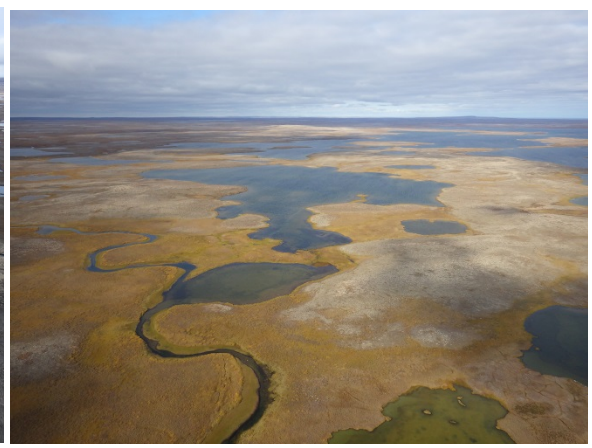
Towards the Development of the Canadian High Arctic Research Station (CHARS) as a Centre for Science and Technology in Canada and the Circumpolar North

Regional Social and Ecological Context, Baseline Studies, and Monitoring Pilots



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Introduction

The Canadian High Arctic Research Station (CHARS) was first announced in 2007 in the Speech from the Throne. In that speech, the Government committed to "… build a world-class Arctic research station that will be on the cutting edge of Arctic issues, including environmental science and resource development. This station will be built by Canadians, in Canada's Arctic, and it will be there to serve the world." The Station will have state of the art facilities to support northern research activities, and is on track for opening in July 2017, with its full operating capacity targeted for 2018/19.

Since the original announcement, much effort was put towards confirming a location for the research station, securing the budget and engaging Northerners in consultations on the location, design and implementation of the research station and its associated S&T programs.

In addition to the actual CHARS building, work has also been progressing on establishing baseline ecological studies, and initiating pilot monitoring projects in the area around the Station, with the goal of providing regional and local context for science studies. By 2018/19 CHARS will be able to provide researchers with an accessible research area (the CHARS Experimental and Reference Area – CHARS ERA) that has baseline inventories completed, long-term monitoring pilot projects established, and will provide a safe environement with required infrastructure, transporation and other logistical support. This report provides regional context for science studies at CHARS, and a summary of progress to date on baseline studies and long-term monitoring pilots in the CHARS ERA.

CHARS' Science Vision, Mission, and Objectives

Consultations with Northern Canadians, both Aboriginal and non-Aboriginal citizens and government bodies, confirmed the need for CHARS to serve as a coordinator of northern science and technology, directing relevant and applied outcomes that provide solutions to issues facing the North. This led to the formulation of the vision, mission, objectives and five-year Science and Technology priorities for CHARS, which were announced on December 3, 2010 by the Honourable John Duncan, Minister of INAC (now known as AANDC).

Vision: A world-class Arctic research program at the service and for the benefit of Northerners and the world.

Mission: To be a world-class research program in Canada's Arctic that is on the cutting edge of Arctic issues. The Station will anchor a strong research presence in Canada's Arctic that serves Canada and the world. It will advance Canada's knowledge of the Arctic in order to improve economic opportunities, environmental stewardship, and the quality of life of Northerners and all Canadians.

Objectives: Mobilize Arctic science and technology:

- to develop and diversify the economy in Canada's Arctic;
- to support the effective stewardship of Canada's Arctic lands, waters, and resources;
- to create a hub for scientific activity in Canada's vast and diverse Arctic;
- to promote self-sufficient, vibrant, and healthy Northern communities;
- to inspire and build capacity through training, education, and outreach, and;
- to enhance Canada's visible presence in the Arctic and strengthen Canada's leadership on Arctic issues.

CHARS' Science Partnerships

The CHARS five year organizational Plan (2014 to 2019) targets cross-disciplinary, cross-sectorial issues that require collaboration across multiple organizations, including government, NGOs, industry, academia, and international. Recognizing current existing and historical investments and the need to include and build upon these activities, CHARS will enhance partnerships and collaborations both nationally and internationally. A collaborative and coordinated partnership approach will result in greater efficiencies and derive the maximum benefit for all S&T activities in the North. To establish a world-class station, S&T program and polar knowledge mobilization, the CHARS organization will enhance linkages between relevant industry, academia, Aboriginal, and Northern governments. By leveraging their expertise, experience and resources to address shared goals and contribute to Canada's priorities, CHARS will deliver on its S&T mandate and strengthen polar knowledge for Canada.

Arctic S&T in Canada is high in quality but the capacity to initiate and conduct required research and monitoring is limited due to the vastness of the Canadian North. The high profile of Canada's new investment in Canadian Arctic research has resulted in competing expectations on a number of fronts, resulting in multiple requests for collaboration and funding, especially internationally, as Canada is seen as a collaborative partner with a large percentage of the circumpolar region. As many multi-disciplinary challenges must be addressed and not-one organization can solve these issues in isolation, CHARS will need to be strategic in developing partnerships with key stakeholders and partners. This strategy will develop and apply a consistent process for identifying, targeting and prioritizing high value partnerships that efficiently and strategically advance the CHARS organization's mandate.

Implementation of this strategy will ensure that the CHARS organization can establish and maintain strategic partnerships, on both the national and international front, in order to better position CHARS to deliver on the five S&T priorities and knowledge mobilization activities.

