) (Appendix 5c). This is considerably higher than the average for all posts of 8.5 and 7.2 days of freeze-up and break-up references per year. Fort Selkirk's higher than average contribution to the Ice activity subcodes is likely due to the importance of the Pelly and Lewes (Yukon) rivers to the post. Fort Selkirk was located at the confluence of the two rivers and was significantly impacted by ice and flooding activity, eventually resulting in the relocation of the post. Frances Lake and Pelly Banks were also located on the water; however, neither post was as dramatically impacted by the water as Fort Selkirk. Frances Lake did record the highest number of references to Summer water activity, 8.5 days per summer season. Fort Selkirk recorded 6.4 days on average to Summer water activity and Pelly Banks had no references. The majority of summer water references at Frances Lake's were in July while Fort Selkirk's were in June.

Overall, the winter season reported the highest number of Starvation references (Appendix 5d). The majority of the starvation references occurred from January to March when the rations acquired in the summer and fall began to run low and when hunting and fishing proved the most problematic. Averaged for all posts, references to "starving Indians" were the highest due to a higher than average number of references from the Fort Selkirk journals. However, both Fort Selkirk and Pelly Banks had a higher number of combined references to "starving hunters" and "starving at the post" (Appendix 5a-b).

Biological references were reported the most in the fall, due to the high number of Fall migration references (Appendix 5d). Fort Selkirk had double the number of annual references to biological activity (20 days per year) with a particularly high bias toward the number of Fall migration references (10.5 days) compared to Spring migration (2.9 days). Frances Lake and Pelly Banks had, on average, less than a one-day difference between the number of spring and fall migration references.

Frances Lake Temperature Record

The Frances Lake journals were the only HBC post documents to record actual temperature data. One to four temperature readings were recorded each day for the period December 1842 – May 1844. The three readings per day likely represented a morning, noon and night reading and, in rare cases, a fourth temperature reading was taken. There are remarks in the journals to suggest that days with only two readings represented the morning and evening values. In total, 929 temperature readings were recorded amounting to 382 days with temperature data. The majority of the record is covered by at least two temperature readings per day. Only 47 days (12%) of the record had only one daily temperature reading.

A large gap of almost three months occurs in the temperature record from April 23, 1843 to July 20, 1843. No explanation is given in the journals for the lack of temperature readings. In fact, no journal entries are available for the entire month of June. References in the journal indicate that the author (likely Robert Campbell) was away from the post from June 1 until July 15, 1843. The departure was due to an expedition down the Pelly River to further explore the region and make contact with hunters and guides. Campbell indicates that some men did remain at the fort during his trip but it appears that the journal was not maintained. Appendix 6 contains the original daily readings (converted from Fahrenheit to Celsius). Please refer to the attached CD to review all the daily temperature readings recorded at the post. Figure 21 presents the daily temperature record for Frances Lake based on the multiple readings. Figure 22 presents the minimum and maximum daily temperature values. No adjustments have been made to the original readings, other than conversion from Fahrenheit to Celsius.

Table 19 lists the monthly mean, minimum and maximum temperature values for Frances Lake. The minimum and maximum values are based on the average of the daily minimum and maximum values for the month. Some of the monthly values are based on months with partial data. Table 16 in Chapter 3 outlines the missing days for each month.

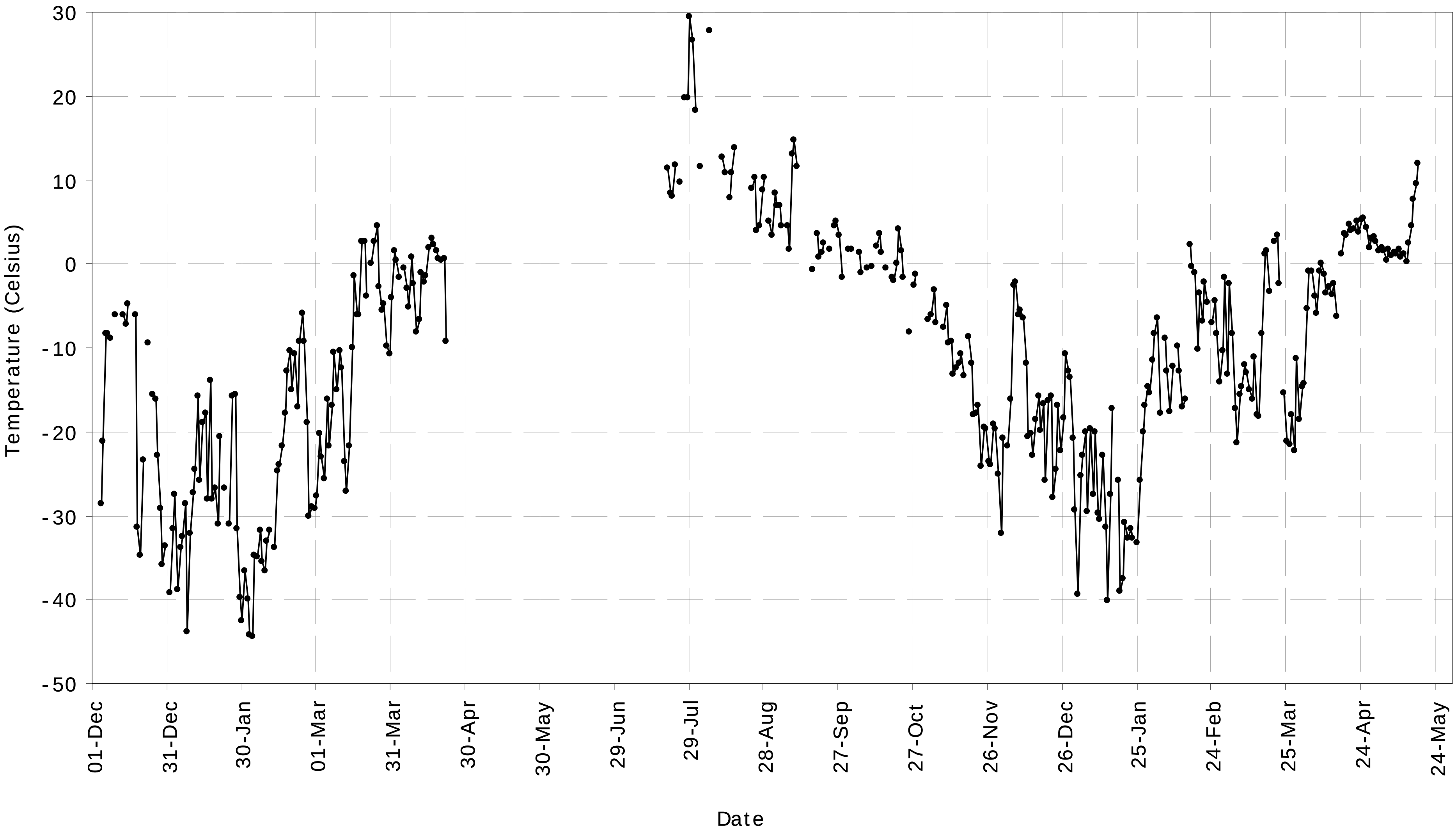


Figure 21: Average daily temperatures for Frances Lake from December 1842 to May 1844. Temperature values may be an average of up to four daily readings. Multiple readings likely represented morning, noon and night temperatures.

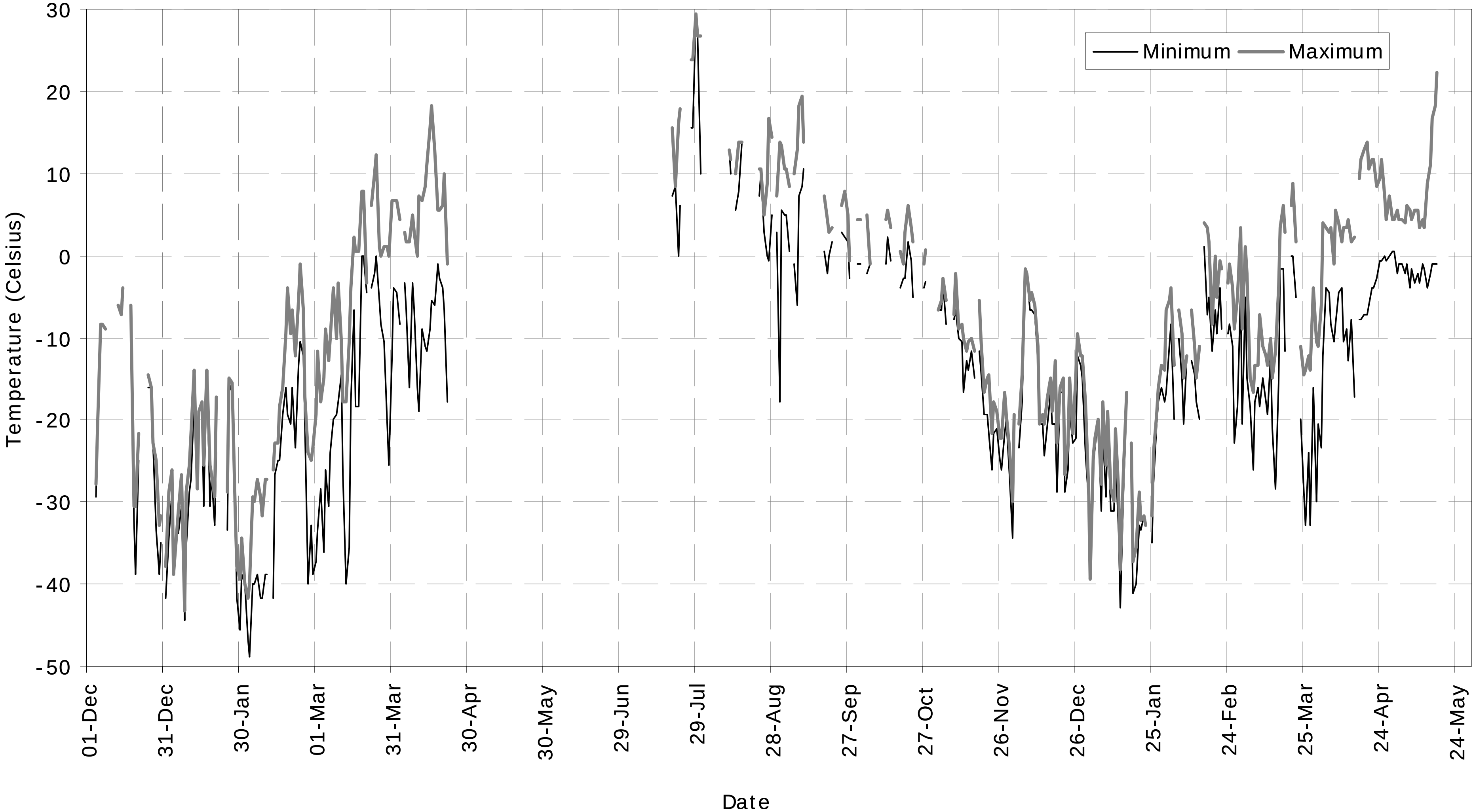


Figure 22: Average minimum and maximum daily temperatures for Frances Lake from December 1842 to May 1844. Minimum and maximum values may be based on up to four daily readings representing morning, noon and night.

Table 19: Monthly mean, minimum and maximum temperatures for Frances Lake

	1842			1843			1844		
Month	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
January				-28.6	-30.0	-27.2	-26.6	-28.1	-25.2
February				-25.4	-30.2	-21.3	-8.5	-11.5	-5.4
March				-10.8	-18.1	-4.0	-11.9	-17.0	-7.4
April				-1.4	-8.2	6.6	0.1	-6.3	5.9
May							2.9	-2.0	7.9
June									
July				16.3	12.5	20.5			
August				10.0	7.9	13.0			
September				4.9	1.1	8.6			
October				0.1	-2.1	2.3			
November				-14.0	-15.6	-12.5			
December	-17.9	-18.8	-16.9	-17.2	-18.5	-15.8			

Note: Empty cells indicate months with either no temperature data or fewer than four days of temperature data.

Seasonal Warm/Cold Index

The seasonal warm/cold index is the culmination of the study. It highlights the seasonal normals and extremes for the historical period. The index is primarily based on the qualitative Temperature subcodes. However, it does rely on both direct and indirect references in order to support reliability. The index ranges from –1 (extreme cold), 0 (normal) and +1 (extreme warmth). Figure 23 shows the seasonal warm/cold index. Table 20 contains the monthly warm/cold index values used in the construction of the final seasonal index.

First and Last Dates

The first and last dates provided for ice break-up, ice freeze-up, frost, snowfall, rainfall and migration are not as comprehensive as those used in other Canadian studies (Moodie and Catchpole 1975; Ball 1983). Ice activity and phenological first and last dates have been the basis for numerous warm/cold index constructions, particularly in Europe (Brooks 1926; Le Roy Ladurie 1971; Lamb 1977). In order for first and last dates to be meaningful, the historical sources utilized must have consistent, detailed notes on such activity. Whereas HBC records from the Hudson Bay region have proved extremely successful in this regard, the HBC's records from the southern Yukon have not. The main reason that the post journals from the Yukon are weak in terms of first and last dates is the lack of detailed information. The authors do refer to ice activity, migration, snowfall and rainfall. Yet the information is sporadic and not set within a definitive framework that indicates the exact first and last dates. For example, not all the first references to bird migration in the spring season indicate that the birds were seen for the absolute first time or even what species of bird was seen. Often references to ice activity did not indicate the final date of complete freeze over or if ice break-up activity had occurred prior to the first reference. Therefore, no index has been constructed solely from the first and last dates. Rather, the first and last dates of ice break-up, ice freeze-up, frost, snowfall, rainfall and migration have been used as secondary direct and indirect evidence in the construction of the aforementioned

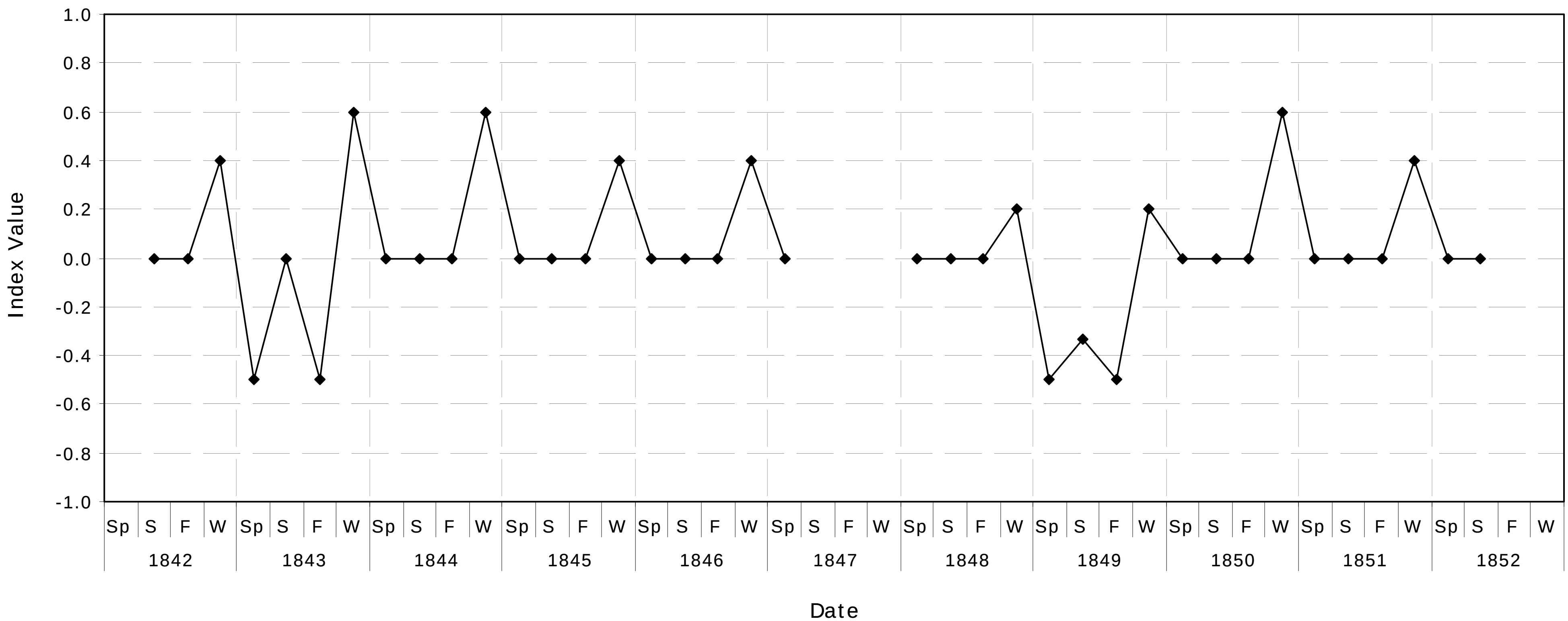


Figure 23: Seasonal warm/cold index for the southern Yukon. On the x-axis: Sp = Spring (April – May), S = Summer (June – August), F = Fall (September – October) and W = Winter (November – March).

Table 20: Monthly and seasonal warm/cold index values

Month	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852
January		0	0	1	1	0		1	-1	0	1
February		0	1	1	0	1		0	0	1	0
March		1	1	1	0	1		0	0	1	0
April		0	0	0	0	0		0	0	0	0
May		-1	0	0	0		0	-1	0	0	0
June			0	0	0		0	0	0	0	0
July	0	0	0	0	0		0	0	0	0	0
August	0	0	0	0	0		0	-1	0	0	0
September	0	-1	0	0	0		0	0	0	0	
October	0	0	0	0	0		0	-1	0	0	
November	0	0	0	0	0		0	0	0	1	
December	1	1	0	1	0		0	0	1	0	

seasonal warm/cold index. Table 21 provides the first and last dates for ice break-up, ice freeze-up, snowfall, rainfall and migration. These dates do not represent the absolute first and last date for each activity; rather, the dates represent only the first and last journal reference. The following section discusses and compares the results in relation to modern climate data and other paleoclimatic proxy information.

Table 21: First and Last dates for specified factors

Activity	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852
First Spring ice break-up		?	May 17	May 18	May 11	Apr. 25		May 20 (L) May 21 (P)	Apr. 12 (P)	Apr. 21	May 4
Last Spring ice break-up		May 22	?	?	?			May 30	May 11(P) May 13 (L)	May 12	May 18
First Fall ice freeze-up	?	Nov. 16	Oct. 22	Nov. 15	Sep. 5		Oct. 2	Oct. 13	Oct. 18	Oct. 7	
Last Fall ice freeze-up	?	Nov. 27	Nov. 22	Nov. 22	Oct. 29		Nov. 27	Oct. 29 (P) Nov. 1 (L)	Nov 29 (P) Nov 28 (L)	Nov. 5 (P) Dec. 1 (L)	
First snow	Sep. 9	Sep. 21	Oct. 17	Sep. 12	Sep. 16		Oct. 5	Oct. 21	Oct. 18	Sep. 8	
Last snow		Apr. 15	May 11	May 11	May 3 May 28	Apr. 18		May 27	Apr. 27	May 22	Apr. 10
First rain		Apr. 30	Feb. 17	Mar. 12	Feb. 20	Apr. 4	May 25	Apr. 6	Apr. 8	May 4	May 2
Last rain	Oct. 17	Sep. 20	Sep. 26	Sep. 28	?		Oct. 7	Sep. 22	Dec. 27	Nov. 24	
First Spring migration		Apr. 16	Apr. 18	Apr. 25	Apr. 23	Apr. 16		May 9	Apr. 29	Apr. 19	?
First Fall migration	Aug. 6	Sep. 1	Aug. 26	Aug. 23	Aug. 18		Sep. 8	Aug. 30	?	Sep. 11	

Note: Empty cells represent years with no journal coverage. Cells with “?” symbol indicate years where no reference is made to the activity. In brackets: L = Lewes river, P= Pelly river.