Objectives:

- Identify and target international and national partnership opportunities, using consistent criteria, that can build upon and leverage Canada's objective to develop world-class science and technology research and knowledge mobilization organization in Canada's North;
- Enhance CHARS' engagement with key national and international organizations interested in Arctic science and technology and polar knowledge by promoting our capabilities and strengthening strategic partnerships;
- Strengthen the capacity of organizations and networks to do research and monitoring by facilitating work in Canada's Arctic, brokering partnerships and mobilizing resources in support of Arctic S&T and polar knowledge;
- Learn, promote and contribute to good practices in Arctic S&T and become world leaders in polar knowledge mobilization.

Figure 1. Locations of CNNRO and other potential partner locations from a network of northern Canadian research sites

As an example of the strategic partnerships within Canada that CHARS is developing, Figure 1 shows the network of research sites, colleges and other facilities associated with the Canadian Network of Northern research operators (http://cnnro.org/CNNRO.html). Partnerships with international interests, other academic networks, territorial and federal governments, Aboriginal organizations and not-for-profit groups will fill out the network of organization with whom CHARS will be partnering. Although this document focuses on the Cambridge Bay and the area around CHARS, the CHARS S&T program will reach out across the Canadian North and around the circumpolar North.

CHARS-led Monitoring and Reporting of Northern Social and Ecological Change

All recent assessments of change in the North have emphasized the important role that monitoring can play by providing useful and timely information on how and how rapidly northern communities and ecosystems are changing—knowledge that can directly inform government and industry, and support the implementation of proactive management approaches and risk-based decision making.

CHARS will work to establish the Cambridge Bay area as a world-class monitoring site that will act as the 'hub' for a 'hub and spoke' model of northern partners (Figure 1), the Canadian Arctic Monitoring and Prediction (CAMPNet). CAMPNet 'spokes' will include the network of colleges and science stations across the North for terrestrial and freshwater monitoring, and will work to engage a network of northern coastal communities for coastal and marine monitoring. Monitoring and reporting of northern social change will benefit from existing territorial, federal, community and academic programs, and will add value as required based on consultations with subject experts. CHARS will lead development of the State of the Canadian Arctic Report (SoCAR) every 5 years—the SoCAR will integrate results from the CAMPNet with other relevant monitoring work by governments, communities, industry and academics to produce an assessment of a small suite of relevant social and environmental indicators that can inform decision-making and provide predictions of potential upcoming changes. CHARS will also engage internationally to link Canadian approaches to those employed across the circumpolar area.

Development of the CHARS-led monitoring program will include the direct input and efforts of northerners and strive to meet the communicated needs of northern knowledge clients. The proposed approach would integrate monitoring of environmental and social science drivers, processes, and indicators across spatial scales from local communities to the circum-polar North, and be based on the latest science developments and technological advancements. Finally, the program will include co-development of science-based with local and traditional knowledge, and include a special emphasis on data management.

Program priorities will be developed through an inclusive Working Group structure that builds on existing work (such as the recent CPC monitoring report, the GoC FiNeST Report, territorial and federal monitoring programs, TK and community monitoring programs) to identify program priorities and actions. The program will also build on existing monitoring protocols developed by proven programs such as ITEX, NEON, EC/WMO, EC/CIS, NRCan/ADAPT/CRYONet, EC/PRISM, and CEN. To ensure the highest relevance for monitoring results monitoring indicators will be developed based on consultations with a northern knowledge client network that will include northern community, territorial, and federal governments, Aboriginal organizations, northern based operational industries, and the northern academic community.

The Regional Setting – A Social and Ecosystem Context for CHARS Science

CHARS is being constructed in the community of Cambridge Bay in the Nunavut Territory in Canada (Figure 2). Cambridge Bay is in turn located in the Kitikmeot Region of Nunavut, and the closest communities within the region include Kugluktuk, Gjoa Haven and Taloyoak. The communities are small with a high population of Aboriginal people, many of whom still speak Inuinnaqtun, their Mother Tongue (*Table 1*). Although many in these communities do not have formal training or Western education, there is a very important base of local intelligence on land, sea and biota in the Traditional Knowledge (TK) held within these communities – intelligence based on centuries of living and relying on local ecosystems for sustenance. CHARS intends to work with these communities to identify key issues that are relevant to community leaders and members, to create local capacity through training and employment, and to use both science and TK approaches to deal with identified issues.

Table 1. Some population characteristics of four hamlets in Kitikmeot (Statistics Canada, 2011 Census)

		Cambridge Bay	Kugluktuk	Gjoa Haven	Taloyoak
Population		1,608	1,450	1,279	899
Population composition (%)	Aboriginal	81.7	90.6	96.5	96.1
Language Characteristics (%)	Aboriginal Mother Tongue	16.4	22.2	47.6	62.5
Education: Total (%)	No Diploma	48.2	57.8	66.5	65.5
	High School Diploma	15.9	10.4	7.9	6.1
	Trade Diploma	8.8	8.3	9.7	6.1
	College Diploma	12.8	14.6	10.9	4.6
	University Diploma	14.1	9.4	4.3	2.3
Labour Participation (%)	Total Population	70.8	64.1	59.1	51.3
Unemployment (%)	Total Population	14.4	30.9	33.0	27.6