Chapter 5: Discussion

The historical temperature record from Frances Lake and the warm/cold index compiled for the period 1842-1852 offer insights into normal and extreme conditions for the Yukon Territory. The discussion section first focuses on the historical temperature record with comparison to modern station data. The next section concentrates on verifying the results of the warm/cold index. The last section of the chapter highlights notable seasons from 1842-52 and integrates findings from additional paleoclimatic studies.

Frances Lake Historical Temperature Record

The historical temperature record for Frances Lake spans the period December 1842 to May 1844. The period December - April (1842 and 1843) provides a basis for internal comparison of the historical record. Most of the monthly means for this period were within two degrees Celsius of agreement with one another (Table 19). However, February 1843 and 1844 were notably different (Figures 21 and 22). February 1843 had a monthly mean of –25.4°C while February 1844 had a mean of –8.5°C (Table 19). This 16.9°C difference between the months cannot be attributed to missing values. At the most, only four days of data are missing from the February records.

The historical temperature record for Frances Lake was compared to modern temperature data for the nearest climate normal station, Watson Lake A. Watson Lake A is nearly 150 km southeast of Frances Lake but it does provide a reliable temperature record for the period 1971-2000. Table 22 compares the normal and historical mean monthly temperatures for Watson Lake A and Frances Lake. Averages for the historical period, 1842-1844, were also calculated based on the available data. Table 22 reveals some significant differences between mean monthly temperatures for the normal and historical period. These differences are described below; however, a caveat must be attached to the historical temperature readings. Although there is no evidence to doubt the reliability of the Frances Lake record, there is also no information within the journals describing instrumentation or location. Therefore, some biases or errors may be present in the record that cannot be accounted for.

December

December 1842 and 1843 were warmer than the normal period by 4.5ºC and 5.0ºC. These warmer than normal means were the result of extended periods of time (i.e. more than five days) with temperature above -20°C. Figure 24 compares the 1842 and 1843 average daily temperature values with the normal period (1971-2000). December 1842 is missing 11 days of values; however, it appears to indicate that the month, on the whole, was well above normal. A particularly warm two-week spell, with temperatures between –5°C and –10°C, is seen in the first half of the month. December 1843 also experienced a warm period during the second week with temperatures hovering near –5°C. Both historical records show variable daily temperatures, which, at times, fell well below the mean monthly value of the normal period. Only nine out of the thirty years of data in the normal period exhibit a mean monthly temperature warmer than –22.4°C and eight of these warmer years occurred after 1984. The warmer historical mean monthly temperatures were within one standard deviation of the normal period mean. However, the standard deviation for the December normal period is 5.5°C, indicating that the month experiences a wide range of daily temperatures.

Table 22: Comparison of mean monthly temperatures (degrees Celsius) for the normal period (1971-2000) and the historical period (1842-1844)

Month	Normal 1971-2000	Std. Dev.* (1971-2000)	1842	1843	1844	Average 1842/43 or 1843/44
January	-24.2	+/- 5.8		-28.6	-26.6	-27.6
February	-17.9	+/- 4.3		-25.4	-8.5	-17.0
March	-10.0	+/- 3.1		-10.8	-11.9	-11.4
April	0.0	+/- 2.2		-1.4	0.1	-0.7
May	7.4				2.9	2.9
June	12.8					
July	15.1			16.3		
August	13.0			10.0		
September	7.5			4.9		
October	-0.5			0.1		
November	-15.0			-14.0		
December	-22.4	+/- 5.5	-17.9	-17.2		-17.6

*Std. Dev.: This is the standard deviation of the normal mean monthly temperatures based on the period 1971-2000. Standard deviations were only calculated for months, which also had two years of historical temperature measurements.

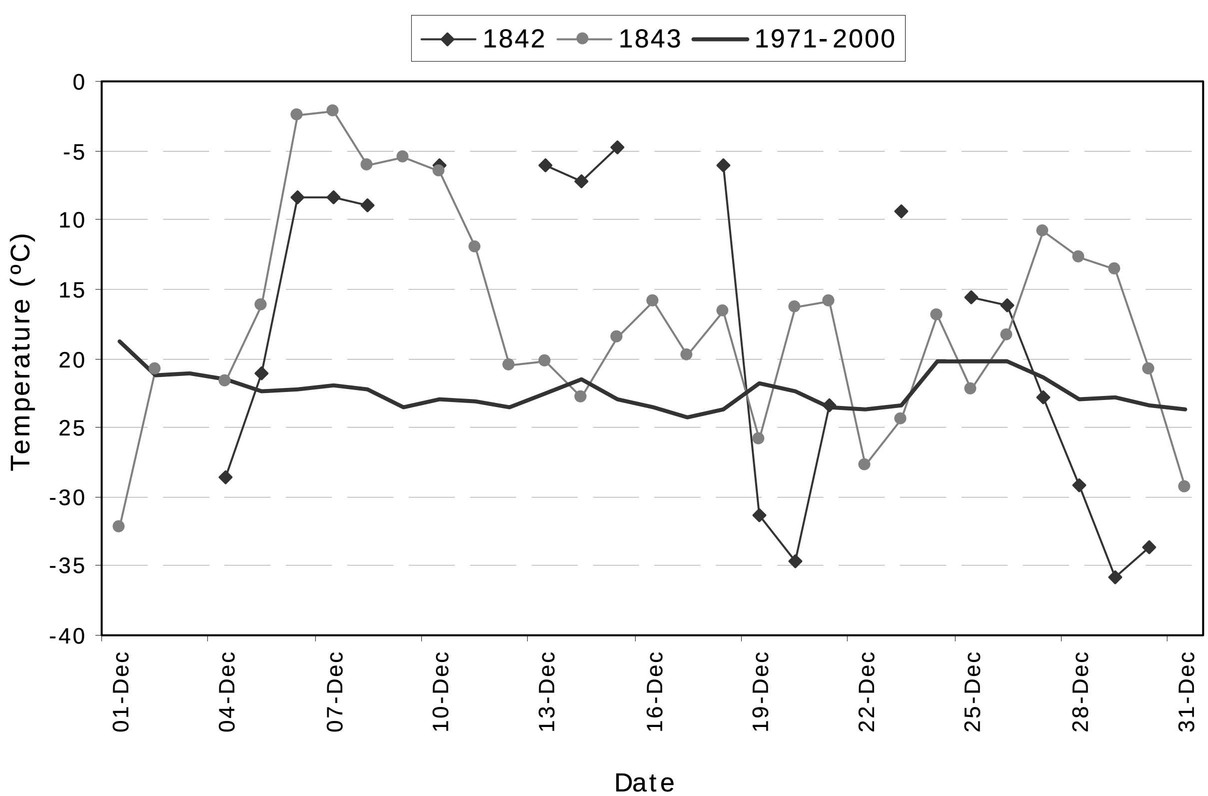


Figure 24: Comparison of average daily temperature for December 1842 and 1843 for Frances Lake and the normal period (1971-2000) for Watson Lake.

January

January 1843 and 1844 exhibit a negative trend when compared with the normal period. Both years were colder by 4.4°C and 2.4°C respectively (Table 22). Colder years are not unusual during the normal period. Nine out thirty years from 1971-2000 actually had mean monthly January temperatures colder than –28.6°C. Figure 25 shows that there are no clear temperature trends in the historical temperature record. Daily temperature values were recorded that are both warmer and colder than the normal period. However, approximately 60% of the days for January 1843 and 1844 were below the normal monthly mean.

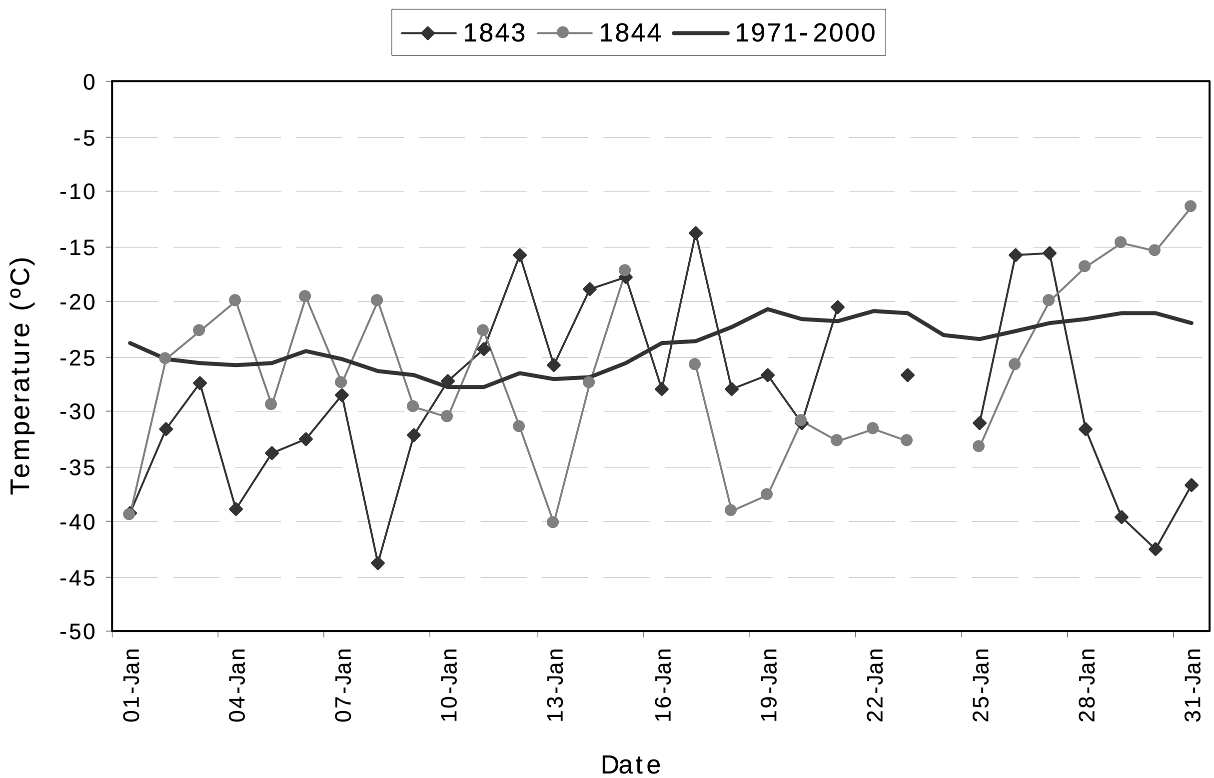


Figure 25: Comparison of average daily temperature for January 1843 and 1844 for Frances Lake and the normal period (1971-2000) for Watson Lake A.

February

February 1843 and 1844 provide the most notable differences in monthly means within the historical record as well as compared to the normal period (Table 22). The normal (1971-2000) monthly mean for February is –17.9°C. The monthly mean for February 1843 is considerably colder, -25.4°C, while February 1844 is much warmer than the normal period, -8.5°C. These differences between the historical period and the normal period are significant. Only three years in the normal record, 1972, 1977 and 1994, have been colder than February 1843, which was two standard deviations below the normal monthly mean (i.e. more than 8.6ºC colder than normal). On the other hand, February 1844 was three standard deviations above the normal monthly mean and there have been no Februarys during the normal period as warm as the February 1844 record. The warmest year from 1971-2000 was 1977 (-9.3°C). Figure 26 compares the daily average temperatures for the historical and normal period. For the first half of February 1843, daily temperatures were on average 13.5 degrees below normal. However, from February 16-24th, daily temperatures were on average 6.5 degrees warmer than normal.

Overall, though, February 1843 was on average 7.5 degrees cooler than the normal monthly mean. February 1844 displays a distinct trend of warmer-than-normal daily temperatures throughout almost the entire month. Temperatures near or above zero were even recorded. During the February normal period, only six days had daily mean temperature values above zero.

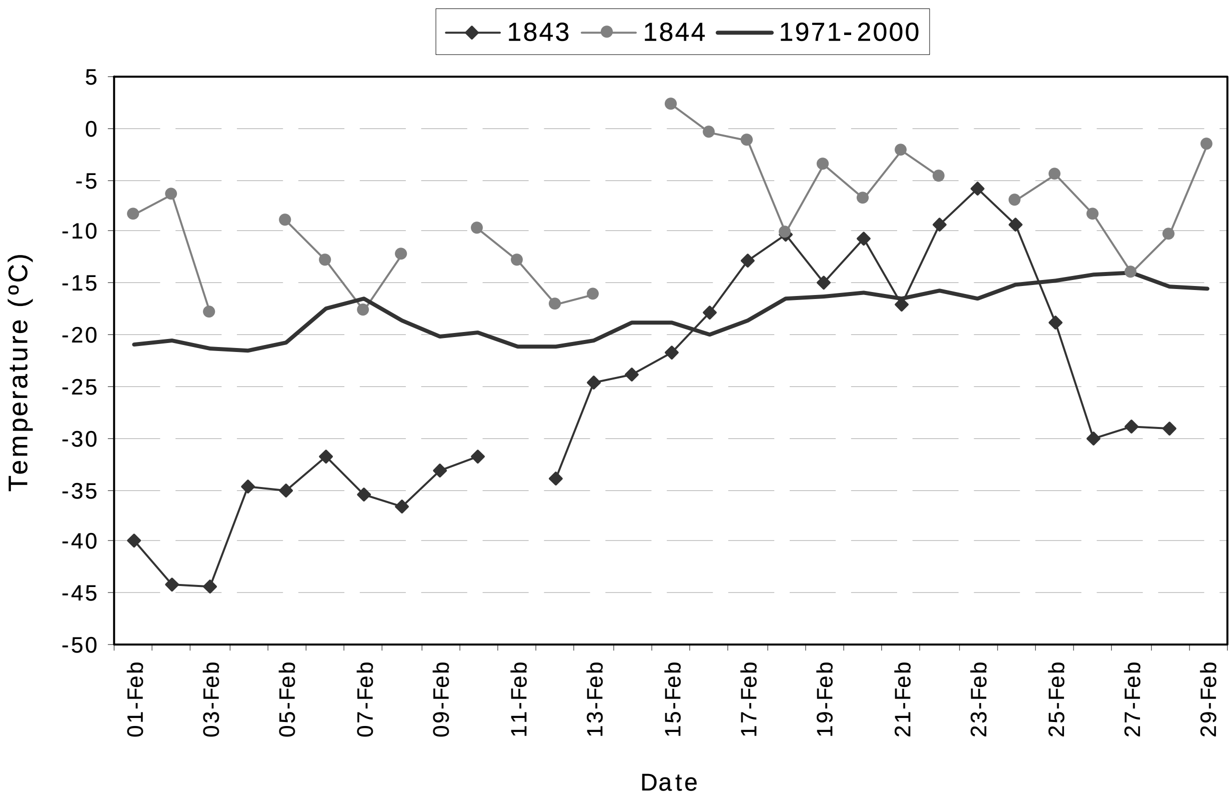


Figure 26: Comparison of average daily temperature for February 1843 and 1844 for Frances Lake and the normal period (1971-2000) for Watson Lake.

March and April

March and April represent the remaining months from the historical record that are also represented by two years of data (1843 and 1844). Both March 1843 and 1844 were cooler than the monthly mean for the normal period; however, the difference was less than two degrees (Table 22). This difference is well within one standard deviation of the normal monthly mean. April 1843 and 1844 are also within one standard deviation of the normal period mean, although the former is colder than normal while the latter is slightly warmer than normal.

December – April

Figures 27 and 28 show the average daily temperatures for the period December 1842 to April 1843 and December 1843 to April 1844, compared to the normal period (1971-2000). The standard deviation (+/- 2) for the normal period is also plotted on the graphs, highlighting the fact that some of the daily temperatures far exceeded normal period mean. For example, from approximately January 30 to February 14, 1844, Frances Lake experienced average daily temperatures two standard deviations below the norm (Figure 27). Temperatures approached –45°C. Figure 28 shows that both December 1842 and February 1843 experienced average daily temperatures two standard deviations above the norm (i.e. 8°C to 11°C above normal). As well, a one-week colder-than-normal period was experienced from late March to the beginning of April 1844.

May to November

The remaining months, May-November, are discussed together, since these months represent historical data that are recorded in one year, 1843 or 1844. Also, the majority of these months are only represented by partial records, which calls into question reliability (Table 16). No temperature data exists for May 1843, and May 1844 is only represented by the first 17 days of the month. The mean monthly temperature for May 1844 is 2.9°C, while the normal period has a value of 7.9°C. This lower than normal mean may be due to missing data or may reflect actually lower temperatures. No temperature readings exist for June 1843 or 1844, likely due to the journal author(s) spending time away from the post. Daily temperature records for the months of July-October are also suspect because of missing data (at least 12 days per month). Some of the months, August and September 1843, both have monthly means approximately four to six degrees below normal. The remaining months (July, October and November) are all within two degrees of the normal monthly mean, despite missing data.

Seasonal Warm/Cold Index

The warm/cold index developed for the historical period is based on qualitative thermal references as well as additional direct and indirect evidence of monthly conditions. The index shows a number of normal and extreme seasons for the period 1842-1852 (Figure 23). The majority of the extreme seasons for the historical period were warm. However, two extreme cold periods were seen in the record: one at Frances Lake and one at Fort Selkirk. According to the index, both spring and fall 1843 were colder than normal. As well, an extended cold period occurred for half of 1849. The summer of 1849 was the only extreme summer on record.

Interestingly, the remaining extreme seasons were all warm winters. In fact, all winter seasons for the period were extremely warm according to the index. Index values for warm winters ranged from 0.20 (i.e. one month out of five) to 0.60 (i.e. three months). Table 20 (Chapter 4) shows that not all winter seasons had extended periods of extremely warm temperatures. In some cases, months early and late in the winter season exhibited warmer tendencies (e.g. 1842/43), while other years had consecutive months with prolonged warm conditions (e.g. 1844, 1847, 1851). The winters of 1843/44, 1844/45 and 1850/51 were the warmest in the index.

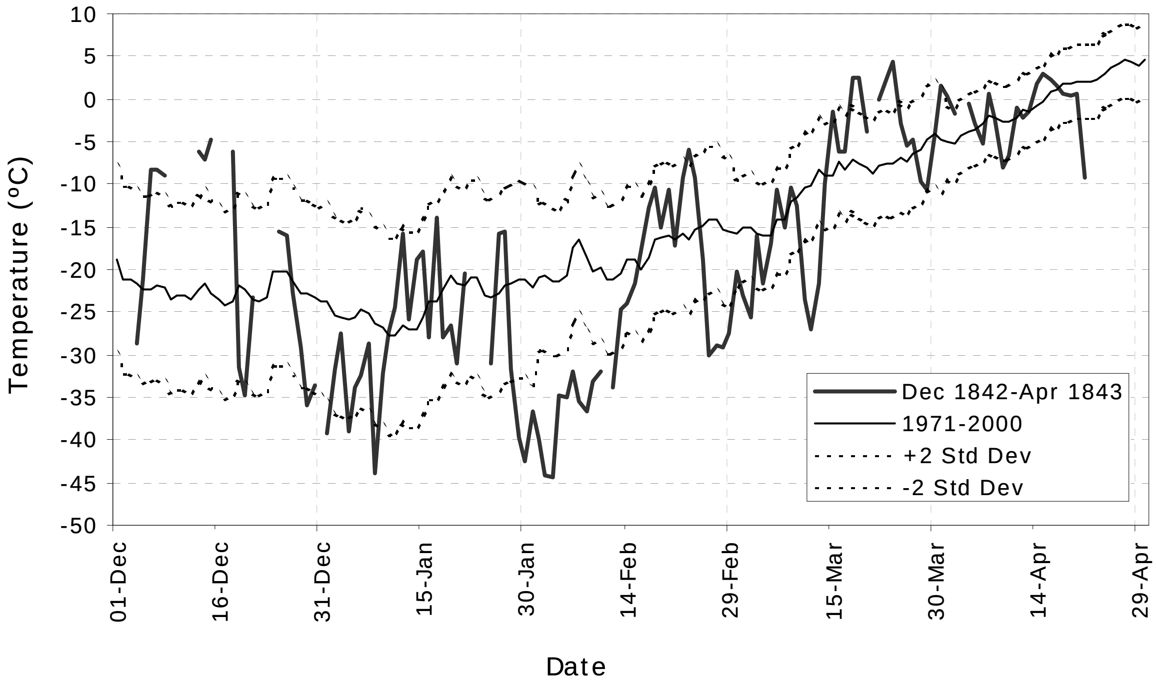


Figure 27: Comparison of December 1842 – April 1843 average daily temperatures to the mean daily temperature for the normal period (1971-2000). Dotted lines represent two standard deviations above and below the normal mean.