The CHARS regional area is one of high scientific and research interest for a number of reasons. There is a very strong climatic gradient within the region, as expressed in the wide range of terrestrial Ecozones that occur (Figure 3). Terrestrial ecozones range from Sub-arctic Forest on mesic sites just south-west of Kugluktuk, through shrubs to 80 cm in Subzone E, 40 cm in Subzone D and less than 15 cm in Subzone C, across a distance of about 400 km. The bioclimatic zonation shown in Figure 3 is the result of a circumpolar classification by the CAVM Team (2003) and provides a unifying overview of circum-arctic terrestrial ecosystems for planning and comparing ecological monitoring and research. CHARS ecosystem classification and mapping presently being developed in the CHARS Experimental and

Figure 2. The CHARS regional ecosystem, showing social and ecosystem context for CHARS science in the Cambridge Bay area.

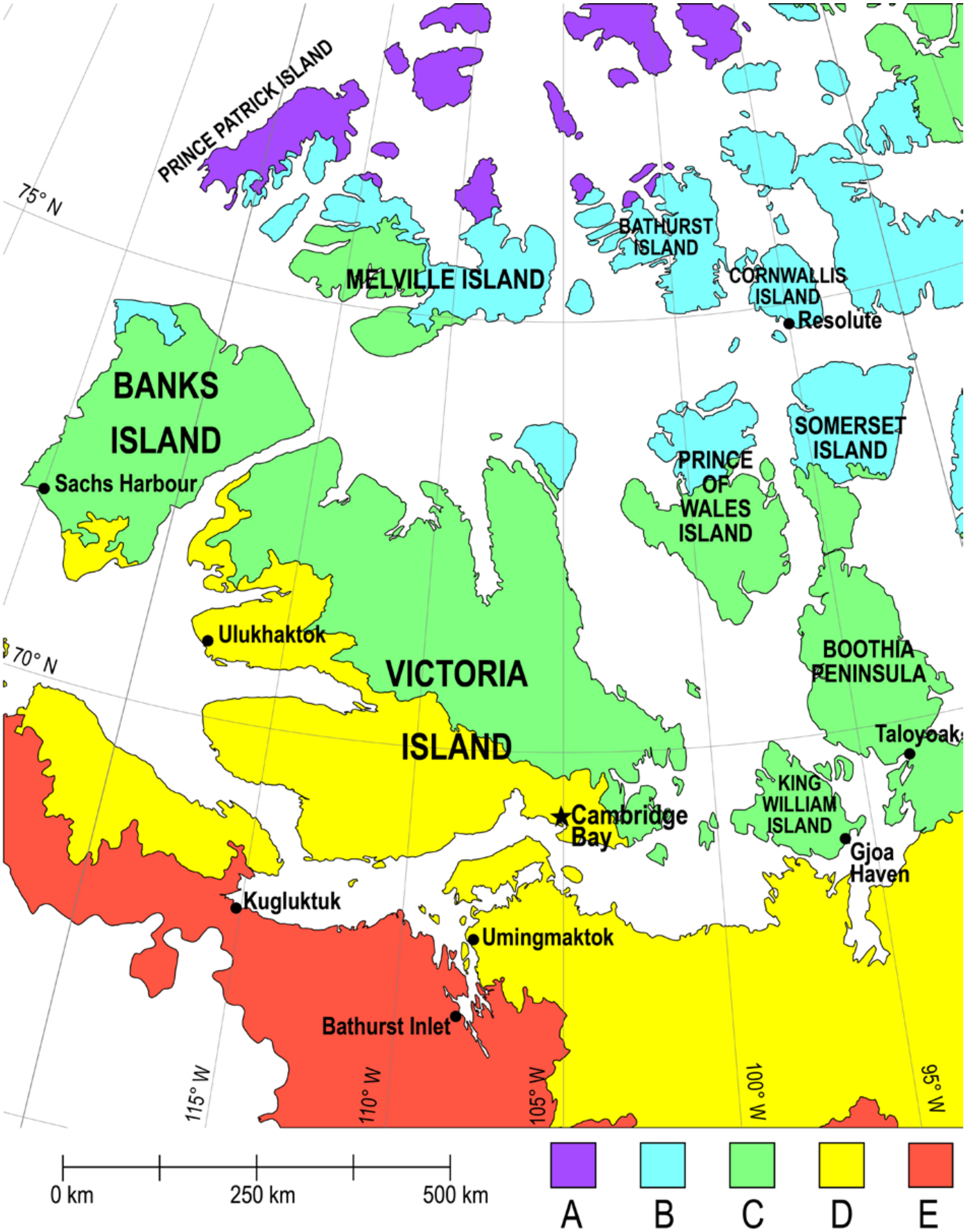

Figure 3. Bioclimatic subzones in the CHARS regional ecosystem

Reference Area (ERA) links directly to this broader classification system, and so permits extrapolation and comparison of research and monitoring results across the entire circumpolar area.

An additional opportunity conducting research in the Cambridge Bay region is the Traditional Knowledge of local ecosystems and species held within the Inuit of the 4 communities in the regional ecosystem. The Copper Inuit have lived in this area of the Arctic for over 800 years and over that time have accumulated deep and important knowledge that can inform and widen strict science approaches. The CHARS S&T Program is strongly committed to working with local Inuit with mutual benefits in terms of capacity building and research outcomes that directly inform community issues.