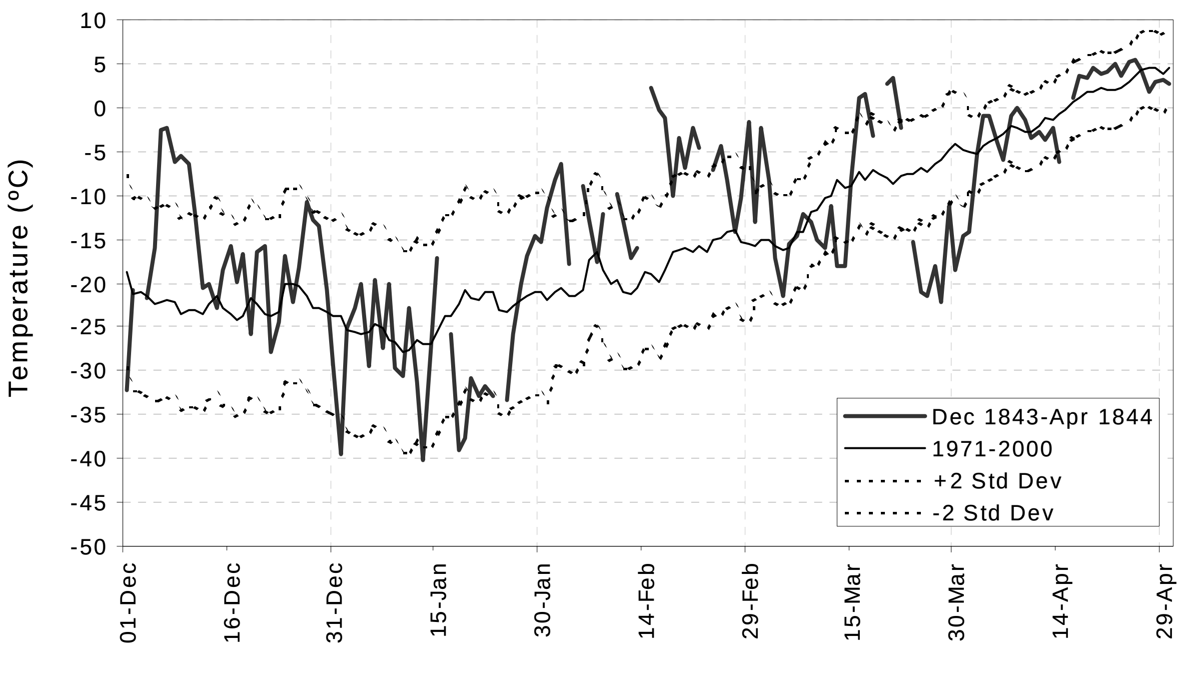


Figure 28: Comparison of December 1843 – April 1844 average daily temperatures to the mean daily temperature for the normal period (1971-2000). Dotted lines represent two standard deviations above and below the normal mean.

Verification of the Index

The indication that all winters during the historical period were extremely warm may indicate a bias within the data. Regardless of whether a bias is suspected, verification of the reliability of the index is paramount. It is preferable to verify paleoclimatic data by using a period of overlap between the historical and modern data set. However, this is impossible with the HBC's journals since the historical period ends in 1852 and the modern record does not commence until nearly 100 years later. Fortunately, a historical temperature record for Frances Lake exists which can be used for verification.

The historical temperature record for Frances Lake was compared to the modern climate station data for Watson Lake A. Seasonal temperature anomalies were calculated based on the seasonal divisions used for the index. A positive seasonal anomaly indicates warmer than normal conditions while a negative temperature anomaly indicates a colder than normal season. Figure 29 compares the seasonal warm/cold index to the seasonal temperature anomalies over six seasons (from winter 1842/43 to spring 1844). Agreement between the index and temperature anomaly record is relatively good except in two instances. The index does identify the three most extreme seasons for the overlap period: the extreme cold spring and fall of 1843 and the extreme warm winter of 1844. However, the index does not identify the winter of 1842 as extremely cold; rather, it is extremely warm according to the index. Also, the summer of 1843 and spring of 1844 both have index values of zero (i.e. normal conditions) but the temperatures anomalies for the seasons indicate colder than normal conditions.

There are a number of explanations for the disagreement between the index and the temperature anomaly record. The disagreement may be due to errors in the index or the temperature anomaly record itself. The winter of 1842/43 has the most conspicuous disagreement since the index indicates conditions contrary to the temperature anomaly. Further examination of the monthly and seasonal temperature anomalies indicates that the winter of 1842/43 was not consistently colder than normal. Table 23 shows that overall the winter was 2.1 degrees colder than normal (it should be noted that the temperature anomaly for the winter of 1842/43 is based on data only from December-March). December 1842 was 4.5°C warmer than normal and March 1843 was near normal. December was correctly assigned an index value of +1. March was also assigned a positive index value, despite a temperature anomaly of -0.8°C.

Surprisingly, March 1843 had the highest number of <u>Mild</u> references for Frances Lake (12 days). The average number of mild days in March at Frances Lake was 7.5. Mild days in March are considered an indication of extremely warm conditions since March is part of the winter season. March 1843 was missing only one day of temperature readings; therefore, the discrepancy between the index and the temperature anomaly cannot be attributed to missing data. March marks the transition from winter to spring, so the authors may have been biased towards reporting warmer conditions, resulting in a positive index value.

Both January and February 1843 were assigned normal index values (i.e. 0). Yet the temperature anomalies for the months were negative, particularly February, which had the second largest temperature anomaly for the overlap period (-7.5°C). So why was the index unable to identify these months as extremely cold? The answer is that a combination of factors influenced the author's impression of the

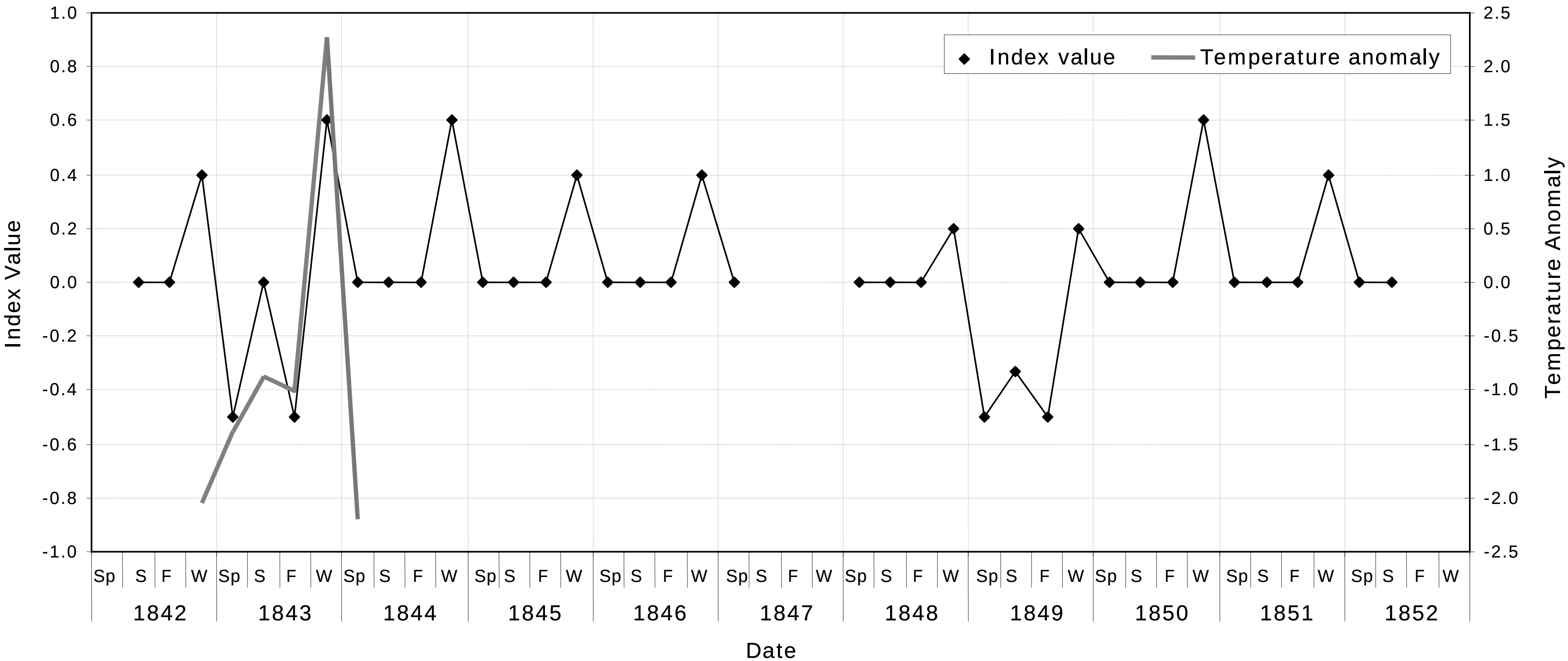


Figure 29: Comparison of the seasonal warm/cold index with seasonal temperature anomalies between the historical Frances Lake temperature data set and the Watson Lake modern climate data. Note the temperature anomaly for spring 1843 is based on April data only and summer 1843 is based on July and August data only (for both the historical and modern record).

Table 23: Mean monthly and seasonal temperature anomalies (°C) and index values for Frances Lake

Season or Month	1842	1843	1844
Spring		-1.4 (-0.50)	-2.2 (0.00)
Summer	n/a (0.00)	-0.9 (0.00)	
Fall	n/a (0.00)	-1.0 (-0.50)	
Winter	-2.1 (0.40)	2.3 (0.60)	
January		-4.4 (0)	-2.4 (0)
February		-7.5 (0)	9.4 (1)
March		-0.8 (1)	-1.9 (1)
April		-1.4 (0)	0.7 (0)
May		n/a (-1)	-4.5 (0)
June		n/a (n/a)	
July		1.2 (0)	
August		-3.0 (0)	
September		-2.6 (-1)	
October		0.6 (0)	
November		1.0 (0)	
December	4.5 (1)	5.2 (1)	

* Note: Index values are given in brackets. Empty cells indicate either months or seasons outside of the overlap period.

temperature. In the case of January 1843, the number of extreme cold and warm qualitative references were nearly the same: five versus seven days respectively. The ratio of these extreme days to days with normal qualitative thermal references was below two-thirds; therefore, the month was assigned an index value of zero. There is no indication in the journal entries that the month was viewed as overwhelmingly cold. The author does note many mild days, even stating on the 12th, "The weather is so mild that all the detriots of the lake are broke up the ice having decayed" (HBCA B.73/a/1). The average temperature for that day was -15.8°C. Days that were referenced as Mild had temperatures ranging from -15.6°C to -24.4°C. The normal monthly mean for January is –24.2°C, so it appears that the author was correctly associating above normal temperatures with qualitative descriptions of mild weather. The same holds true for references to Very cold weather. Days in January 1843 associated with the term "very cold" ranged from –28.1°C to –43.9°C. However, all of the references to Cold weather (i.e. normal conditions) contained temperature readings well below the normal monthly mean. Thus, it appears that the author was not always consistent in the use of temperature terminology with regards to actual weather conditions. It could be argued that other factors, such as housing and nutrition, may have influenced the author's perception of the cold.

February 1843 is similar to January. There are no obvious entries in the journal that indicated the month is colder than normal (Appendix 2a). The ratio of extreme cold/warm references to normal qualitative temperature references was approximately 0.5, indicating that the number of extreme warm and extreme cold days was the same (Appendix 3). As in January, the author generally associated Mild days with temperatures warmer than the normal monthly mean and Very cold and Cold days with temperatures well below. There are additional weather conditions that may support the colder than normal month for February 1843. A higher than average number of calm and clear days was reported for the month. Some years at Frances Lake reported no calm days at all, although this may reflect of lack of reporting rather than lack of calm days. February 1843 indicated there were at least 10 days of calm weather. The average number of calm days during the month was 4.5 days. However, Robert Campbell noted that calm days in December and January were expected but that February was known for its windy weather: "I may remark that the weather in these Arctic latitudes is generally very calm in Dec. and Jany. Feby. is called by the Indians the 'windy moon', which is always impatiently looked forward to, as it is then they are able to kill moose" (Campbell 1958). Therefore, it appears that February 1843 may have been anomalous in terms of the calm weather. In the case of clear winter skies, Frances Lake reported on average 2.75 clear days per month in February. But February 1843 reported 7.0 days. Generally, clear days in winter are cooler due to the lack of clouds reflecting outgoing longwave radiation back to the earth for warming. The high number of clear days in 1843 may support the colder than normal temperature anomaly. However, this "clear equals colder in winter" rule is not absolute. December 1843 also reported a very high number of clear days, but both the temperature anomaly and index support a warmer than average month. Consequently, the index does not integrate cloud or wind conditions.

The other two extreme seasons that the index does not capture is the summer of 1843 and the spring of 1844. The summer of 1843 was on average 0.9 degrees cooler than normal. However, this temperature anomaly must be examined with caution. The historical temperature record for this summer season is fragmented. No June temperatures were recorded and more than half of July and August have missing data. Only four qualitative references to colder than normal weather are recorded in the journal, all in August. Two of the references cite frost, which was not unusual in the late summer at Frances Lake. The negative temperature anomaly may be inaccurate due to the missing temperature readings; therefore the normal seasonal index value is considered reasonable.

The historical temperature record indicates that the spring of 1844 was an extremely cold season but this finding is also based on a partial record. Both April and May have index values indicating normal seasonal temperatures. There are no other direct or indirect indications of extreme cold for the month. April 1844 was actually 0.7 degrees warmer than the normal period. The index may not reflect an extremely warm month for April because it may not be sensitive to temperature anomalies of less than one degree. May 1844 was 4.5 degrees cooler than normal. However, it was assigned an index value of 0. There are 14 missing days in the historical temperature record from the last half of May, which would likely include the warmest temperatures for the season. The mean temperature for this month may have been negatively biased by the lack of data in the latter half of May. Also, only two qualitative thermal references were available for May 1844 for the index value calculation.

Index Limitations

Comparison of the seasonal warm/cold index with the temperature anomaly data for Frances Lake shows that the index may have some limitations. Months and seasons with temperature anomalies less than one degree Celsius may not be consistently identified as extreme years (e.g. October and November 1843, April 1844). There are some instances in the overlap period where the index was unable to identify months or seasons with much larger temperature departures (i.e. up to 7.5 degrees). However, these discrepancies between the index and the temperature anomaly record cannot be blamed on the index entirely. Missing temperature data from the historical Frances Lake record are likely responsible for some disagreement, particularly for August 1843, January 1844, and May 1845. The winter of 1842 is the only case where the index indicated extreme conditions that were opposite compared to the temperature anomaly record. In this case, the discrepancy is due to the type and ratio of thermal qualitative references used by the journal author.

Examinations of the daily thermal qualitative references in conjunction with temperature readings on the same day indicate that the authors were consistent in associating Mild references with mild temperatures (i.e. temperatures above the normal monthly mean). The same holds true for Very cold references. The problem then lies with Cold references, which were often associated with temperatures also colder than the normal monthly mean. A number of reasons could explain why days were referenced as cold when in reality the temperature was much colder than normal. Additional weather factors, such as wind and cloud cover, may have made the temperature feel less cold than it was. These factors may not have influenced the actual temperature readings, only the qualitative thermal descriptors. Bias on the part of the author is another possibility. After a number of days with temperatures below normal, the author may have become used to very cold conditions and viewed the very cold weather as normal (i.e. cold). This may explain why February 1843 was normal according to the index but extremely cold according to the temperature anomaly record.

The historical temperature record itself may be responsible for some of the disagreement. The time the temperatures readings were taken may have influenced the daily average and thus the monthly mean. It is assumed that the multiple temperature readings per day represented a combination of morning, noon and night values. Evidence early on in the journals supports this assumption. However, by February 1843 the author(s) was not consistently indicating the time of the readings. Therefore, it is possible that some days are represented by temperatures taken only in the morning and/or at night, likely representing the lowest temperatures of the day. This may bias some of the data to reflect lower average daily temperatures. Also, although there is no indication, the thermometer(s) may have been placed in more than one, possibly unsuitable, location.

Examination of the index reveals that every winter in the record appears as extremely warm. It has already been established that it is unlikely that the winter of 1842/43 was warmer than normal. But is it likely that all the other winters were warmer than normal? As discussed previously, qualitative temperature references were the highest in winter with Mild references being the highest temperature condition noted (Figure 20; Appendix 4a-d). The high number of references to mild weather in the winter could possibly reflect a bias on the part of the authors to record extreme warm conditions. Warm conditions in winter were likely to be more noticeable than an amplification of the normal cold weather. Extreme cold conditions were noted as well but it has been shown that some qualitative thermal references to Cold (i.e. normal) conditions may actually reflect Very cold conditions. Consequently, the true number of very cold winter days at the posts is, in at least some cases, underestimated. One of the authors of the Frances Lake journals, which were used for the verification of the index, was Robert Campbell. He was also the sole author of the Pelly Banks journals and the co-author of the Fort Selkirk journals. Therefore, any bias towards supporting Very cold days as Cold may be carried forward to the other journals as well.

Despite these issues, references to mild winter weather have been shown to indicate milder temperatures than normal. The authors appear to be consistent in noting the number of mild days. Although the number of normal and extreme cold days may be underestimated, the higher number of mild references during winter months appears to identify months that were warmer than normal. Additional evidence, such as ice break-up activity and thawing, supports many of the positive index values for winter months (Appendix 5a-d). It is probable that the seasonal index is more sensitive to warm winters compared to other seasonal extremes due to the high number of mild references in winter. Focus on winters with index values of 0.20 should be limited since only one month out of five was extremely warm. Instead, warm winters with higher index values that reflect greater warming over a number of months should be considered as representative of warmer than normal conditions.

It should also be noted that the seasonal index is only a measure of whether a season was normal or extreme. Inferences on temperature anomalies represented by extreme years should be made with caution. Comparison between the modern and historical temperature records indicates that the index may have difficulty identifying months with temperature anomalies less than one degree Celsius. February 1843 also shows that even large temperature anomalies (i.e. 7.5°C) may be missed in the index. However, seasons identified with the largest positive and negative index values (e.g. winter 1843/44, summer 1849) should be taken as true representations of extreme seasons.