The strong eco-climatic gradient across the regional ecosystems makes the area an excellent location for many kinds of studies of climate change effects on marine, freshwater and terrestrial ecosystems. The regional area provides important habitat for many species including marine mammals (polar bear, seals, belugas), arctic char, caribou and muskoxen, grizzly bear, wolverine and wolf, as well as waterfowl. The area is particularly important for caribou habitat, with three very large caribou herds finding critical calving habitat in Low Tundra ecosystems across the full extent of the region south of Coronation and Queen Maud Gulf. All of these species are important to local communities as subsistence food, so that understanding climate-driven effects on these important species, and the ecological drivers that control their survival, is an important science priority.

The regional area shown in Figure 2 includes much of the area of the Slave Geological Province, a geologic area rich in gold, zinc, precious metals and diamonds. A number of developed or proposed mining operations are ongoing or planned for the regional area around CHARS (Figure 2). The Ekati and Diavik diamond mines in the south end of the area are perhaps the most well known. TMAC operates a gold development just south of Cambridge Bay on the kent Peninsula at Hope Bay. The most significant new proposal is for an all-weather road to connect Coronation Gulf at Gray’s Bay with the Izok Lake Property, linking other mining operations along the length of the proposed road. Ships from Gray’s Bay would travel west out through the Beaufort Sea to Asia, and east through the Northwest Passage to Europe, with attendant issues on local ecosystems and communities. CHARS has a strong obligation to work with communities, governments, industry and academia to provide baseline information to inform development in resource-rich areas such as the Slave Geological Province.

CHARS Experimental and Reference Area (ERA)

In the immediate area of CHARS and the Hamlet of Cambridge Bay, an Experimental and Reference Area (ERA) has been proposed as a place where scientists using the CHARS facility can conduct detailed research on marine, freshwater and terrestrial ecosystems (Figure 4) in a safe and supported environment near the Station. The approach is to conduct inventories and to establish long term monitoring projects that will inform the ecological context for research studies to take place within the ERA—progress on the baseline studies and monitoring projects is described below and is planned for completion by summer 2019.

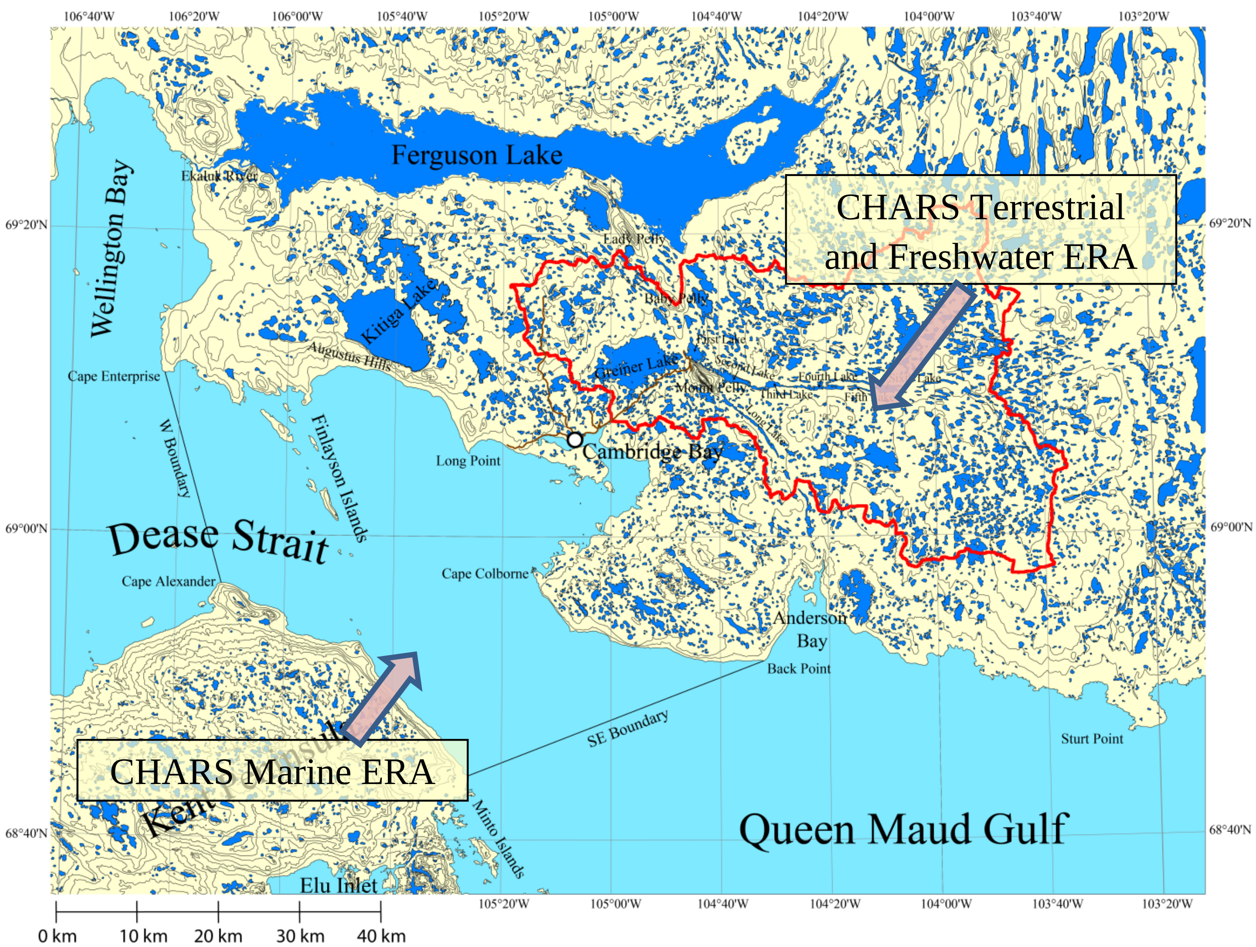

Figure 4. Proposed CHARS Marine and Terrestrial/Freshwater Experimental and Reference Areas (ERAs)

The CHARS ERA has two main components: a Marine ERA in the Dease Strait area and a Terrestrial-Freshwater ERA in the 3,300 km^2 watershed of Greiner Lake (Figure 4). In the Marine ERA, Dease Strait funnels west-to-east flowing Pacific water that originates in the North Pacific and travels through Bering

Strait, the Beaufort Sea, and on through the Canadian Arctic Archipelago. A team from the University of Manitoba is presently conducting ice and productivity studies in this area (Mundy et al 2015) and is developing baseline research studies that will support the establishment of long term marine monitoring for the area. In the Terrestrial-Freshwater ERA, CHARS science staff are being supported by a number of university and government academics to conduct regional studies on many aspects of terrestrial and freshwater classification and description.

The design for the CHARS ERA is to incorporate the ERA area as one inter-connected system from tundra through streams to lakes to rivers to the ocean adjacent to Cambridge Bay, all connected to the community of Cambridge Bay at the mouth of Freshwater Creek where it enters marine water at Cambridge Bay.

CHARS ERA Climate Summary

Johann Wagner[1]

The climate in the CHARS ERA is influenced by both the proximity of large land areas and the narrow and shallow bodies of marine water that typify the Canadian Arctic Archipelago (Figure 5, Table 2). These factors result in a high degree of climate continentality, demonstrated by a large mean annual temperature range (42–45°C) and some of the lowest annual precipitation amounts (100–150 mm) encountered in the Canadian Arctic.

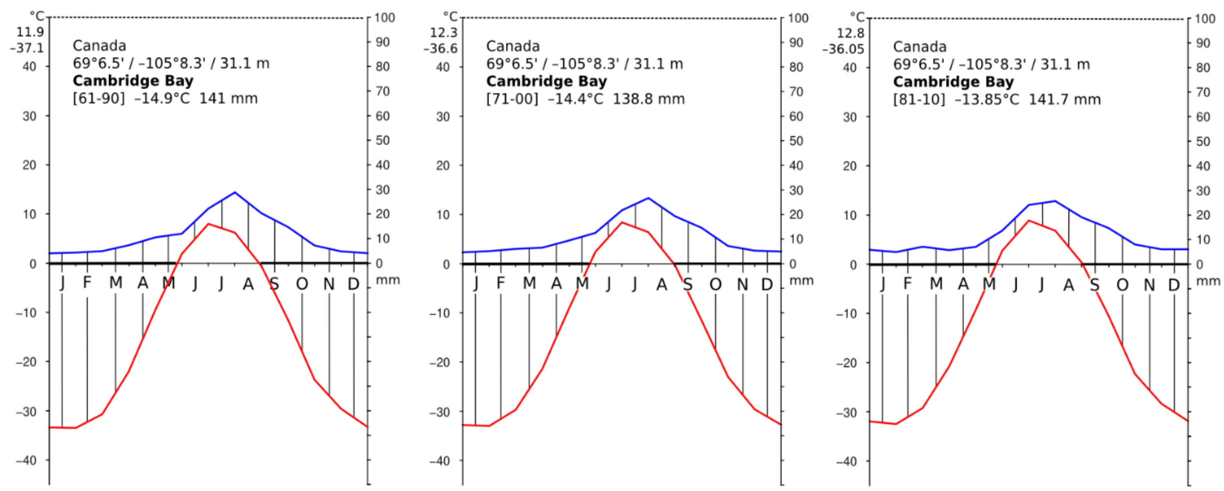

Figure 5. Cambridge Bay climate diagrams for three climate data periods (1961–90, 1971–2000, 1981–2010).

A comparison of climate normals over a few periods shows that there is warming of the climate in this region. During the climate normal periods of 1961–1990, 1971–2000, and 1981–2010, the annual mean temperature in Cambridge Bay increased by 1.1°C (from –14.9°C to –13.8°C), with most warming occurring during the winter months (October–April). It is expected that continued warming would cause significant changes in the ecosystem process and composition in the CHARS ERA, and in the CHARS regional ecosystem.

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Table 2. Temperature and precipitation normals for Cambridge Bay, Nunavut, for the periods 1961–1990, 1971–2000, and 1981–2010).