Rainfall and Snowfall

Comparison of the average monthly number of rainfall and snowfall days for each of the posts and their nearest climate stations indicates that for the most part all the posts recorded less rainfall and snowfall than normal. Table 24 outlines the average number of rainfall and snowfall days for the HBC posts and their associated modern climate stations. The largest differences between the historical and modern records were found during the months when rainfall and snowfall were the highest (i.e. rainfall= May to October, snowfall= November to March). For example, from May to October, Frances Lake recorded on average eight days less rainfall than normal (Table 24). During the winter season Pelly Banks recorded seven days less snowfall than normal. Over the entire year, the average difference between the post records and the modern data was the highest for Frances Lake (four days) and the lowest for Fort Selkirk (two days).

Despite the overall trend for lower than normal precipitation, there were a few instances when the average historical record indicated higher rainfall and snowfall than normal. Frances Lake reported a higher than normal number of rainfall days in February and March. Fort Selkirk reported 1.34 more snowfall days in May than normal. Overall, these higher than normal precipitation days were represented by transition seasons (i.e. spring and fall) and had only slightly higher averages than normal.

The overwhelming trend of lower than normal precipitation days for all posts represents two possible situations. Either the posts were actually experiencing lower than normal precipitation days or the authors were not recording every single day of precipitation. There are no overt indications in the journals that the authors felt the posts were experiencing prolonged drought conditions, either in summer or winter. References were made to “low water” or “water falling”, which may indicate drought conditions but many of these references were made in conjunction with ice break-up activity from May to June. However, there are some indications that Fort Selkirk did experience some dry weather that may be due to precipitation (NA MG19-D13):

> Took up the nets, only three fish taken. The weather colder this morning, & the ice thicker. In a channel up the Lewis now almost dry, saw 37 salmon trout dead in the space of 30 or 40 fathoms in length.
>
> (October 30, 1848)

Table 24: Average number of rainfall and snowfall days for each HBC post and its nearest climate normal station (1971-2000)

Month	Rainfall						Snowfall					
	Frances Lake	Watson Lake A	Pelly Banks	Faro A	Fort Selkirk	Pelly Ranch	Frances Lake	Watson Lake A	Pelly Banks	Faro A	Fort Selkirk	Pelly Ranch
January	0.00	0.26	0.00	0.00	0.00	0.00	6.50	14.10	3.00	10.60	4.50	9.60
February	0.50	0.11	0.00	0.00	0.00	0.03	1.50	11.70	2.50	9.00	4.12	7.50
March	1.00	0.26	0.00	0.09	0.00	0.23	5.75	9.50	4.67	7.20	4.43	5.20
April	0.50	2.30	1.07	1.30	0.75	2.20	2.75	5.40	1.60	3.90	1.50	3.40
May	1.33	11.6	2.00	10.30	3.52	9.20	1.33	1.80	1.00	0.35	1.64	0.30
June	5.00	13.1	6.00	13.20	6.40	11.8	0.00	0.00	0.00	0.00	0.00	0.03
July	6.82	14.4	8.00	17.70	7.60	14.4	0.00	0.00	0.00	0.00	0.00	0.00
August	7.00	13.7	6.00	15.00	9.13	12.2	0.00	0.18	0.00	0.17	0.00	0.03
September	4.75	13.00	6.00	13.60	3.58	11.00	1.25	0.97	4.00	2.40	0.33	0.93
October	0.25	7.00	0.65	5.00	0.85	3.50	3.75	8.90	3.87	8.90	3.10	8.00
November	0.00	0.31	0.00	0.13	0.27	0.07	5.00	15.00	3.00	12.50	7.69	11.30
December	0.00	0.19	0.00	0.09	0.27	0.00	3.25	13.90	2.50	11.60	4.24	9.40
Annual	2.26	6.35	2.48	6.37	2.70	5.39	2.59	6.79	2.18	5.55	2.63	4.64

*Note: Averaged for each of the HBC posts is weighted by the number of years with monthly data available. The climate normal data is based on days with rainfall greater or equal to 0.2 mm and snowfall greater or equal to 0.2 cm.

> The Potatoe have been up some days, at least a few of them, but the continual dry weather prevents this progress. Weather as yesterday. Water falling.
>
> (June 25, 1849)

The first quotation indicates low water levels in October 1848. During this month Campbell also noted that ice was forming on the rivers and water levels were rising at times. The dry channel he referenced may be a channel that is fed only by precipitation. June 1849 also indicates dry weather but not necessarily drought. There were five days of rainfall in June 1849 and this may not have been enough sustain the potatoes at Fort Selkirk, but that does not indicate drought conditions. Since there is no indication of prolonged drought conditions at any of the posts, it is probable that the lower than normal number of precipitation days are a reflection of a lack of recording, rather than a lack of occurrence.

Notable Seasons from 1842-1852

Both the warm/cold seasonal index and the historical temperature record have shown that the same extreme conditions were experienced at the posts. This section will discuss the most notable seasons in more detail, providing excerpts from the journals. The most common seasonal extremes in the index were mild winters. Mild winters were the product of one to three months of abnormally warm conditions during the period November to March. The warmest winters for the historical record were 1843/44, 1844/45 and 1850/51. Each of these winters had three months that were warmer than normal.

Winter 1843/44

The winter of 1843/44 was one of the three warmest winters (index= 0.60) for the period 1842-1852. December 1842, and February and March 1843 were all warmer than normal according to the index. Temperature records for the period indicate that December was 5.3°C warmer than normal (Table 23). February was 9.4°C above normal – a monthly mean that has not even been recorded in the modern record. According to the temperature records, March 1843 was actually 1.9°C colder than normal, but the high number of references to mild conditions during the month actually resulted in an index value of +1. The journal author for 1843/44 is generally assumed to be Robert Campbell but references to Campbell, by name, are made in the January entries, indicating that he is not the author for at least those entries. There is little indication that the journal author(s) recognized the post was experiencing a mild winter in December 1843. The author(s) consistently recorded daily weather entries, although qualitative thermal descriptions were not always present. Weather comments were straightforward and short, such as "clear and mild", "fine, clear and mild", "very fine and mild" and "the weather fine and mild" (HBCA B.73/a/2). By February 1844, there is more indication that the mild temperatures were now noticeable. The author writes on the 2nd, "Weather uncommonly mild". On the 15th of the month, thaw conditions are noted and on the 17th rain fell. No further comments reference the unusually warm conditions during the month except for days referencing "mild weather". Instead, the author is very concerned with the lack of food supplies. On February 1st, he notes, "Weather beautifully fine and mild- but oh! how dull to us who are famishing of want". Conditions worsen throughout the month. By the 5th, the last of the meat and barley is eaten and the men rely on flour for sustenance. On the 22nd, the author notes "Our bag of Flour is now emptying and we look forward now in despair to a most dishonourable death, that by starvation. Our dogs are dying having not had anything this month". By this point, all the men, women and children at the posts were searching for food.

Concerns regarding the food supply first arose in January 1844, although indications of the fisheries failing in November 1843 were noted. References were made in January 1844 to the men becoming weaker and to starving hunters. The reason for the lack of food is blamed on bad hunting weather and failing fisheries:

> Late last night Hoole arrived starving. In the three Lakes which he tried he could get no fish. All the Indians who are in that quarter have left it and are gone off in quest of animals towards the Pelly… the weather, till lately, has been too cold for hunting. We are now very low, for the last week, we have each 1 fish and ½ Pint of Barley per diem. All our fish are done now and our Barley which was only a veg at first and nearly so. Weather very mild for the season. 2, 20 and 12 [°F].
>
> (January 31, 1844)

By February 1844 the weather had warmed considerably, creating better hunting conditions. However, it wasn't until the last week in the month that any of the hunters met with success. Food supplies improved throughout March as meat caches became restocked. On March 28th, 1000 lbs of meat was brought to the post, effectively ending the food crisis.

The winter of 1843/44 was notable for two reasons. The weather, overall, was milder than normal and the post was suffering through a period of very poor food supplies. This winter recorded the highest number of references to starvation (20) for any year. February 1844 had the single highest number of starvation references for a month (10 days). February 1844 also recorded the second highest number of references to south winds (six days). Clear conditions were noted twice as often as cloudy conditions during the winter season, although clear conditions generally dominated in the winter season throughout the historical record (Appendix 4a-d). Poor food supplies and the mild weather were related but not directly. The poor food supplies were a result of a lack of provisions supplied to the post by the HBC. The company's belief that the post could be self-sufficient was misplaced on the idea that the fisheries, hunting and agriculture could supply enough sustenance for a year at a location that very little was known about. Fortunately, the mild weather of February heralded a change of fortune for Frances Lake by creating favourable hunting conditions.

Winter 1844/45

Three consecutive months (January-March) of warmer than normal conditions tied this season with 1843/44 and 1850/51 as the warmest winter in the historical period. The winter of 1844/45 had no starvation references. By now, Frances Lake had been in operation for two years. Lessons learned from the two previous winters had likely influenced the way food supplies were managed at the post for the better.

The milder conditions also favoured better hunting. A few temperature measurements are available for this season. On November 24, 1844, the author noted, “The weather clear and uncommonly cold for the season. -32, -32 and –28 [ºF]” (HBCA B.73/a/3). The average temperature for that day was –34.8°C, which is considerably lower than the normal monthly mean of -15°C. However, there is no indication that the cold weather lasted more than the one day. References to the mild weather in January 1845 indicated that the author(s) recognized the conditions were abnormal for the season: “Weather overcast and very mild for the season” (January 6), “Delightful weather for the season, calm, clear and sunshine” (January 9), and “Fine weather for the season, so mild and calm” (January 19). There are some references to very cold weather early in February 1845. Two temperature readings on the 2nd (-41.7°C) and 11th (-33.3°C) support the qualitative thermal descriptors (i.e. Very cold). However, the number of references to mild weather far outweighed the very cold and the one remaining temperature reading for the month, -10°C (February 17), supports the positive index value. By March 12, 1845, thawing conditions were noted and on the 13th the author wrote, “Southerly wind which freshened into a gale at the close of the day accompanied by rain. The snow fast disappearing”. There were three rain days during March, which is 11 times higher than the normal period (Table 24). The winter 1844/45 was dominated by clear skies and the highest number of windy days for the entire historical period (i.e. 35 days). Sixty-five per cent of the wind direction references were from the east and southeast.

Winter 1850/51

The winter of 1850/51 was the warmest winter recorded at Fort Selkirk. December, February and March were all warmer than normal according to the index. Campbell notes on December 23rd, “The weather uncommonly mild. Rain dropping from the houses- with strong southerly wind” (NA MG19-D13). Interestingly, the winter of 1850/51 was the cloudiest winter for the historical period (i.e. 31 days). Unlike the winters at Frances Lake, the number of cloudy and clear days was almost equal during winters at Fort Selkirk. Also, the prevailing wind for most winter seasons at Fort Selkirk was northwest, not southeast as was common at Frances Lake and Pelly Banks. Campbell and Stewart both realized that the winter of 1850/51 was unusual. On December 28th and 29th, Stewart wrote, “Never saw such continuation of mild weather at this season. Snow soft all day & no frost at night … River all covered with water & snow nearly all gone in the evening. The wind went to the North.” A period of colder weather in late January interrupted the mild spell. But by February, mild weather had returned along with references to reduced food supplies and “starving Indians”. Greater snowfall in January and February may have impeded the hunters. January 1851 reported eight days of snowfall and February recorded seven. The average number of historical snowfall days recorded at Fort Selkirk in January and February was 4.5 and 3.8 days respectively. On February 23rd, Stewart remarked, “Peter returned this afternoon having been unable to proceed to LaPie’s Lake owing to the road being entirely blocked up by drifts”. By the end of March, hunters were able to kill five caribou and four moose.

Cold winter 1842/43

Although the seasonal warm/cold index does not identify the winter of 1842/43 as extremely cold, the historical temperature record indicates that both January and February 1843 were below normal (Figure 27). This cold winter is similar to the warmer winters in a number of respects. Clear conditions dominated the season, accounting for over 60% of the Cloud conditions references. The total number of snow days in the winter 1842/43 was five days fewer than 1843/44 but three days more than 1844/45, indicating that the cold weather was not influencing the number of snow days recorded. The number of calm and windy days for the 1842/43 season was almost the same as 1844/45 (Appendix 3). However, more wind from the north and east was reported than from the southeast in 1842/43, which was the most common direction cited for the other winter seasons at Frances Lake. The cold winter of 1842/43 had the second highest number of starvation references for the entire historical record (i.e. 14 references). Campbell, the author of the majority of the Frances Lake journals, states (HBCA B.73/a/1):

> Rennie Boucher accompanied by Gauche arrived from Finlayson Lake and brought all the fishing tackles. The fishery having so completely failed that they were latterly unable to support themselves on the produce of the nets, this is a gloomy news too as in our present destitute condition but let us trust in the will of a kind and gracious Providence. The hunters in that quarter have had no success in killing animals either though it would appear that animals are not scarce... The weather fine and frosty. Thermometer at 7 AM -21 and at 2 PM –18 [ºF].
>
> (December 4, 1842)

> Thus we have 23 nets constantly in water which from their being so far apart... the whole procedure is very trifling but to us in our delicate condition we have no other source to supply our want... The weather very fine and mild. 11 [ºF].
>
> (December 12, 1842)

> The weather overcast and blowing from the N. –19 [ºF]. ... Thus close up on us the year 1842 with only 106 fish in the Store, 8 bags (a Depot) not an ounce of any kind of meat the last was laid out this evening.
>
> (December 31, 1842)

These quotations indicate that the HBC's problems with the food supplies and fisheries were present from the beginning of settlement at Frances Lake. December 1842 was actually warmer than normal, yet those warmer temperatures did not help the hunters as it did in the following winters. The expectation that there was enough fish in the surrounding lakes to supply the needs of the post may have been unrealistic. Problems with hunting were partly due to a lack of knowledge of the region. Campbell (1958) acknowledges this in his personal journal: "Our fisheries [proved] insufficient to meet our daily wants much less allow us to lay aside fish for the winter, strangers as we were to the country..." However, Campbell does imply that a lack of snow during the winter of 1842/43 was hindering some hunters. In January 1843, he writes:

> The weather very cold. -38 [°F] … Late Dick cast up from Ketza and Quiche camp beyond Finlayson Lake and the news he conveys is of the most gloomy description that in place of some animals being killed and secured for us they are all starving. They had not the luck to kill any since we had last though they have it would appear extended their hunting excursions in various directions and animals are saw to be plenty from cold and want of snow they cannot come up to them.
>
> (January 4, 1843)

> Dick arrived and says there are plenty rein Deer tracks close by but the snow is so loose and hard to walk through that he did not attempt to approach them… Snowing the greatest part of the day. -16.
>
> (January 23, 1843)

The intense cold and calm weather in February 1843 were blamed for poor hunting. Campbell writes on the 3rd, "Intensely cold. Dawn -56. Close -40…. Deer it would appear are plenty there but the weather is too cold and calm for hunting". But by the 24th over 20 animals had been killed despite the prevalence of very calm weather throughout the month.

Coldness of 1849

The only prolonged period of cold weather in the index was recorded at Fort Selkirk. The spring, summer and fall of 1849 were all extremely cold according to the index. Each season had one month that was colder than normal. This prolonged cold period is unique in the index because it represents extreme conditions that persisted throughout many seasons. May, August and October 1849 were all colder than normal, indicating that the months fluctuated between cold and normal conditions. The ratio of extreme cold to normal conditions in the construction of the index did not originally yield a negative index value for May 1849. However, additional examination of the journal entries for the month indicated that the month was anomalous. There were numerous comments by Stewart referencing conditions that were unusual for the season (NA MG19-D13):

> Weather colder for the season. The Wind after shifting to every point of the Compass remained North.
>
> (May 6, 1849)

> …went off to hunt ducks but only got a few owing to the bad weather…This has been the coldest day I have ever seen at this season, blowing hard with snow wh: was drifting as dry as in the middle of winter.
>
> (May 12, 1849)

> Water rose a little but the river holds fast still. We must be farther North than we think or else this is a very late season.
>
> (May 18, 1849)

> Extraordinary Weather for the season. We had a regular snowstorm this morning…. This is the latest season I have known in the North.
>
> (May 27, 1849)

> Barley in the upper field about an inch above ground. Here ends the month of May. Dreary and cold in the extreme, little or no vegetation & the banks of the river covered with Ice still…
>
> (May 31, 1849)

To further support a colder month, May 1849 had five snow days which is almost five times the number recorded at the nearby climate normal station, Pelly Ranch. May 1849 also had the latest first and last break-up dates for the Pelly and Lewes River (Table 21). As well, May 1849 also had the latest first reference to spring migration at Fort Selkirk (i.e. May 9th). All the other references to spring migration from the posts indicated migration commenced from April 16-29th.

August 1849 was the only cold summer month for the historical record. The initial index value for this month was zero but additional direct and indirect evidence supported a colder than normal month. Campbell made references to snowfall on the nearby mountains, stating on the 30th, "Pouring down rain all night but snowing in the Mts. They were coated with white to within a short distance of the water edge this morning, indicating an early winter. Flocks of geese passing" (NA MG19-D13). This reference also indicated the earliest date of fall migration recorded at Fort Selkirk (Table 20). Four days of frost were noted at the post, double the number recorded in previous years. August 1849 was wetter than normal. Seventeen days of rainfall were noted, well above the normal monthly mean of 12.2 days. Despite these additional indicators, Stewart and Campbell never referred directly to colder than normal temperatures. August 1849 highlights the importance of cryospheric and phenological data.

The last month of colder than normal weather during this prolonged period was October 1849. Campbell noted 10 days of Cold weather. On the 29th he wrote "The ice set fast on the Pelly & drifting full channel from the Lewis. The day very cold for the season". October 1849 also recorded the earliest freeze-up dates for the Pelly and Lewes rivers (i.e. October 29th and November 1st, respectively). Even in September, which was assigned a normal monthly index value, Campbell commented on the poor weather conditions from spring through summer. On September, 27th he wrote: "Took up the potatoes in the upper field which but for the early frost & late spring would have yielded a tolerable return or had the season been as favourable as the last. As it is they are very small and but little more than the seed sown". The following day he stated, "Took up Potatoes in next field, say our entire crop. They are of larger size than what was digged yesterday & there is in all about a keg and a fourth or half, say 10 or 12 gallons, but for the very untowards season we had there would have thrice as much… But few cranes passing today. Weather cold & raw". It appears that Campbell's comment in August concerning an early winter was confirmed by the end of October. It is unlikely that the authors were biased to record colder than normal conditions. By this point, they had already spent one entire year at Fort Selkirk and up to seven years in the Yukon Territory. Both Campbell and Stewart were arguably familiar with the variety of weather conditions the region offered.

Comparison with other Paleoclimatic Reconstructions

Comparison of the warm/cold index and the historical temperature record to other paleoclimatic studies provides further information on whether the conditions recorded at the posts were local or regional in scale. Significant work on the past climate of the Yukon using physical proxies has been conducted. The majority of the studies have focused on tree rings (e.g. Szeicz and MacDonald 1995; D'Arrigo and Jacoby 1995), although work has been done with ice cores (Holdsworth et al. 1995; Wake et al. 2002) and lake sediments (Cwynar 1995; Anderson et al. 2005).

Comparison of the warm/cold index with some paleoclimatic studies is problematic due to resolution. For example, studies which used pollen records from lake sediments have low temporal resolution, on the time scale of hundreds to thousands of years (e.g. Cwynar 1995). Conversely, the high resolution of the warm/cold index can pinpoint extreme months. The historical temperature record from Frances Lake can identify weeks and days that fall outside of the normal range. Fortunately, tree-ring data do provide higher resolution reconstructions (seasonal to yearly) for comparison. However, tree-ring data are generally best correlated to the growing season (Jacoby et al. 1985; Szeicz and MacDonald 1995). The growing season is represented in the warm/cold index but the other monthly and seasonal extremes identified by the historical Yukon data may not be identified by tree-ring reconstructions (i.e. winter seasons).