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)	61–90	−33.4	−33.5	−30.7	−22	−9.5	1.9	8	6.2	−0.6	−11.5	−23.7	−29.6	−14.9
	71–00	−32.8	−33	−29.7	−21.4	−9.2	2.4	8.4	6.4	−0.3	−11.5	−23	−29.6	−14.1
	81–10	−32	−32.5	−29.3	−20.8	−9.3	2.7	8.9	6.8	0.3	−10.4	−22.3	−28.3	−13.8
	change	+1.4	+1.0	+1.4	+1.2	+0.2	+0.8	+0.9	+0.6	+0.9	+1.1	+1.4	+1.3	+1.1
Precipitation (mm)	61–90	4.0	4.3	4.9	7.3	10.5	12.0	22.2	28.8	20.3	14.7	7.2	4.8	141.0
	71–00	4.6	5.1	6	6.5	9.4	12.5	21.7	26.7	19.3	14.6	7.2	5.3	138.8
	81–10	5.8	4.9	7.1	5.7	7.0	13.6	24.1	25.7	19.1	14.7	8.0	6.1	141.8
	change	+1.8	+0.6	+2.2	−1.6	−3.5	+1.6	+1.9	−3.1	−1.2	0	+0.8	+1.3	+0.8

Bedrock Geology

Robin McKillop[2] and Derek Turner[3]

Most of Victoria Island is underlain by Middle Cambrian to Upper Silurian carbonate rocks, unconformably overlying terrestrial and marine Upper Precambrian sediment and deformed rocks of the Shaler Group to the northwest, and the Wellington Inlier west of Cambridge Bay. The Shaler Group consists of marine sandstone, siltstone, shale, limestone, dolomite and gypsum that form the Shaler Mountains. These topographic highs trend northeast from Prince Albert Sound to Hadley Bay. The youngest and highest Shaler Group rocks are Upper Proterozoic basalt and breccias of the Natkasiak Formation, reaching elevations up to ~430 m.a.s.l. The Wellington Inlier in the Wellington Bay area is composed of fluvial sandstone, siltstone and conglomerate of the Burnside River Formation (Dixon, 1979; Okulitch, 1991).

The Paleozoic limestone and dolomite found across the majority of Victoria Island were deposited on the southern margin of the Arctic Platform, which formed on the northern edge of the Canadian Shield. This platform was composed of several shallow Paleozoic basins surrounded by Precambrian topographic highs. The structural elements of these basins likely control the large channels that cross

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Victoria Island (England, 1987). Erosion of the Arctic Platform into a series of ~10-50 m high escarpments divides the island into a central interior plateau and an outer coastal plain (Sharpe, 1992).

The mainland across the Queen Maud and Coronation Gulfs to the south is composed of Archean and Early Proterozoic rocks (Okulitch, 1991), including the Thelon Tectonic Zone, composed of high grade pink gneiss and granites (Thompson *et al.*, 1985). Erratics from this zone are spread across southern Victoria Island and provide a useful indicator of ice flow direction (Sharpe, 1992; Stokes *et al.*, 2009). Along the southern coast of Victoria Island and across Dease Strait are Upper Cambrian quartzite, dolomite and clastic sediments of the Saline River Formation.

Glacial History and Quaternary Geology

The western Canadian Arctic Archipelago was repeatedly glaciated throughout the Pleistocene by the northwestern edge of the Laurentide Ice Sheet (Barendregt *et al.*, 1998). Laurentide ice advanced from the Keewatin Dome, centred northwest of Hudson Bay, and flowed north until it was deflected northwest by the Innuition Ice Sheet to the north, and local ice caps on Melville Island (England *et al.*, 2006). Although it has been proposed that pre-late Wisconsinan deposits (Vincent, 1982) and megafaunal remains (Harington, 2005) persist on the western edge of the Canadian Arctic Archipelago, it has since been shown that all earlier deposits were reworked or eroded by ice during the late Wisconsinan (England *et al.*, 2010; Lakeman and England, 2012).

During the last glaciation, ice overran Victoria Island, deflecting around topographic highs such as the Shaler Mountains, and extended as an ice shelf past Banks Island sometime after ~31 ^{14}C ka BP (Dyke and Prest, 1987; Lakeman and England, 2013). This ice was a significant source of icebergs for the Arctic Ocean (Scott *et al.*, 2009). Little is known about ice flow conditions on Victoria Island between the initial advance of the ice sheet and ~16 ka BP. Most of the ice flow indicators (e.g. drumlins, flutings, eskers) reflect late-stage glacial ice flow (Fryles, 1963; Sharpe, 1992).

Warming and rising sea level across the Arctic caused rapid marginal retreat, and by ca. 14 ka BP the M'Clure ice stream and Shaler Mountain ice divide had shut down (Stokes *et al.*, 2009). From ca. 14–13 ka BP, the ice margin was stationary and ice flowed across eastern Victoria Island from an ice divide in McClintock Channel. Between 13–12 ka BP, ice in the Prince of Wales Strait between Banks and Victoria Island melted (Lakeman and England, 2012), the Amundsen Gulf ice stream rapidly retreated and ice streaming was reinitiated in McClintock Channel. From 12–10 ka BP, ice retreated quickly across northwestern and central Victoria Island (Sharpe, 1992). Warm-based ice continued to flow at this time across southeastern Victoria Island, forming northwest-trending sets of ice flow indicators (Stokes *et al.*, 2009). Most of the ice flow indicators in southeastern Victoria Island cross-cut these earlier sets and were deposited by a late-stage re-advance of the Laurentide Ice Sheet ca. 9.5 ka BP (Fryles, 1963; Stokes *et al.*, 2009). This deposited west-trending drumlins, flutings, eskers and moraines northeast of Cambridge Bay (Storrar and Stokes, 2007).