This study falls within a time period (i.e. mid-nineteenth century) that has been the focus of much debate in the paleoclimatic community. The end of the Little Ice Age (LIA) in northern Canada has been suggested to range from 1800 to 1850 (Wilson 1982; Luckman 2000; Moore 2001). Research on the magnitude and duration of the LIA contributes to our further understanding of natural climate variability, putting the current warming trend of the last 150 years into much-needed context. Many of the paleoclimatic studies for the Yukon Territory identify the mid-nineteenth century as a cool period. Jacoby and Cook (1981) found that white spruce annual ring widths from the Ogilvie Mountains in the Yukon indicated an increase in growth commencing around 1850 and lasting to 1950, with the mid-1800s possibly being the coldest period in the last 400 years. However, the ring-widths for this study correlated best with total degree-days above 10°C for June and July. Therefore, the results are only indicative of summer temperatures. The HBC journals from the Yukon Territory only identify one summer season, 1849, as anomalously cold.

Additional evidence for a cool early to mid-nineteenth century was found by associating tree rings with sea-level pressure anomalies (Cropper 1982). A strengthening of the summer North Pacific High occurred between 1830-1850 and was found to be associated with low summer temperatures at Fairbanks, Alaska and, by extension, the Yukon Territory. Further work by Jacoby et al. (1985) found a general warming trend with intermittent cooling periods lasting several years occurred from the 1840s-1950. Szeicz and MacDonald (1995) reconstructed summer temperatures for sites in the Yukon and Northwest Territories using age-dependent modelling which also indicated a warming trend since 1850. Comparison of the $\delta^{18}O$ record from Mount Logan, Yukon Territory, with tree-ring records indicated that the series showed a climate perturbation after 1850. Further work by Moore et al. (2002) on Mount Logan suggested an increase in average annual snowfall began after 1850, implying higher temperatures, since warmer air has a higher saturation vapour pressure and thus can transport more snow. One small-scale regional study in the Yukon did indicate an earlier onset than 1850 (i.e. 1840) for the warmer temperature trend (Jacoby and D'Arrigo 1989). However, further work also indicated that the period 1820-1900 was cooler by up to 2°C for the calibration period 1880-1974 (D'Arrigo and Jacoby 1995).

Regional and hemispheric studies have also shown that a warming trend commenced in the 1800s. However, some of the studies indicate that the warming trend began earlier than 1840 or 1850. Overpeck et al. (1997) conducted a comprehensive study of Arctic environmental change and identified the 1840s as the beginning of a warming trend that lasted over 100 years. However, only summer temperatures were reconstructed and the 1840s were still identified as having some of the coldest summers in the last 400 years. Jones et al. (1998), Crowley and Lowery (2000) and Briffa et al. (2001) all show a warming trend commencing between 1800 - 1825.

Comparison with other historical climatology studies in the Hudson Bay region also shows some disagreement. Historical temperature records from Churchill and York Factory on the Hudson Bay identified November 1849 as warmer than normal, indicating a transition out of the LIA (Ball 1995). Conversely, this study has shown that in the Yukon approximately half of 1849 was colder than normal. Table 24 compares the reconstructed spring temperature anomalies for the east coast Hudson/James Bay for 1840-1860 (Catchpole 1995). Over 50% of the spring seasons between 1840-1860 are anomalously cold at Hudson Bay. The warm/cold index and Frances Lake historical temperature record indicate that the springs of 1843 and 1849 were anomalously cold. The Hudson/James Bay record also indicates colder than normal springs for these years. Catchpole's study also shows that the spring of 1844 was anomalously cold. The spring index for 1844 is normal but the historical temperature record for May 1844 indicates the month was 4.5°C colder than normal for the first of the month. However, a number of spring seasons that were two degrees cooler than normal at Hudson Bay were not seen in the Yukon Territory (i.e. 1842, 1845, 1852). Some of the disagreement is likely due to site differences. The two locations are separated by thousands of kilometres and are not necessarily influenced by the same pressure systems. Also, the spring seasonal divisions between the sites differ. The HBC data from the Yukon are based on an April/May season, while the Hudson/James Bay is May/June.

Disagreement between the HBC data from the Yukon and other paleoclimatic studies is not indicative of errors within the index. Rather, the climatic information captured with the journals is of such a high resolution that comparison to many data sets is impractical. Many of the physical proxies are only able to point to general trends of warming or cooling with approximate start and end dates that can have a range of 10 years or more (e.g. Jacoby and Cook 1981; D'Arrigo and Jacoby 1995). These data are often unable to identify monthly or even seasonal normals and extremes. As well, many of the studies have focused on summer temperature reconstructions. The warm/cold index shows almost no extreme summer seasons for

Table 24: Reconstructed spring (May/June) temperature anomalies for the east coast of Hudson/James Bay

Year	0	1	2	3	4	5	6	7	8	9
1840			-4.00	-3.50	-2.00	-3.00	0.50	-1.50	-2.50	-3.50
			0.00	-0.50	0.00	0.00	0.00	0.00	0.00	-0.33
1850	0.50	0.00	-3.00							
	0.00	0.00	0.00							

Note: The first value represents the reconstruction temperature anomaly (degrees Celsius) for the Hudson Bay. The second value represents the southern Yukon warm/cold spring index value. Cells with no data reflect years not covered by the warm/cold seasonal index.

the historical period. Rather, it suggests that much of the extremes that were experienced in the southern Yukon occurred in the winter.

The warm/cold index may not agree with paleoclimatic studies from other parts of the country or world because the index may be reflecting very local or regional conditions in the southern Yukon. The suggested end date of the mid-1800s for the end of the LIA is supported by this study. Most studies estimate the end of the LIA around the 1850s. The index suggests that the Yukon may have been exiting the LIA period as early as the 1840s due to the persistence of milder than normal winters. It also suggests that much of the warming trend may have occurred during the winter instead of the summer. The reality that some physical proxies (e.g. tree rings, ice cores) are poorly correlated with winter temperatures shows that historical documents from the Yukon Territory offer the potential to fill in the "paleoclimatic puzzle" by offering weather data from all seasons.

Chapter 6: Summary, Conclusions and Recommendations

This section summarizes the findings of the study. As well, some conclusions on the study itself and the applicability of historical climatology on the Yukon are discussed. Finally, recommendations for further work in the field are given.

Summary

Over 80 historical documentary sources from the Yukon Territory covering the period 1840-1900 were initially examined to determine if sufficient material existed for paleoclimatic reconstruction. The period 1842-1852 was selected for the focus of the study since it provided near daily documentation of the weather from a previously proven reliable source – the Hudson's Bay Company (HBC). Three HBC posts, Frances Lake, Pelly Banks and Fort Selkirk, operated in the southern Yukon Territory during the period 1842-1852. Each of the posts offered daily journals from different years of the study's temporal focus although some overlap between the Frances Lake and Pelly Banks journals occurred in 1845. The daily journals of the HBC posts provided direct and indirect weather information. Direct weather data included qualitative references to temperature, cloud conditions, wind strength, wind direction, snowfall and rainfall. Indirect weather references included information on biological activity, ice activity, human impacts and miscellaneous remarks. The Frances Lake journals also provided an almost gap-free historical temperature record from December 1842 to May 1844.

The weather information in the journals was digitized. A hierarchical coding scheme was developed that coded the daily entries by category and subcode. For example, the category called <u>Temperature</u> was further divided into nine subcodes: <u>Very cold</u>, <u>Cold</u>, <u>Cool</u>, <u>Mild</u>, <u>Warm</u>, <u>Hot</u>, <u>Frost</u>, <u>Thaw</u>, <u>No frost</u>. The total number of monthly references for each individual subcode was determined. Monthly and seasonal averages were weighted by the number of years with available data for the month or season.

A warm/cold seasonal index was developed for the period 1842-1852. The index was based on the number of normal versus extreme weather references per month. Extremely warm months were assigned an index value of +1, extremely cold months were –1, and normal months had an index value of 0. Additional direct and indirect weather evidence was also used to refine the monthly index values. The index was verified through comparison to a temperature anomaly record, which was determined by subtracting the mean monthly temperature for the climate normal period (1971-2000) from the historical Frances Lake temperature record. The average number of monthly rainfall and snowfall days for Frances Lake, Pelly Banks and Fort Selkirk was also compared to the number of snowfall days for the normal period (1971-2000) for the climate stations Watson Lake A, Faro A and Pelly Ranch respectively.

The warm/cold seasonal index revealed the presence of persistent mild winter seasons throughout the historical record. This winter warming may be linked to the end of the Little Ice Age (LIA) in the southern Yukon. This finding is in agreement with other paleoclimatic studies that have identified the mid-1800s as the end date of the LIA in North America. A cold period that lasted for half of 1849 was also found.

Conclusions

This study has demonstrated that historical documents from the southern Yukon Territory can be used for paleoclimatic reconstructions. The detailed weather information stored within the Hudson's Bay Company's journals has provided enough information to categorize months and seasons as normal or extreme. Previous work with HBC journals in Manitoba had utilized historical temperature measurements and meteorological ledgers specifically designed for the recording of weather data (Wilson 1988; Ball 1995). Extensive use was also made of phenological and ice-activity data which have been strongly linked to temperatures (Moodie and Catchpole 1975; Ball 1983). However, this is the first thermal index based solely on qualitative thermal descriptors from all seasons using HBC data. It is also the only historical climatology study in Canada that has successfully used a short-term data set (i.e. fewer than 10 years) for paleoclimatic reconstruction. Previous work with other HBC journals or historical sources utilized at least 50 years of weather references. Very few studies from other regions have focused solely on short-term records. The attraction to long-term weather records is reasonable but in some cases long-term weather qualitative records may not be available. This study has developed a methodology that can be applied to those areas.

One of the major drawbacks associated with historical climatology research is the amount of time required to fully investigate the sources and customize a methodology for analysis. Jones et al. (2001) commented that a decline in the field may be due to the time and effort involved. Historical documents may provide descriptions of actual weather conditions but the skill required for analysis is just as great or greater than that required for physical proxies, since the data cannot be as easily quantified or related to the modern record. The lack of easily quantifiable data, statistical tests and overlap periods with the modern instrumental record are all barriers to the research. First time researchers in the field may require a much longer acclimatization period than their counterparts who work solely with physical proxies. The initial time devotion for a study that covers a short or long temporal duration can be very similar in length, which also explains why researchers tend to focus on areas that provide longer-term records.

Recommendations

The focus on the period 1842-1852 was necessitated mainly by the fact that it represented the earliest period of consistent, stable, reliable weather records. However, there are numerous other historical documents in the southern Yukon Territory that could be used to further build on the paleoclimatic picture. Appendix 1 lists the historical sources initially consulted for the study housed in the Hudson's Bay Company Archives (HBCA), the National Archives (NA) and the Yukon Archives (YA). A larger number of the sources date from the 1880s onwards. Many of the sources are concentrated around the Dawson City region (also known as the "gold-rush" region). Considering the fact that the majority of the weather station data for the Yukon commenced in the 1940s, extending the climatic record back to the late 1800s is desirable. Many of the historical sources that could be examined come from government organizations or business. The weather information from these records is likely to be as reliable as the HBC data used in this study. For example:

- George M. Dawson – Geological Survey of Canada
- William Ogilvie – Geological Survey of Canada
- Otto Julius Klotz - Dominion Topographic Surveyor

- Charles Constantine – Chief Inspector of the Northwest Mounted Police

There are also a number of personal diaries, letters and papers that can provide weather information for the southern Yukon. Nevill Alexander Drummond Armstrong was a miner and hunting guide in the Yukon during the late 1800s and early 1900s. His 22 diaries contain numerous weather references, particularly for the Russell Creek area (YA MG30-E2). One of his diaries contains a temperature record of Russell Creek for 1905-1906. The Partridge family fonds also contain daily weather information. Mrs. Partridge produced three diaries, 1898-1926, detailing their daily activities, the arrivals and departures of steamers, and the weather at Mill Haven, Yukon Territory, as well as Ben-My-Chree (northern British Columbia) (YA MSS 201 81/187). The diary contains a section entitled "Lowest Temperature before Xmas 2 [degrees Fahrenheit] or lower" for the period 1898-1917.

Historical documentary sources for the rest of the Yukon Territory are also numerous. The highest number of documents centre around the Dawson/Klondike area and date from the onset of the gold rush era (i.e. 1897). The HBC also established other posts in the northern Yukon Territory, such as La Pierre's House, Shingle Point, Herschel Island, and Rampart House. However, not all of the daily journals survive for these posts and some were established in the 1900s. The Northwest Mounted Police established numerous detachments throughout the Yukon in the late 1800s and early 1900s. Although the collection of weather information was not the official mandate, some posts and employees did record official and private weather data.

The sources in Appendix 1 represent a broad list of historical documents for the southern Yukon Territory from 1840 onwards. Since the modern instrumental record extends only until the 1900s for the majority of the Yukon, the potential for historical documents in lengthening the record is great. The high-resolution data offered by historical documents are important for placing the extreme and normal conditions that have been or will be experienced in the region within a more informed context. At least one of the months captured in the historical HBC record was shown to be well outside of the range of normal conditions. February 1844 was warmer than any other February within the 1971-2000 normal period. This is information that tree-rings, lake sediments and ice core data were unable to supply. Historical documents from the Yukon Territory and, hence, the rest of Canada, can play a major role in our understanding of the climate of at least the last 150 years.

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Appendix 1: All sources consulted

File Name	Reference Number	Institution	Period Covered	Type	Description
Anderson, Egan	MSS 8 82/145	Yukon Archives	1898-1900	Letters, newspaper clippings	Translated from Norwegian
Anderson, Maud Case	MSS 172 81/91	Yukon Archives	Text	1903, 1953	Typewritten transcriptions of thirteen letters describing travelling to the Yukon and life in a mining camp with her father.
Armstrong, Nevill Alexander Drummond	MG30-E2	National Archives	1894-1926	Diaries	22 diaries covering Armstrong's short stay in New Mexico and his life in the Yukon Territory as a miner and leader of hunting expeditions. Has a temperature chart for 1905-06 at Russell Creek as well as some sketches. Diaries are well laid out and explained. Does comment on weather.
B Division	R196-86-X-E, R196-89-5-E, R196-90-1-E, R196-91-3-E	National Archives & Yukon archives (microfilm)	1898-1938	Letterbooks, general and special orders, daily journals, and subject files.	Yukon division of NWMP. Some temperature data in letterbooks. Correspondences indicate weather equipment was inquired about and used.
Ball, Ben E.	MSS 46 83/83	Yukon Archives	1899	Narrative - printed in 2-3 parts in the Charles City Press	Type story "In the Land of Gold - Adventure of Charles City Lady's Husband in the Eldorado of Precious Metal". Basically a transcript of his diary. Does mention the weather.
Ballou, William	MSS 9 82/154	Yukon Archives	1889-1918	Story based on reality.	Fonds contain an item called "Jack- A true story of adventure in Alaska" which Ballou wrote, as well as newspaper articles.
Bartsch, Chris & Grace	MSS 82/146 or 149	Yukon Archives	1900	Diary	Grace's diary describes her trip to the Klondike (77 pages).
Bates, Stu	MSS 125 89/40	Yukon Archives	1988	Narrative	Typed history of Minto & NWMP (photocopied it).
Bennett Sun	N-1 Reel 1	Yukon Archives	1899	Newspaper	Early newspaper record- references the weather.
Bennett, Gordon	MSS 40 82/221	Yukon Archives		Staff Report	History of Livingstone Creek (YT)
Bobillier, Father	CAIN No. 86276	Dawson City Museum	1915-1977	Unpublished memoirs. Compiled from daily diaries.	Missionary, based in Fort Selkirk for eight years (region from Lake Laberge to Dawson City). Offer information about the day to day life of a missionary in the Yukon.
Bompas, Bishop William Carpenter	MSS 125 (81/38)	Yukon Archives	1865-1900	Letters to family and friends.	Diocese of Yukon (Forty Mile). Lived in Carcross. Letters describing travels (comments on Indian, wildlife, scenery).

File Name	Reference Number	Institution	Period Covered	Type	Description
Bostock, Hugh Samuel	MG55/30-No.142	National Archives	1897-1926	Diaries, books, and writings.	A history of Russell Creek, Yukon Territory (1897-1926). Based on diaries and writings of Lt. Col. Nevill Alexander Drummond.
Bostock, Hugh Samuel		Geological Survey of Canada (GSC) publication	1898-1933	Geological Survey of Canada Memoir 284	"Yukon Territory- Selected Field Reports of the Geological Survey of Canada 1898-1933", compiled and annotated by H.S. Bostock. Appendices list meteorological registers. Only original edition of GSC publication contains the appendices.
Bowen, R.C.	MSS 007 82/119	Yukon Archives	1910	Diary	RCMP officer in 1910. Contains patrol reports and official diary.
Bowen, R.J.	MSS 201 88/39	Yukon Archives	1898	Narrative	"Incidents in the life of the Reverend Richard John Bowen among Natives, Trappers, Traders, Prospectors and Goldmines. In the Yukon Territory ... Before and after the Gold Rush of the year 1898." 205 typed pages
Burpee, Lawrence Johnston	MG30-D39	National Archives	1697-1945	Publication	Burpee was a historian. Published in 1910 the "Journals of the Yukon" (based on the journals of Robert Campbell, Alexander Hunter Murray and the letters of John Bell). Historical research: including correspondence from the Hudson's Bay Archives.
Campbell, Robert	MG 19 A25	National Archives	1808-1851	Personal diary/ narrative	Journal of Robert Campbell 1808-1851 (1910). Similar to an abbreviated memoir. More like a narrative than a diary- some comments on weather.
Campbell, Robert	MG 19 D13	National Archives	1848-1852	HBC Journal, Misc papers	Journals from post of Lewes and Pelly Rivers (i.e.: Fort Selkirk).
Campbell, Robert	MG19 A25	National Archives	1845-1847	HBC Journal	Journal of Occurrences at Pelly Banks 1845-1847
Campbell, Robert	E 48/6-7	HBC Archives	1808-1851	Journal	Personal journal of Robert Campbell- written in a narrative fashion, somewhat organized by date. There are two versions of the journal, one version is longer than the other and they differ from each other somewhat.
Campbell, Stewart	MSS 122 81/129	Yukon Archives	1898-1899	Diary	Type-written diary from Jan. 26, 1898 to August 1899 from the Klondike. From June 1898-Aug 11, 1899, he is in the Yukon and he does record weather information in his diary.
Camsell, J.S.	MSS 169 (81/72	Yukon Archives	1881	Letter	Photocopies of two handwritten letters sent to Robert Bell from Julien Stewart Camsell, from Fort Simpson (1881). In the letters Camsell discusses obtaining bird's eggs, game specimens, and trophies for Bell, and also describes the weather at Fort Simpson.