Marine Limits

The limit of marine incursion onto land following deglaciation of the Laurentide Ice Sheet varies across the western Canadian Arctic. This reflects differences in the pattern of deglaciation, and in the rates of sea level rise and isostatic uplift of the underlying crust. The marine limit on western Banks Island is between 22 and 40 masl (Lakeman and England, 2013), whereas the limit along western Victoria Island is between 55 and 85 masl (Lakeman and England, 2012) and ca. 130 masl on northern Victoria Island (Hodgson, 1994). This eastward increase is because sea level rise during deglaciation outpaced isostatic uplift, causing progressively higher elevation points to be covered by advancing oceans later in deglaciation. The highest marine limit in southeast Victoria Island is on Mt. Pelly in the CHARS ERA at ∼200 masl (Sharpe, 1993). Shells at 150 masl in the same area date to between ca. 7.3 and 6.6 ka ^{14}C ka BP, indicating that crustal rebound was lowering sea level by this time.

Marine incursion onto the northern Nunavut mainland continued later than on Victoria Island. This was in part due to the low elevation in this area and in part because of its closer proximity to the retreating ice. The area south of the Coronation Gulf was submerged until between 7.5 and 7 ka ^{14}C ka BP. The low elevation Back Lowlands, south of Queen Maud Gulf, remained underwater well after 7 ka ^{14}C ka BP, with parts of Adelaide Peninsula and King William Island continuing to be submerged until ca. 5 ka ^{14}C ka BP (Dyke and Dredge, 1989). Sea level elevation was time-transgressive across the study area during deglaciation, but reached approximate maximums of 120 masl at ca. 10.7 ka ^{14}C ka BP on Wollaston Peninsula on the western coast of Victoria Island (Sharpe, 1992), 225 masl near Bathurst Inlet (ca. 10 ka ^{14}C ka BP) and between 215 and 200 masl on the south side of Queen Maud Gulf (ca. 9 ka ^{14}C ka BP; Dyke and Dredge, 1989). Areas of high elevation marine limit likely correspond to where ice retreated early during deglaciation, causing submergence before full deglaciation allowed isostatic rebound. This relationship between retreating ice, isostatic uplift and marine incursion is significant for the potential peopling of northern mainland Nunavut and Victoria Island in the early Holocene.

Permafrost and Periglacial Landforms

Permafrost is nearly continuous across Victoria Island. The maximum thickness of permafrost is largely unknown, but it reaches depths of 350–600 m on neighbouring islands (Taylor, 1988). The active layer, or surface layer of seasonal melt, varies in thickness but is generally <1 m. Measured active layer thicknesses are typically minimums and are rarely collected at the time of maximum melt. These thicknesses vary greatly with elevation, texture, soil moisture, drainage, snow pack and vegetation cover. Well-drained soils insulated by thick annual snow cover tend to have thicker active layers than exposed, poorly drained areas.

Victoria Island hosts a wide range of periglacial landforms. Patterned ground and thermal expansion cracks are common in areas with a fine-grained mineral soil component. These features form from frost heave of groundwater in the active layer. Sharpe (1992) suggests that many of these features initiated immediately after deglaciation, when temperatures were much colder than at present. This explains why patterned ground is more pervasive on Victoria Island above the marine limit, where land was exposed during periods of high sea level. Patterned ground also occurs as stone stripes on gentle slopes, and as sorted polygons where the fine and coarse grain sizes have been separated by freeze-thaw processes.