File Name	Reference Number	Institution	Period Covered	Type	Description
Canadian Development Company	COR 128 82/485	Yukon Archives	1900-1901	Corporate records	Registers maintained at various mail posts- record the arrival and departure of mail. Some comments on weather with reference to trails but not consistent.
Canadian Northern Affairs Program- Water Resources Program	GOV 1184 81/90	Yukon Archives	1895-1975	Publication	Yukon historical flood report "Historical review of Dawson City flood data: 1895-1975". Used "White Pass and Yukon Route" daily journals.
Canham, T.H.	RMF 6	Yukon Archives	1881-1934	Letters, diaries, notebooks, sermons	Missionary. Posted at: St. James Mission, Lower Yukon River, 1888-1892; Tukudh Mission, 1888-1891; St. Andrew, Selkirk, Yukon, 1892-1910; St. Saviour, Carcross, 1910-1922.
Chapman, Benjamin F.	MG 29 C52	National Archives	1898-1900	Diary	Was a postal clerk in Dawson 1898-1900. Records weather info (ex: temp) in his diary.
Childs, Will	MSS 166 84/65	Yukon Archives	1899-1900	Letters	Two letters sent from Whitehorse and Dawson City. Letters describe travelling to the Klondike, and life as a miner in Dawson City, Yukon.
Claxton, Fred J.	R9970-0-X-E	National Archives	1865-1910	Photos	Photo of Fort Selkirk 1898 and other areas in Yukon.
Cobban, G.M.	H 608	Yukon Archives	1908	Chart	Contains an elaborate circular meteorological chart called "Meteorological conditions in the Klondyke Goldfields, Yukon Territory". Has temperature, precipitation data for the entire year.
Coffey, George	MG29-C46	National Archives	1898	Diary	Diary of journey to Dawson City and of work for the Klondike Government Concession Company.
Connolly, Tom & Shirley	MSS 16 82/188	Yukon Archives	1936-1937	Diaries	Two handwritten trapper diaries from the Ross River area.
Constantine, Charles	MG30-E55	National Archives	1870-1908	Diaries, subject files, and letterbooks.	Chief Inspector for Northwest Mounted Police. Numerous volumes range from 1896-1908 at least. Kept detailed daily journals (some comments on weather).
Coults (Israel Lee)	MSS 91	Yukon Archives	1890s	Letters, diaries	Letters describe journey to Dawson- has general weather info. Diary contains many references to weather (including some temperature data).
Craig, Morte H.		Dawson City Museum	1898-1907		The textual records include a weather chart.
Craig, R.B.	MSS 10 82/160	Yukon Archives	1898-1900	Diaries	Two diaries from Dawson August 1, 1898 to June 5, 1900.

File Name	Reference Number	Institution	Period Covered	Type	Description
Dawson, George Mercer	RMF 8 80/115	Yukon Archives		Diaries & Letters	Copy of Dawson's handwritten diaries and notes (almost illegible). Letters concern Alaska boundary dispute. *Note- See references for "Ross" for transcription of Dawson's diaries.
Dawson, George Mercer			1898	Publication	Entitled "Report on an exploration in the ***Yukon*** district, N.W.T., and adjacent northern portion of British Columbia, 1887"
Dawson, George Mercer			1898	Publication	Entitled "Historical notes on the Yukon District". Publisher: University of Toronto
Dall, William Healey			1898	Publication	Entitled "The Yukon Territory; the narrative of W.H. Dall, leader of the expeditions to Alaska in 1866-1868; the narrative of an exploration made in 1887 in the Yukon district by George M. Dawson; extracts from the report of an exploration made in 1896-1897 by Wm Ogilvie...". Published: London, Downey & Co..
Dewey, Fred	MSS 166 81/48	Yukon Archives	1898-1899	Letters to family and friends.	Letters sent home from the Klondike. Does write a lot about the weather in the Yukon in his letters.
Dobrowolsky, Helene.	PAM 1988-0098	Yukon Archives		Reference list	Fort Selkirk bibliography: a listing of sources for Fort Selkirk and the Yukon Field Force found in Yukon Archives and elsewhere / compiled by Helene Dobrowolsky.
Dominion Land Surveyor's diaries	R214-73-0-E	National Archives	1881-1930	Diaries	Contains official diaries of Dominion Land Surveyors relating to surveys Yukon Territory. The diaries detail the day to day activities of surveyors while on duty in the field. The details of the survey work are also in the published reports of the Surveyor General, which appeared annually in the report of the Department of the Interior.
Finnie, Richard Sterling	MG31-C6	National Archives	1890-1987	Correspondence, diaries and manuscripts.	Expert on history and geography of region. Contains information on Klondike Gold Rush, Captain J.E. Bernier's Arctic Expeditions in 1924 to 1925 and the Arctic patrol in 1937.
General Arctic correspondence	MG31-C6	National Archives	1923-1986	Correspondence, manuscripts, and clippings.	The history of the Alaska Highway, CANOL, Arctic oil, J.E. Bernier, the M.V. Arctic and the ship's bell of the original ARCTIC, V. Stefansson etc.
HBC - Fort Selkirk		Heritage Branch - YK Government	1848-1852	Journal	Published and edited version of the "Journal of occurrences at the forks of the Lewes and Pelly Rivers May 1848 to September 1852" (recorded by Robert Campbell and James Stewart).
Hudson's Bay Company - Fort Selkirk	B. 196/d/1	HBC Archives	1851-1852	Account Books	Has section called "Packing Account 1851". Describes furs (number & type) in each pack.

File Name	Reference Number	Institution	Period Covered	Type	Description
Hudson's Bay Company - Fort Selkirk	B. 196/2/1	HBC Archives	1847-1851	Misc. Items	4 pages in total - 3 of which listed "Furs Traded".
Hudson's Bay Company - Frances Lake	B. 73/a/1-4	HBC Archives	1842-1846	Journal	Daily journals of the Frances Lake outfit.
Hudson's Bay Company - Pelly Banks	MSS-255	Yukon Archives	1845-1847	Daily Journal	"Journal of occurrences at Pelly Banks Outfit" for 1845-1847.
Hudson's Bay Company - Teslin Post	B. 356/d/1-3	HBC Archives	1898-1900?	Account Books	Account books and misc. papers of Teslin post. Teslin post was located very close to the border between the Yukon and British Columbia.
Hudson's Bay Company - Teslin Post	B. 356/dc/1	HBC Archives	1898-1900	Correspondences	Teslin post was located very close to the border between the Yukon and British Columbia.
Hoare, William Henry Beer	MG30-B128	National Archives	1928-1929	4 journals	Missionary and public servant. Journals cover an expedition from Fort McMurray to Baker Lake. In diary of Thelon Game Sanctuary area he does comment on the weather generally but it for the dates 1928 onwards.
Innes-Taylor, Alan	1603 Series 10, Administration	Yukon Archives	1890-1974	Personal papers	The majority of the textual records (ca. 1890-1974) include personal correspondences; survival notes and lectures; Byrd expedition records; Vilhjalmur Stefannson correspondences and reports; Belmore Brown correspondences and reports.
Jones, Elizabeth	MSS 199 87/53	Yukon Archives	1900-1901	Letters	Photocopies of letters describing experiences and impressions of life in the north.
Kline, George A.	MSS 199 83/70 or 87/70	Yukon Archives	1898	Diaries	Copy of a typed transcript of a diary about the 1898 trip from Whitehorse to Dawson City, time spent in Dawson and the Klondike Gold Fields, and their travel down the Yukon River to St. Michael. Does contain weather references.
Klondike Nugget Daily	N-4 Reel 3	Yukon Archives	1900	Early newspaper	
Klotz, Otto Julius	MG30-B13	National Archives	1866-1923	Correspondences, notes, reports, and memoranda.	Mostly concerns the Alaskan boundary dispute. Report (1889) has a chapter (#2) on "Physical features" where the weather is briefly described. Personal diaries are numerous and very detailed.
Lamarque, Ernest C.W.	MG30-B39	National Archives	1897-1900 1903-1907 1907-1956	Memoirs	Worked for HBC and CPR (surveyor). Memoirs mention the weather but not in much detail.

File Name	Reference Number	Institution	Period Covered	Type	Description
Linklater, Charles	MS 0/S 006	Yukon Archives	1903-1941	Diaries	Copy of a typed transcript of the diaries of Charles Linklater, a trapper at Old Crow. The entries include a brief note on the weather, daily hunting and trapping activities.
MacKenzie, George	MG30-E529	National Archives	1896-1932	Correspondence, diaries and reports. Speeches, dispatches, clippings, and summary reports (RCMP).	Personal papers on Arctic expeditions and the RCMP. Was the Gold Commissioner in the Yukon and as Commander of Eastern Arctic Explorations for the federal government. Has the Arctic diary (1925), which has weather comments throughout with location by latitude and longitude.
McConnell, R.G.	CIHM 09385		1891	Publication	Entitled " Report on an exploration in the Yukon and Mackenzie basins, N.W.T."
McMichael, Alfred G. aka Juilet Reinicker fonds	MSS 100 79/68	Yukon Archives	1898-1899	Letter, Diary in manuscript format	Diary called "4th of July Creek: The Story of Alfred G. McMichael's Trip to Alaska During the Gold Rush of 1898". Letters are very descriptive and cover trip to the north, hike along the Chilkoot Trail and over the Pass, the people on the trail, gambling, and the weather. Also, describes life as a miner in the Klondike.
Morison, William T.	MSS 007 82/112	Yukon Archives	1887-1893	Diary	Worked on Alaska boundary expedition. Surveyor on Ogilvie's party (1887-1890). There is a typed copy of the diary, with comment on weather and some temperature data.
Murray, Alexander Hunter	MG19-A27	National Archives	1848-1910	Journal/ letter.	Worked for American Fur Company and Hudson's Bay Company. Composed his own "Journal of the Yukon". Journal details the building of Fort Yukon (in Alaska). Page 152 (91) is a section on "Notes on the Meteorological Journal". Journal written in the form of a letter.
NWMP - B Division	MF 29 Reel 10 (Series III)	Yukon & National Archives	1896-1920	Daily Journals	Some journals do contain weather info. Has info for Lake Bennett, Tagish, Dawson, Bennett (BC), Fort Resolution (NWT).
NWMP - Fort Constantine	PAM 1897-95	Yukon Archives	1897	Report	"Report of trip to the Yukon 1897 by Inspector W.H. Scarth" dated Fort Constantine, 17th June, 18997. Small book, typed, organized by date.
NWMP - Forty Mile		Yukon Archives	1908-1912	Weekly reports	In a letter format, organized by dates, regular comments on weather. Originals in poor condition.
NWMP - General Orders	MF 29 Reel 8	Yukon Archives	1900s	General orders	Lists orders by name. Also shows info on fines, leaves, transfers. No weather info apparent.
NWMP - Letterbooks	MF 29 Reel 1-7	Yukon Archives	1900s	Letters	Compilation of letters, subjects vary from transfers, info on misbehaviour of staff, food supplies, posts etc. No weather info

File Name	Reference Number	Institution	Period Covered	Type	Description
Partridge family	MSS 201 82/187	Yukon Archives	1898-1930	Records, letters, diaries.	Three diaries handwritten by Mrs. Partridge, 1898-1926. Describes their daily activities, the arrivals and departures of steamers, and the weather. Diary #1 indicates they were at Mill Haven, which is 10 miles west of Carcross.
Ogilvie, William	CIHM 15796		1887	Publication (microfiche)	Entitled " Report of Wm. Ogilvie exploration survey of the Yukon River District."
Ogilvie, William	CIHM 14529		1897	Publication (microfiche)	Entitled "Information respecting the Yukon district from the reports of Wm. Ogilvie, Dominion land surveyor and from other sources"
Ross, W.J.	Book 917.110 432	Yukon Archives	1887 (Published 1996)	Book	"The travels of George M. Dawson with the 'Yukon Expedition' in the year 1887". Ross transcribed Dawson's field notebooks. Shows that it has weather info.
Schwatka, Lt. Frederick	MSS 170 81/73	Yukon Archives	1893	Letter	Has a military journal (1891) features one of the first records of a Chilkoot Pass crossing by a white man.
Seattle Hotel	COR 327 80/95	Yukon Archives	1901-1904	Hotel registry	Seattle Hotel Register, Fort Selkirk, Oct. 23, 1901-June 20, 1902. Part way through it becomes the register for the Cold Springs Roadhouse, November 1910 to December 1910 and then the Carpenter Roadhouse Register, January 1904 to April 20, 1904. Have Temperature readings in margins of some pages.
Selkirk Hotel	COR 209 82/494	Yukon Archives	1900-1930	Hotel registry	The fonds consist of the Selkirk Hotel guest register (1900-1902), fur inventory (1924) and stock inventory (1925-26) in one hard-bound volume. The Selkirk Hotel was located at Fort Selkirk on the Yukon River.
Skye, Olaf	MSS 199 87/54	Yukon Archives	1901	Memoirs, letter.	Entitled "Along the Trail of '98". It is an account of the journey to the Klondike Gold Fields and the experiences once there.
The Dawson News	N-2 Reel 1	Yukon Archives	1900-1902	Newspaper	Does have weather info but not constant and have to review each issue for it. Early issues (1900) had Monthly Temperature tables, while later issues (1902) had official (?) temperature each day but no temperature tables.
Thimmell, Timothy L.	MSS 122 82/460	Yukon Archives	1897-1900	Diary	Prospector around Dawson City, Yukon. Diary briefly describes daily activities, travels, the weather and the amounts of gold being found in the Klondike Gold Fields.
Tinck, John A.	MSS 061 82/437	Yukon Archives	1898-1899	Diary, poem, photos	Staff sergeant for NWMP. Diary (from May 3, 1898 to September 8, 1899) recounts journey to the Yukon and time at Dawson City & Fort Selkirk. Does comment on weather in diary.

File Name	Reference Number	Institution	Period Covered	Type	Description
White Pass & Yukon Route	COR 823-830 82/451 Series VIII-I (vol 1-3)	Yukon Archives	1902-1957	Company records	Contains meteorological records from 1902-1957. Compiled by B.Y.N. Co. River Division personnel in Whitehorse. Has daily water levels in Whitehorse, data for Marsh Lake Dam, Carcross, Lake Laberge and numerous other locations (info telegraphed).
White Pass & Yukon Route	COR 368 or 868 82/452	Yukon Archives	1901	Manager records	File # 1/539- "Daily Weather Reports" for a number of locations (organized by time)
White Pass & Yukon Route	COR 82/12	Yukon Archives		Daily journal	Has annual meteorological summary for Dawson City 1931-1960.
Whitehorse Star	N-5 Reel 1	Yukon Archives	1900-1902	Newspaper	Have some weather info in articles, but no official tables until 1901 (list weather info for many places in the Yukon).

Appendix 2a: Example of journal information transcribed: Frances Lake

Please see attached CD for all transcribed journal entries

Hudson Bay Archives – B.73/a/1

Note: Frances Lake Journal 1842/3 - "Journal of daily Occurrences on the way to and at Frances Lake. Mackenzies River District Outfit 1842."
Note: Journal author for first outfit year 1842/43 likely Robert Campbell. Journal authors for the other outfit years likely Campbell and William Hardisty.
Note: Temperature values were recorded as 0/21 [meaning 21 below zero or –21] or 18/0 [meaning 18 above zero or +18]. I changed the original format to either + or – values for simplicity and continuity with other records.

January 1843

1 The weather clear and very cold. Dawn –43. Noon –36. Close –37.
2 The weather clear and not so cold. Dawn –30. Close –20.
3 The weather clear, calm and frosty. Dawn –30. Close –15.
4 The weather very cold. –38…Late Dick cast up from Ketza and Quiche camp beyond Finlayson Lake and the news he conveys is of the most gloomy description that in place of some animals being killed and secured for us they are all starving. They had not the luck to kill any since we had last though they have it would appear extended their hunting excursions in various directions and animals are saw to be plenty from cold and want of snow they cannot come up to them.
5 The weather cold –29.
6 The weather overcast and snowing a little. –29 and –24.
7 … our entire stock of fish now remaining to 10… Dawn –16, dusk –23.
8 The weather clear and very cold. Dawn –48. Close –46.
9 The weather overcast. Dawn –32. Close –20.
10 The weather overcast and snowing a little. Dawn –20. Close –14.
11 Laying snow all day and the weather mild. Dawn –17. Close –7. I had to lessen our pemmican for rations having nothing else now in Store remaining.
12 [From 23 nets got 3 fish]… our situation is becoming more and more forlorne and dreary, how are we to get through the winter in this back region God only knows. The weather is so mild that all the detriots [?] of the lake are broke up the ice having decayed. Dawn 0. Close 7.
13 The weather fine and clear. Dawn –19. Close –10.
14 The weather fine and clear. Close –2.
15 Beautiful weather. Thermometer at 0. Dick cast up very unwell with the gloomy tidings that neither Hoole nor himself can secure any rabbits the former however still remaining there. This renders our condition more and more dreary.
16 The weather overcast and most cold. –23 and –14.
17 Snowing all day and now there is a great depth upon the ground. Close 7.
18 The weather overcast with much appearance of snow. Dawn –23. Close –14.
19 …The fishing has now dwindled to nothing that from 25 fish [nets?] we cannot procure on an average 5 fish per day but having no other source to supply us the nets are kept still in the waters… Blowing snowing and drifting all day from the W. –16.
20 The weather overcast and cold. –27 and –21.

21 Snowing all day of there is now a great quantity on the ground. The weather mild. Dawn –11. Close 1.
22 The weather boisteraced [?] with snow and drift from the W.
23 … Dick arrived and says there are plenty rein Deer tracks close by but the snow is so loose and hard to walk through that he did not attempt to approach them… Snowing the greatest part of the day. –16.
24 [Hoole got 19 hares]. The weather cold and snowing a little.
25 The weather overcast and cold. –28 and –20.
26 The weather very mild. Dawn 2. Close 5.
27 The weather clear mild. Calm and fine. 4.
28 The weather cold and clear. –25.
29 Cold and clear and sunshine. Dawn –43. Close –36.
30 Desperately cold. Dawn –50. Close –39.
31 The weather still clear and cold. Dawn –38. Close –30…Our entire stock of eatables in store is just 5 Pemican Bays [Bags?] and that same being a depot for the intended operation of next season but necessity has already obliged me to broach upon it.

Appendix 2b: Example of journal information transcribed: Pelly Banks

Please see attached CD for all transcribed journal entries

National Archives of Canada - MG A25-A28

Note: Called the "Journal of Occurrences at Pelly Banks 1845-1847. The author is Robert Campbell.
Note: Text is quotes unless otherwise indicated. All comments on the text are inserted in square brackets.

August 1846

1	The wind westerly and cloudy.
2	Wet rainy afternoon.
3	Pouring down rain all the afternoon.
4	Heavy showers of rain during the day.
5	The weather cleared up.
6	Showers and sultry.
9	Calm and sultry.
10	Calm and sultry.
11	Cloudy and cool...We have nets in the water this long time but we don't catch a fish.
16	Wind from the N. West.
17	A hard frost this morning which was the unkindest [?] of all to our Experimental farm.
18	Wildfowl passing by the south.
20	The sun very warm during the day.
21	A frosty morning and the sun burning warm all day.
22	A gale from the west.
24	A rainy afternoon and blowing strongly from the North West.
25	Cold frosty morning and wind from the north.
28	A wet rainy afternoon.
29	Heavy showers of rain in the afternoon.
30	Overcast with North wind.
31	Hard frost over night and weather clear.

Appendix 2c: Example of journal information transcribed: Fort Selkirk

Please see attached CD for all transcribed journal entries

Fort Selkirk – "Journal of Occurrences at the Forks of the Lewes and Pelly Rivers May 1848 to September 1852"

Archival references: National Archives MG 19 D13

Edited version reference: Heritage Branch – Government of Yukon – Occasional Papers in Yukon History No. 2

Note: The authors of the journals are Robert Campbell (Clerk) and James Stewart (Assistant Clerk). In the edited version, the editors, Llewellyn R. Johnson and Dominique Legros, have noted changed in authorship throughout the published journals where appropriate.
Note: Three volumes make up the post's journals. Two are co-written by Campbell and Stewart, covering the periods May 23, 1848 to October 19, 1849 (Vol. 1) and October 20, 1849 to December 31, 1851 (Vol. 2). The third volume is written by Stewart only and covers the period October 20, 1849 to September 9, 1852. This third volume is overlaps with the latter half of Volume 2 and provides an alternative source.
Note: Unclear words are placed in square brackets with a ? mark. All editorial comments have been inserted in brackets.

June 1850 – [Campbell's handwriting]

1	Fine farming weather, light shower & thunder in the west.
2	Most Delightful Weather. The water in both rivers as low as it was in September.
3	Blowing from the E.
4	The same kind of weather.
16	[There is] plenty of excellent fish taken… The water has rose considerably and is now pretty high. The weather has been sultry of late with thunder & rain. Blowing from the north today.
17	Fine weather.
18	Fine weather wind NW. Mosquitoes troublesome but my friend's net protects me from their attacks at night.
19	The same Kind of weather.
20	Wind NW with showers.
21	The water falling. Weather fine. The face of the country looks beautiful. Everything in full bloom but flies so bad that we can hardly take courage to walk abroad to enjoy the scene of nature in its prime.
22	Showers of rain & some peals of thunder. Wind variable.
23	A charming day.
24	Some of our potatoes have been tinged with frost the last or preceding night…. Same weather.
25	Our potatoes which were coming on beautifully have been frozen to cinders last night by a hard frost. Although it is rather singular to have frost at this time of year when the day is at its longest and the sun hardly two hours below the horizon. My endeavours to rise a crop of Potatoes

have been abortive. An unfortunate fatality has attended them at every turn for these three seasons.

26 Hard frost overnight & very warm through the day.

27 Warm.

28 Warm weather & plenty flies.

29 Weather warm, wind variable. Peal of thunder heard to the southward.

30 Wind variable. Thunder in the west & a shower of rain in the evening.... The water has been daily falling since the beginning of the week [24th] & the river is now pretty low.

Appendix 3: Example monthly subcode totals: Fort Selkirk – Temperature

Please refer to the attached CD for the complete version of Appendices 3a-c

	1849	1850	1851	1852	Ave 1	Total	1849	1850	1851	1852	Ave 1	Total	1849	1850	1851	1852	Ave 1	Total
Category	Jan	Jan	Jan	Jan			Feb	Feb	Feb	Feb			Mar	Mar	Mar	Mar		
Cool														1			1	1
Cold	6	7	15	1	7.25	29	7	5	6	1	4.75	19	7	8	2	3	5	20
Very cold	5	11	5		7	21	8				8	8		1				1
Mild	15	7	11	7	10	40	4	5	14	2	6.25	25	9	5	6	2	5.5	22
Warm								1			1	1						
Hot																		
Frost																		
Thaw				1	1	1		3			3	3			2	1	1.5	3
No frost				1	1	1												

	1849	1850	1851	1852	Ave 1	Total	1848	1849	1850	1851	1852	Ave 1	Total	1848	1849	1850	1851	1852	Ave 1	Total
Category	Apr	Apr	Apr	Apr	Apr			May	May	May	May	May			Jun	Jun	Jun	Jun		
Cool			2		2	2		5		5	1	3.67	11	2	1		5	1	2.25	9
Cold	4	6	5	2	4.25	17		1	5	2	1	3.4	17				1		1	1
Very cold								2				2	2							
Mild	8	3	2		4.33	13				2		2	2							
Warm	3		3		3	6		3	5	4	1	3.25	13	6	5	4	6	2	4.6	23
Hot										5		5	5	10	4	1	7	2	4.8	24
Frost	3		5	1	3	9		7	2	5	1	3.75	15		1	3			2	4
Thaw	3	8	11	2	6	24		3				3	3							
No frost	1	1			1	2														

	1848	1849	1850	1851	1852	Ave 1	Total	1848	1849	1850	1851	1852	Ave 1	Total	1848	1849	1850	1851	Ave 1	Total
Category	Jul	Jul	Jul	Jul	Jul			Aug	Aug	Aug	Aug	Aug			Sep	Sep	Sep	Sep		
Cool				3		3	3	1			2		1.5	3	1			2	1.5	3
Cold		1		2		1.5	3				2		2	2	1	2		2	1.67	5
Very cold																				
Mild										2			2	2	3			1	2	4
Warm	4	2	13	6	2	5.4	27		5	5	7		5.67	17	5	3		2	3.33	10
Hot	3	2	5	4	2	1	16				2	3	2.5	5						
Frost		1	2			1.5	3	2	4	2	1		2.25	9	6	6		2	4.67	14
Thaw																				
No frost																				

Appendix 3 Continued: Sample monthly code totals: Fort Selkirk – Temperature subcodes

	1848	1849	1850	1851	Ave 1	Total	1848	1849	1850	1851	Ave 1	Total	1848	1849	1850	1851	Ave 1	Total
Category	Oct	Oct	Oct	Oct			Nov	Nov	Nov	Nov			Dec	Dec	Dec	Dec		
Cool				2	2	2		3			3	3	1				1	1
Cold	4	10		10	8	24	6	6	7	5	6	24	5	6	6	15	8	32
Very cold		2		1	1.5	3		3		1	2	4	4	3	1	3	2.75	11
Mild	6		1	8	5	15	5	6	7	17	8.75	35	2	7	19	4	8	32
Warm		4		1	2.5	5												
Hot																		
Frost	6	2	2	3	3.25	13										1	1	1
Thaw	1		1		1	2	1				1	1			2	3	2.5	5
No frost															1		1	1

	Spring- April, May 1848 data for May only								Summer- June, July, August All months represented							
Category	1848	1849	1850	1851	1852	Ave 1	Ave 2	Total	1848	1849	1850	1851	1852	Ave 1	Ave 2	Total
Cool		5		7	1	4.33	2.6	13	3	1		10	1	3.75	3	15
Cold		13	11	7	3	8.5	6.8	24		1		5		3	1.2	6
Very cold		2				2	0.4	2								
Mild		8	3	4		5	3	15			2			2	0.4	2
Warm		6	5	7	1	4.75	3.8	19	10	12	22	19	4	13.4	13.4	67
Hot				5		5	1	5	13	6	6	13	7	9	9	45
Frost		10	2	10	2	6	4.8	24	2	6	7	1		4	3.2	16
Thaw		6	8	11	2	6.75	5.4	27								
No frost		1	1			1	0.4	2								

	Fall- Sept, Oct All months represented							Winter- Nov-March No Jan/Feb 1848, No Dec 1852							Overall Total All Years
Category	1848	1849	1850	1851	Ave 1	Ave 2	Total	1848	1849	1850	1851	Ave 1	Ave 2	Total	
Cool	1			4	2.5	1.25	5	1	4			2.5	1.25	5	38
Cold	5	12		12	9.67	7.25	29	30	32	36	25	30.75	30.75	123	192
Very cold		2		1	1.5	0.75	3	18	18	6	4	11.5	11.5	46	51
Mild	9		1	9	6.33	4.75	19	35	30	57	32	38.5	38.5	154	190
Warm	5	7		3	5	3.75	15		1			1	0.25	1	102
Hot															50
Frost	12	8	2	5	6.75	6.75	27				1	1	0.25	1	68
Thaw	1		1		1	0.5	2	1	3	4	5	3.25	3.25	13	42
No frost										1	1	1	0.5	2	4

Appendix 4a: Monthly, Seasonal and Annual Direct Subcode Averages – Frances Lake

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Cool	1.0		0.3		0.3			0.3	0.3		0.3		0.3	0.3	0.3	1.5	2
Cold	5.8	3.0	3.8	2.0	2.0			0.3	1.5	2.0	4.7	4.8	4.0	0.3	3.5	22.0	30
Very cold	2.3	2.3			0.0					0.8	0.8	0.3			0.8	5.5	6
Mild	6.3	4.5	7.5	8.8	1.0	3.0	0.3	0.5	0.5	3.5	3.2	8.5	9.8	3.8	4.0	29.9	47
Warm				1.5	1.7	1.5	1.1	3.0	1.0	0.3			3.2	5.6	1.3		10
Hot						2.5	0.9	0.3		0.0				3.6			4
Frost	0.3				0.7		0.3	0.5	1.8	1.0	0.8	0.5	0.7	0.8	2.8	1.5	6
Thaw		0.3	1.8	1.5	1.0						0.3		2.5			2.3	5
No frost																	0
All Temperature	15.5	10.0	13.3	13.8	6.7	7.0	2.6	4.8	5.0	7.5	10.0	14.0	20.4	14.3	12.5	62.8	110
Calm	2.0	3.0	3.0	1.3	1.7	5.5	4.3	3.5	4.5	4.8	1.6	1.8	2.9	13.3	9.3	11.3	37
Light	0.3	0.3	0.3	0.8	1.0	1.0	0.9	0.5	0.8	0.5	1.1	0.5	1.8	2.4	1.3	2.3	8
Strong	0.8	1.0	1.3	0.5	1.0	1.5	2.8	2.8	2.0	1.5	2.4	0.8	1.5	7.1	3.5	6.1	18
Gale			0.8		1.0	3.5	0.9	2.5	3.8	2.8	0.3		1.0	6.9	6.5	1.0	15
Windy	0.8	0.3	0.5	0.5	0.7	0.5	2.0	2.8	2.8	2.8	1.8	0.5	1.2	5.2	5.5	3.8	16
All Wind strength	3.8	4.5	5.8	3.0	5.3	12.0	10.8	12.0	13.8	12.3	7.1	3.5	8.3	34.8	26.0	24.6	94
North	0.3	0.3		0.3				0.3		0.3	0.5	0.3	0.3	0.3	0.3	1.3	2
South		0.5	1.3	0.3	1.3	0.5			1.3	0.3	0.3	0.8	1.6	0.5	1.5	2.8	6
East	0.5	0.3	0.3		0.3	1.0	0.3	1.5	0.8	1.0	0.5	0.3	0.3	2.8	1.8	1.8	7
West	0.8	0.0	0.3	0.3	0.3	0.0	0.6	1.0	0.8	0.3	0.3		0.6	1.6	1.0	1.3	4
Northeast						1.0			0.8					1.0	0.8	0.0	2
Northwest			0.3					0.3	0.3	1.3	0.8			0.3	1.5	1.0	3
Southeast	0.3	0.5	0.3	0.3	2.0	1.0	2.0	2.3	3.3	2.3	1.3	0.5	2.3	5.2	5.5	2.8	16
Southwest							0.3		0.3					0.3	0.3		1
Changeable																	0
All Wind direction	1.8	1.5	2.3	1.0	4.0	3.5	3.1	5.3	7.3	5.3	3.7	1.8	5.0	11.9	12.5	10.9	40
Partly clear/cloudy				0.3							0.3		0.3			0.3	1
Cloudy	4.5	1.5	2.0	2.5	3.3	2.5	3.7	6.3	2.8	2.5	2.9	2.5	5.8	12.4	5.3	13.4	37
Clear	5.5	2.8	6.3	3.5	1.3	3.0	1.1	1.5	1.5	1.8	5.0	5.3	4.8	5.6	3.3	24.8	38
All Clouds	10.0	4.3	8.3	6.3	4.7	5.5	4.8	7.8	4.3	4.3	8.2	7.8	10.9	18.1	8.5	38.4	76
Light					0.7	1.5	2.0	1.0	1.8				0.7	4.5	1.8		7
Heavy							1.1	0.5	0.5				0.0	1.6	0.5		2
Showers		0.5		0.3			0.3	1.8	1.3	0.3			0.3	2.0	1.5	0.5	4
Raining			1.0	0.3	0.7	3.5	3.4	3.8	1.3				0.9	10.7	1.3	1.0	14
All Rainfall		0.5	1.0	0.5	1.3	5.0	6.8	7.0	4.8	0.3			1.8	18.8	5.0	1.5	27
Light	1.3	0.3	1.8	1.0							1.1	0.5	1.0			4.8	6
Heavy			0.3	0.3						0.3	0.3	0.0	0.3		0.3	0.5	1
Snowing	5.3	1.3	3.8	1.5	1.3				1.3	3.5	3.7	2.8	2.8		4.8	16.7	24
All Snowfall	6.5	1.5	5.8	2.8	1.3				1.3	3.8	5.0	3.3	4.1		5.0	22.0	31
TOTAL	37.5	22.3	36.3	27.3	23.3	33.0	28.1	36.8	36.3	33.3	34.5	30.3	50.6	97.9	69.5	160.7	378.7

Appendix 4b: Monthly, Seasonal and Annual Direct Subcode Averages – Pelly Banks

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Cool								1.0						1.0			1
Cold	2.5	1.0	0.7	1.1		1.0		1.0	2.0	0.6	2.0	5.0	1.1	2.0	2.6	11.2	17
Very cold	1.5	0.5									0.5	0.5				3.0	3
Mild	4.5	2.0	5.3	3.7					5.0	5.8	1.5	6.5	3.7		10.8	19.8	34
Warm	0.5				1.0	1.0	2.0	2.0					1.0	5.0		0.5	7
Hot						2.0	2.0	3.0						7.0			7
Frost						2.0		4.0	1.0	0.6				6.0	1.6		8
Thaw		1.0	1.3	1.1	1.0	1.0							2.1	1.0	0.0	2.3	5
No frost				1.6					1.0				1.6		1.0		3
All Temperature	9.0	4.5	7.3	7.5	2.0	7.0	4.0	11.0	9.0	7.1	4.0	12.0	9.5	22.0	16.1	36.8	84
Calm	1.0	1.0	2.0	0.5		1.0	1.0	2.0	1.0	1.3		1.0	0.5	4.0	2.3	5.0	12
Light	1.0	1.0					1.0		2.0					1.0	2.0	2.0	5
Strong	1.0	1.5	2.7	1.6	1.0	2.0	1.0	1.0	1.0	0.6	0.5		2.6	4.0	1.6	5.7	14
Gale								1.0						1.0			1
Windy		0.5	2.0	5.9			1.0	4.0			0.5	0.5	5.9	5.0		3.5	14
All Wind strength	3.0	4.0	6.7	8.0	1.0	3.0	4.0	8.0	4.0	1.9	1.0	1.5	9.0	15.0	5.9	16.2	46
North				1.1				2.0	2.0				1.1	2.0	2.0		5
South				0.5							0.5		0.5			0.5	1
East		0.5		0.5									0.5			0.5	1
West				0.5				2.0					0.5	2.0			3
Northeast				0.5	1.0			0.0	1.0				1.5		1.0		3
Northwest								2.0						2.0			2
Southeast	1.5	1.0	0.7	2.7								0.5	2.7			3.7	6
Southwest							2.0						0.0	2.0		0.0	2
Changeable																0.0	0
All Wind direction	1.5	1.5	0.7	5.9	1.0		2.0	6.0	3.0		0.5	0.5	6.9	8.0	3.0	4.7	23
Partly clear/cloudy			0.7					1.0	2.0					1.0	2.0	0.7	4
Cloudy	1.5	1.0	0.7	1.1			2.0	3.0	2.0	1.3		1.0	1.1	5.0	3.3	4.2	14
Clear	2.5	2.0	2.0	3.2				3.0	2.0	1.3	1.5	5.5	3.2	3.0	3.3	13.5	23
All Clouds	4.0	3.0	3.3	4.3			2.0	7.0	6.0	2.6	1.5	6.5	4.3	9.0	8.6	18.3	40
Light				0.5	1.0	1.0	1.0		2.0				1.5	2.0	2.0		6
Heavy				0.5				3.0	1.0				0.5	3.0	1.0		5
Showers							1.0	1.0		0.6				2.0	0.6		3
Raining					1.0	5.0	6.0	2.0	3.0				1.0	13.0	3.0		17
All Rainfall				1.1	2.0	6.0	8.0	6.0	6.0	0.6			3.1	20.0	6.6		30
Light	0.5	1.0										1.0				2.5	3
Heavy				1.6									1.6				2
Snowing	2.5	1.5	4.7		1.0				4.0	3.9	3.0	1.5	1.0		7.9	13.2	22
All Snowfall	3.0	2.5	4.7	1.6	1.0				4.0	3.9	3.0	2.5	2.6		7.9	15.7	26
TOTAL	20.5	15.5	22.7	28.3	7.0	16.0	20.0	38.0	32.0	16.1	10.0	23.0	35.3	74.0	48.1	91.7	249.1

Appendix 4c: Monthly, Seasonal and Annual Direct Subcode Averages – Fort Selkirk

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Cool			0.3	0.5	2.6	1.8	0.6	0.6	1.0	0.6	0.8	0.3	3.1	3.0	1.5	1.3	9
Cold	7.3	5.2	5.2	4.3	4.0	0.2	0.6	0.4	1.6	6.8	6.4	8.5	8.2	1.2	8.4	32.5	50
Very cold	5.3	2.2	0.3		0.5					0.8	1.1	3.2	0.5	0.0	0.8	12.0	13
Mild	10.0	6.9	5.7	3.3	0.5			0.4	1.3	4.2	9.3	8.5	3.7	0.4	5.5	40.1	50
Warm		0.3		1.5	3.1	4.6	5.4	3.6	3.3	1.4			4.6	13.6	4.7	0.3	23
Hot					1.2	4.8	3.2	1.1					1.2	9.1			10
Frost				2.3	3.5	0.8	0.6	1.9	4.6	3.7		0.3	5.8	3.3	8.2	0.3	18
Thaw	0.3	0.8	0.8	6.0	0.7					0.6	0.3	1.3	6.7		0.6	3.4	11
No frost	0.3											0.3	0.5			0.5	1
All Temperature	23.0	15.4	12.2	18.3	14.1	12.2	10.4	8.1	11.7	18.0	17.8	22.0	34.2	30.7	29.8	90.4	185
Calm	0.3	1.4	1.0	1.0	1.6	0.4	0.4		0.3	0.8	0.3	2.1	2.6	0.8	1.2	5.1	10
Light		1.4	0.8	0.3	0.2	0.8	1.0	0.6	1.0			0.3	0.5	2.4	1.0	2.4	6
Strong	2.3	2.2	2.9	3.0	3.8	3.0	1.2	1.1	1.6	2.5	0.5	1.1	6.8	5.3	4.2	8.9	25
Gale				0.3	0.2				1.3	0.3			0.5		1.6		2
Windy	0.3	0.5	1.0	2.5	3.5	2.0	2.2	1.9	1.0	4.2	0.8	0.5	6.0	6.1	5.2	3.2	21
All Wind strength	2.8	5.5	5.7	7.0	9.4	6.2	4.8	3.6	5.2	7.9	1.6	4.0	16.4	14.6	13.1	19.5	64
North		0.3		0.8	1.4	0.6	0.2			1.1			2.2	0.8	1.1	0.3	4
South		0.5		1.8		0.2	0.6	0.2	1.6	1.4	0.3	0.5	1.8	1.0	3.0	1.3	7
East					1.4	0.4	0.2	0.8	1.3	1.4		0.3	1.4	1.4	2.7	0.3	6
West	0.5	0.3	1.3	0.3	0.2		0.4		0.3	0.3		0.3	0.5	0.4	0.6	2.3	4
Northeast										0.6					0.6		1
Northwest	1.0	1.9	1.6	1.3	1.4	1.8	1.4	0.6		0.6	0.8	0.3	2.7	3.8	0.6	5.5	13
Southeast		0.8	0.8	0.8	1.4	1.0	1.2	0.4		1.7	0.3	0.5	2.2	2.6	1.7	2.4	9
Southwest			0.3			0.2								0.2		0.3	0
Changeable				0.3	0.2								0.5				0
All Wind direction	1.5	3.8	3.9	5.0	6.1	4.2	4.0	2.1	3.3	7.0	1.3	1.9	11.1	10.3	10.3	12.4	44
Partly clear/cloudy	0.3	0.3	0.5	1.0	0.5	0.8	3.0	1.3	0.7	0.6	0.8	0.5	1.5	5.1	1.2	2.4	10
Cloudy	4.0	3.8	2.3	3.0	6.8	5.2	3.0	3.2	1.6	3.9	6.6	2.9	9.8	11.4	5.6	19.7	47
Clear	3.8	4.1	3.6	1.0	1.4	2.0	1.6	2.5	1.0	3.9	2.1	5.0	2.4	6.1	4.9	18.7	32
All Clouds	8.0	8.2	6.5	5.0	8.7	8.0	7.6	7.0	3.3	8.5	9.5	8.5	13.7	22.6	11.7	40.8	89
Light						0.4	1.0	1.7	0.7					3.1	0.7		4
Heavy					0.7	0.4	0.8	1.9	1.0				0.7	3.1	1.0		5
Showers					0.7	3.4	2.2	1.1	0.0				0.7	6.7			7
Raining				0.8	2.1	2.2	3.6	4.5	2.0	0.8	0.3	0.3	2.9	10.3	2.8	0.5	16
All Rainfall				0.8	3.5	6.4	7.6	9.1	3.6	0.8	0.3	0.3	4.3	23.1	4.4	0.5	32
Light	1.8	0.8	1.0							0.6	2.7	1.1			0.6	7.3	8
Heavy		0.5		0.3	0.7					0.3	0.3	0.3	1.0		0.3	1.1	2
Snowing	2.8	2.7	3.4	1.3	0.9				0.3	2.3	4.8	2.9	2.2		2.6	16.6	21
All Snowfall	4.5	4.1	4.4	1.5	1.6				0.3	3.1	7.7	4.2	3.1		3.4	25.0	32
TOTAL	39.8	37.1	32.8	37.5	43.4	37.0	34.4	29.9	27.4	45.4	38.2	40.8	80.9	101.3	72.7	118.8	443.7

Appendix 4d: Monthly, Seasonal and Annual Direct Subcode Averages – All Posts

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Cool	0.4		0.2	0.2	1.5	1.1	0.3	0.5	0.5	0.2	0.4	0.1	1.7	2.0	0.7	1.1	5.5
Cold	5.7	3.4	3.9	2.7	1.8	0.3	0.3	0.4	1.6	3.6	4.7	6.2	4.6	1.0	5.2	23.9	35.7
Very cold	3.3	1.9	0.1		0.2					0.7	0.8	1.4	0.2		0.7	7.5	8.4
Mild	7.4	4.9	6.4	5.6	0.6	0.8	0.1	0.4	1.4	4.2	5.3	8.0	6.2	1.3	5.5	32.0	45.0
Warm	0.1	0.1		1.2	2.3	3.4	3.5	3.2	1.7	0.7			3.5	10.0	2.4	0.2	16.1
Hot					0.6	3.9	2.2	0.9					0.6	7.0			7.6
Frost	0.1			0.9	2.1	0.8	0.4	1.5	2.7	2.0	0.5	0.3	3.0	2.7	4.7	0.9	11.3
Thaw	0.1	0.6	1.3	3.2	0.8	0.1				0.2	0.2	0.5	4.1	0.1	0.2	2.7	7.2
No frost	0.1			0.5					0.1			0.1	0.5		0.1	0.2	0.8
All Temperature	17.2	10.9	11.9	14.4	9.9	10.3	6.8	7.0	8.1	11.5	12.0	16.7	24.3	24.1	19.6	68.5	137.4
Calm	1.1	2.0	2.0	1.0	1.5	1.8	1.9	1.6	2.5	2.6	0.7	1.7	2.5	5.3	5.1	7.6	20.4
Light	0.3	0.8	0.4	0.4	0.5	0.8	0.9	0.5	1.0	0.2	0.4	0.3	0.9	2.2	1.2	2.3	6.6
Strong	1.4	1.6	2.1	1.7	2.4	2.5	1.8	1.8	1.7	1.8	1.3	0.7	4.1	6.0	3.5	7.1	20.7
Gale			0.3	0.1	0.5	0.9	0.3	1.1	2.4	1.3	0.1		0.6	2.3	3.7	0.4	7.0
Windy	0.4	0.4	1.0	2.3	2.1	1.4	2.0	2.5	1.7	2.9	1.1	0.5	4.4	5.8	4.6	3.4	18.3
All	3.2	4.8	5.9	5.6	6.9	7.3	6.9	7.5	9.3	8.8	3.7	3.3	12.5	21.7	18.1	20.8	73.1
All Wind strength	3.2	4.8	5.9	5.6	6.9	7.3	6.9	7.5	9.3	8.8	3.7	3.3	12.5	21.7	18.1	20.8	73.1
N	0.1	0.2		0.6	0.7	0.4	0.1	0.3	0.2	0.5	0.2	0.1	1.3	0.8	0.8	0.6	3.5
S		0.4	0.5	0.9	0.5	0.3	0.3	0.1	1.2	0.7	0.3	0.5	1.4	0.7	1.9	1.8	5.7
E	0.2	0.2	0.1	0.1	0.8	0.5	0.2	1.0	0.9	1.0	0.2	0.2	0.9	1.7	1.9	0.9	5.5
W	0.5	0.1	0.6	0.3	0.2		0.4	0.6	0.5	0.2	0.1	0.1	0.5	1.0	0.7	1.5	3.8
NE				0.1	0.1	0.3			0.5	0.2			0.2	0.3	0.7		1.2
NW	0.4	0.7	0.7	0.5	0.7	1.1	0.7	0.6	0.1	0.8	0.6	0.1	1.2	2.5	0.9	2.6	7.2
SE	0.4	0.7	0.5	0.9	1.5	0.9	1.4	1.1	1.6	1.6	0.6	0.5	2.4	3.4	3.3	2.8	11.8
SW			0.1			0.1	0.3		0.1					0.4	0.1	0.1	0.7
Changeable				0.1	0.1								0.2				0.2
All Wind direction	1.6	2.4	2.7	3.5	4.7	3.5	3.5	3.8	5.2	5.1	2.1	1.5	8.3	10.8	10.3	10.3	39.6
Partly clear/cloudy	0.1	0.1	0.3	0.5	0.2	0.5	1.6	0.7	0.5	0.2	0.4	0.2	0.7	2.8	0.7	1.1	5.4
Cloudy	3.7	2.3	1.9	2.4	4.7	3.9	3.2	4.4	2.2	2.9	3.8	2.4	7.2	11.5	5.1	14.0	37.7
Clear	4.2	3.1	4.5	2.4	1.2	2.0	1.3	2.2	1.4	2.5	3.1	5.2	3.6	5.4	3.9	20.2	33.1
All Clouds	8.0	5.5	6.7	5.4	6.2	6.4	6.0	7.3	4.1	5.6	7.3	7.8	11.5	19.7	9.7	35.3	76.2
Light				0.1	0.4	0.8	1.4	1.2	1.4				0.5	3.4	1.4		5.2
Heavy				0.1	0.4	0.3	0.8	1.4	0.7				0.5	2.5	0.7		3.7
Showers		0.2		0.1	0.4	2.1	1.4	1.3	0.6	0.2			0.5	4.8	0.8	0.2	6.3
Raining			0.4	0.4	1.5	2.9	3.8	3.9	1.7	0.3	0.1	0.1	1.9	10.6	2.1	0.6	15.1
All Rainfall		0.2	0.4	0.7	2.5	6.0	7.4	7.9	4.5	0.5	0.1	0.1	3.3	21.3	5.0	0.8	30.4
Light	1.3	0.6	1.2	0.4						0.2	1.5	0.8	0.4		0.2	5.4	6.0
Heavy		0.2	0.1	0.5	0.4					0.2	0.2	0.1	0.9		0.2	0.6	1.7
Snowing	3.7	1.9	3.7	1.1	1.1				1.2	3.1	4.0	2.6	2.2		4.3	15.8	22.4
All Snowfall	5.0	2.7	5.0	2.0	1.5				1.2	3.5	5.6	3.5	3.5		4.8	21.9	30.1
TOTALS	35.0	26.5	32.7	31.6	31.7	33.4	30.6	33.6	32.3	35.1	30.8	32.9	63.3	97.5	67.4	157.8	386.0

Appendix 5a: Monthly, Seasonal and Annual Seasonal Indirect Subcode Averages – Frances Lake

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Ice break-up				0.3	1.7								1.9				1.9
Ice Freeze-up										0.5	2.4				0.5	2.4	2.9
Summer water						2.5	6.0							8.5			8.5
Winter water	0.5											0.3				0.8	0.8
All ice activity	0.5			0.3	1.7	2.5	6.0			0.5	2.4	0.3	1.9	8.5	0.5	2.9	13.8
Spring migration				2.0	1.7								3.7				3.7
Fall migration								1.0	2.8						3.8		3.8
Spring vegetation					0.3								0.3				0.3
Fall vegetation								0.3							0.3		0.3
All biological				2.0	2.0			1.3	2.8				4.0	1.3	2.8		8.0
Poor food supplies		0.3	0.5	0.3				0.3					0.3	0.3		0.8	1.3
Poor hunting	0.5	0.3								0.3		0.3			0.3	1.0	1.3
Starving at post	2.0	1.8	0.3			0.5	0.6				0.3	0.3		1.1		4.5	5.6
Starving hunters	0.8							0.3			0.5			0.3		1.3	1.5
Starving Indians			0.3	0.3		0.5	0.3	0.3	0.3		0.3		0.3	1.0	0.3	0.5	2.0
Dogs starving		0.5				0.5		0.3						0.8		0.5	1.3
All starvation	3.3	2.8	1.0	0.5		1.5	0.9	1.0	0.3	0.3	1.1	0.5	0.5	3.4	0.5	8.6	12.9
Good	6.0	7.3	10.5	8.5	5.3	5.0	4.3	8.3	12.0	10.3	6.6	9.5	13.8	17.5	22.3	39.8	93.4
Bad	0.5		0.3		0.3		0.3	0.5		0.5		0.5	0.3	0.8	0.5	1.3	2.9
Fog/mist	0.8								0.5	0.3	0.3	0.5			0.8	1.5	2.3
Autumnal Appearance									0.3						0.3		0.3
Wintry Appearance					0.3				0.5	0.3			0.3		0.8		1.1
All miscellaneous	7.3	7.3	10.8	8.5	6.0	5.0	4.5	8.8	13.3	11.3	6.8	10.5	14.5	18.3	24.5	42.6	99.9
TOTALS	11.0	10.0	11.8	11.3	9.7	9.0	11.4	11.0	16.3	12.0	10.3	11.0	20.9	31.4	28.3	54.0	134.5

Appendix 5b: Monthly, Seasonal and Annual Seasonal Indirect Subcode Averages – Pelly Banks

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Ice break-up				0.5									0.5				0.5
Ice Freeze-up									4.0	1.9					5.9		5.9
Summer water																	
Winter water																	
All ice activity				0.5					4.0	1.9			0.5		5.9		6.5
Spring migration				1.6									1.6				1.6
Fall migration								1.0	1.0						2.0		2.0
Spring vegetation					1.0								1.0				1.0
Fall vegetation								1.0	2.0						3.0		3.0
All biological				1.6	1.0			2.0	3.0				2.6	2.0	3.0		7.6
Poor food supplies																	
Poor hunting	0.5	1.5							2.0						2.0	2.0	4.0
Starving at post																	
Starving hunters	1.5	1.0	2.7													5.2	5.2
Starving Indians	0.5	1.5	0.7	0.5									0.5			2.7	3.2
Dogs starving	0.5	0.5	0.7													1.7	1.7
All starvation	3.0	4.5	4.0	0.5					2.0				0.5		2.0	11.5	14.0
Good	0.5	1.5	1.3	1.1	4.0	1.0	1.0		4.0	1.3	1.0	0.5	5.1	2.0	5.3	4.8	17.2
Bad																	
Fog/mist																	
Autumnal Appearance																	
Wintry Appearance																	
All miscellaneous	0.5	1.5	1.3	1.1	4.0	1.0	1.0		4.0	1.3	1.0	0.5	5.1	2.0	5.3	4.8	17.2
TOTALS	3.5	6.0	5.3	3.7	5.0	1.0	1.0	2.0	13.0	3,2	1.0	0.5	8.7	4.0	16.2	16.3	45.3

Appendix 5c: Monthly, Seasonal and Annual Seasonal Indirect Subcode Averages – Fort Selkirk

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Lewes ice break-up				0.5	4.2								4.7				4.7
Lewes ice freeze-up									0.7	2.5	2.1				3.2	2.1	5.3
Pelly ice break-up				0.3	5.9								6.1				6.1
Pelly ice freeze-up										8.2	2.1				8.2	2.1	10.3
Ice break-up				0.8	1.2					0.3			1.9		0.3		2.2
Ice Freeze-up										1.1					1.1		1.1
Summer water						5.0	1.2	0.2						6.4			6.4
Winter water												0.3				0.3	0.3
All ice activity				1.5	11.3	5.0	1.2	0.2	0.7	12.1	4.2	0.3	12.8	6.4	12.8	4.5	36.5
Spring migration				1.5	1.4								2.9				2.9
Fall migration								0.2	9.8	0.6					10.5		10.5
Spring vegetation					2.6	1.2	0.4	0.8					3.8	1.2			5.0
Fall vegetation									2.0	0.3					2.2		2.2
All biological				1.5	4.0	1.2	0.4	1.1	11.7	0.8			5.5	2.7	12.6		20.7
Poor food supplies		0.3	0.3		0.2		0.2						0.2	0.2		0.5	1.0
Poor hunting	0.5	0.8	0.5	0.5	0.2							0.3	0.7			2.1	2.8
Starving at post				0.3	0.2				0.3				0.5		0.3		0.8
Starving hunters	0.3		0.5	1.0	0.2	0.4		0.2				0.3	1.2	0.6		1.0	2.9
Starving Indians	1.8	2.5	1.8	0.5	1.4	0.2	0.2				0.3		1.9	0.4		6.3	8.6
Dogs starving				0.3									0.3				0.3
All starvation	2.5	3.6	3.1	2.5	2.3	0.6	0.4	0.2	0.3		0.3	0.5	4.8	1.2	0.3	10.0	16.4
Good	3.3	5.5	8.6	2.8	3.8	4.0	2.6	6.2	16.6	7.6	3.4	7.4	6.5	12.8	24.2	28.2	71.7
Bad			0.5	0.3	0.5	0.6	1.8	0.6		0.3			0.7	3.0	0.3	0.5	4.6
Fog/mist											1.1	0.3				1.3	1.3
Autumnal Appearance								1.1	2.0					1.1	2.0		3.0
Wintry Appearance									0.3	0.3					0.6		0.6
All miscellaneous	3.3	5.5	9.1	3.0	4.2	4.6	4.4	7.9	18.9	8.2	4.5	7.7	7.2	16.9	27.1	30.1	81.2
TOTALS	5.8	9.1	12.2	8.5	21.8	11.4	6.4	9.3	31.6	21.1	9.0	8.5	30.3	27.1	52.7	44.6	154.8

Appendix 5d: Monthly, Seasonal and Annual Seasonal Indirect Subcode Averages – All Posts

Code Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Fall	Win	Year
Ice break-up				0.8	6.4								7.2				7.2
Ice freeze-up									0.7	5.2	2.6				5.9	2.6	8.5
Summer water						3.8	2.8	0.1						6.7			6.7
Winter water	0.2											0.1				0.3	0.3
All ice activity	0.2			0.8	6.4	3.8	2.8	0.1	0.7	5.3	2.6	0.1	7.2	6.7	6.0	2.9	22.8
Spring migration				1.7	1.3								3.1				3.1
Fall migration								0.6	5.2	0.2					6.0		6.0
Spring vegetation					1.6	0.8	0.2	0.4					2.3	0.6			2.9
Fall vegetation								0.2	1.0	0.1					1.3		1.3
All biological				1.7	2.9	0.8	0.2	1.2	6.2	0.3			4.6	2.2	6.5		13.3
Poor food supplies		0.2	0.3	0.1	0.1		0.1	0.1					0.2	0.2		0.5	1.0
Poor hunting	0.5	0.7	0.2	0.2	0.1				0.2	0.1		0.2	0.3		0.4	1.6	2.3
Starving at post	0.8	0.7	0.1	0.1	0.1	0.1	0.2		0.1		0.1	0.1	0.2	0.3	0.1	1.8	2.5
Starving hunters	0.7	0.2	0.6	0.4	0.1	0.3		0.2			0.2	0.1	0.5	0.5		1.9	2.8
Starving Indians	0.8	1.2	1.0	0.4	0.7	0.3	0.2	0.1	0.1		0.2		1.1	0.6	0.1	3.2	5.0
Dogs starving	0.1	0.3	0.1	0.1		0.1		0.1					0.1	0.2		0.5	0.8
All starvation	2.9	3.4	2.4	1.3	1.2	0.8	0.5	0.5	0.5	0.1	0.5	0.4	2.5	1.8	0.6	9.6	14.5
Good	3.8	5.4	8.2	4.8	4.4	3.9	3.0	6.4	12.8	7.7	4.2	6.9	9.1	13.3	20.5	28.5	71.4
Bad	0.2		0.3	0.1	0.4	0.4	1.1	0.5		0.3		0.2	0.5	1.9	0.3	0.7	3.5
Fog/mist	0.3								0.2	0.1	0.5	0.3			0.4	1.1	1.5
Autumnal Appearance								0.5	0.9					0.5	0.9		1.4
Wintry Appearance					0.1				0.4	0.2			0.1		0.6		0.7
All miscellaneous	4.3	5.4	8.6	4.9	4.8	4.3	4.1	7.4	14.3	8.4	4.7	7.4	9.7	15.8	22.6	30.3	78.4
TOTALS	7.4	8.8	10.9	8.7	15.4	9.5	7.7	9.3	21.7	14.1	7.8	7.9	24.1	26.4	35.8	42.9	129.1

***** Please note that the <u>Ice activity</u> subcodes for the <u>Ice break-up</u> and <u>Ice freeze-up</u> include the Lewes and Pelly River data for the Fort Selkirk journals.

Appendix 6: Example of Frances Lake Temperature Record

Please see attached CD for all temperature readings

Month	Year	Day	Reading 1	Reading 2	Reading 3	Reading 4	Ave	Minimum	Maximum
December	1842	1							
		2							
		3							
		4	-29.4	-27.8			-28.6	-29.4	-27.8
		5	-21.1				-21.1	-21.1	-21.1
		6	-8.3				-8.3	-8.3	-8.3
		7	-8.3				-8.3	-8.3	-8.3
		8	-8.9				-8.9	-8.9	-8.9
		9							
		10	-6.1				-6.1	-6.1	-6.1
		11							
		12							
		13	-6.1				-6.1	-6.1	-6.1
		14	-7.2				-7.2	-7.2	-7.2
		15	-5.6	-3.9			-4.7	-5.6	-3.9
		16							
		17							
		18	-6.1				-6.1	-6.1	-6.1
		19	-30.6	-32.2			-31.4	-32.2	-30.6
		20	-38.9	-30.6			-34.7	-38.9	-30.6
		21	-25.0	-21.7			-23.3	-25.0	-21.7
		22							
		23	-9.4				-9.4	-9.4	-9.4
		24							
		25	-16.1	-14.4	-16.1		-15.6	-16.1	-14.4
		26	-16.1				-16.1	-16.1	-16.1
		27	-22.8	-22.8			-22.8	-22.8	-22.8
		28	-25.0	-33.3			-29.2	-33.3	-25.0
		29	-38.9	-32.8			-35.8	-38.9	-32.8
		30	-35.0	-31.7	-34.4		-33.7	-35.0	-31.7
		31							

(Values are in degrees Celsius)