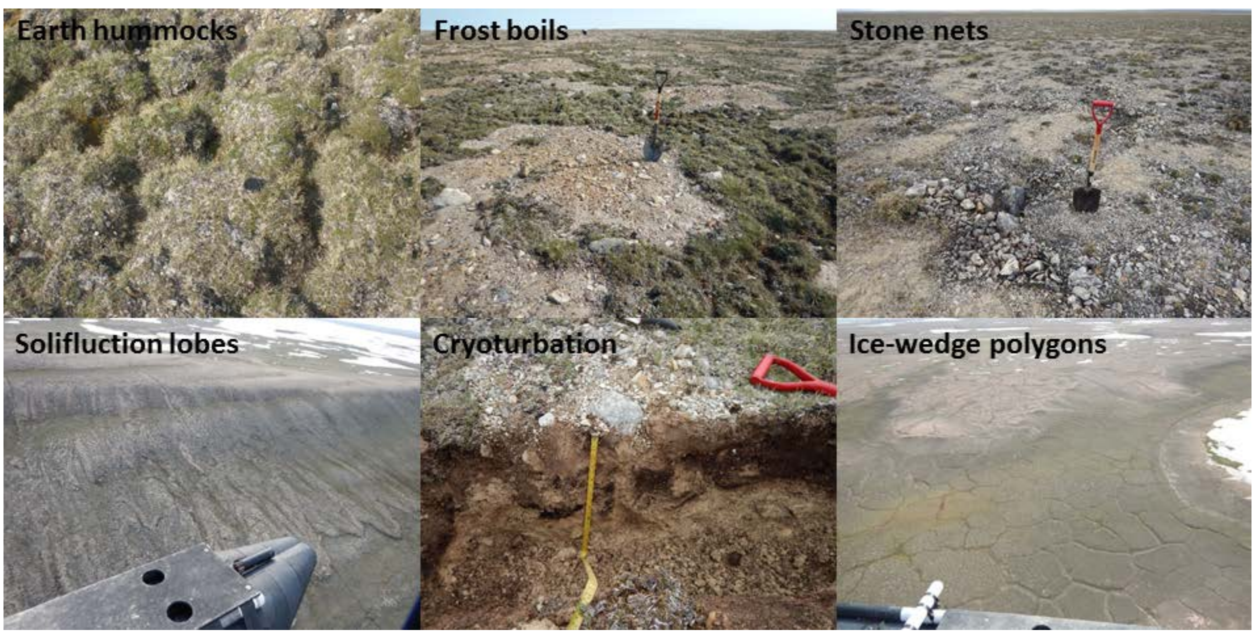

Figure 6. Common periglacial land features in the CHARS ERA and Victoria Island area.

Other common periglacial features on Victoria Island are solifluction lobes, small earth hummocks and thermokarst lakes (Figure 6). Solifluction is a type of soil creep caused by down-slope movement of soil, organics and weathered bedrock by frost heave. Solifluction lobes typically form on north-facing slopes, but can also occur on south-facing slopes under certain conditions. Earth hummocks are caused by heaving of buried segregated ice lenses along cryostatic pressure gradients that develop during freezing from both the surface and the buried permafrost table (Tarnocai and Zoltai, 1978). They are usually cored by organics and mineral soil. These features are pervasive across Victoria Island and occur in a wide range of locations with the necessary near-surface ice, soil temperature, moisture regime and texture. Similarly, thermokarst lakes are found across the island. These lakes form as exposed ground ice melts and slumps, exposing more permafrost and continuing the melt cycle. Thermokarst features likely grew episodically during warm periods in the Holocene.

Human History

Summary from Keith and Freisen (2012)

Evidence from archeological research at Iqaluktuuq (see Figure 2 for location and for chronology) meaning 'place of many fish' suggests that the Cambridge Bay area has been occupied by humans for almost 4,000 years. Evidence of the pre-Dorset culture reflects changes in the marine shoreline on Victoria Island, as discussed above. Sea level was higher than at present, so Iqaluktuuq was not yet a river, and what is now Ferguson Lake was an arm of the ocean. At Iqaluktuuq, Pre-Dorset People lived in smaller groups on a series of small islands and hunted seals and caribou. The Early to Middle Dorset People moved into the area around 500 BC and constructed stone houses and relied heavily on the char runs in the newly formed Iqaluktuuq River. The Late Dorset society (800 to 1250 AD) is marked by large stone longhouses (> 40 m in length) that would have held as many as 100 people. The Thule Inuit, direct ancestors of Modern Inuit, arrived at Iqaluktuuq from Alaska around 1250 AD. Evidence suggests they may have met Late Dorset People, who they refer to as 'Tuniit'. Thule Inuit built large stone houses with deep entrance tunnels and separate kitchen rooms, living in skin tents and travelling in the warmer summer months. Deep deposits of bones and tools suggests the Thule Inuit lived a settled comfortable life at Iqaluktuuq, relying on stored caribou and char to last the winter, and using tools and other technologies easily recognized by today's elders.

Over the last 750 years the Thule Inuit developed the lifestyle and technologies that Modern Inuit utilized up to the period of contact with European explorers beginning about 300 years ago. Winters were spent on sea ice in iglu villages hunting seal, and summers on land fishing for char and hunting caribou. Iqaluktuuq was always an important site because of the rich spring and fall char runs in the

Dates	Archeology Classes	Inuit Classes
1800 to 500 BC	Pre-Dorset	'Tuniit'
500 BC to 800 AD	Early and Middle Dorset	
800 AD to 1250 AD	Late Dorset	
1250 AD to 1500 AD	Thule Inuit	Inuit
1500 AD to present	Modern Inuit	

Table 3. Chronology of cultural occupation at Iqaluktuuk, northwest of Cambridge Bay.

river, and the abundance of caribou that funneled through the area around the west end of Ferguson Lake. It is this Traditional Knowledge gathered over millennia that provides such as rich source of local information that is held within local Inuit culture. It is a key goal of the CHARS S&T Program to work with local Inuit knowledge holders to ensure that Traditional Knowledge becomes a key part of our understanding of local ecosystems, informs and provides context for our science investigations, and is brought to bear in decision-making.

Terrestrial Ecosystem Classification and Mapping – The Artic-Subarctic Terrestrial Ecosystem Classification (ASTEC)

The Canadian High Arctic Research Station (CHARS) has a broad science mandate that includes conducting, promoting and supporting research and monitoring activities across the vast subarctic and arctic landscapes of Yukon and Northwest Territories, Nunavut, Nunavik in northern Quebec, and Nunutsiavut in northern Labrador. CHARS is also strongly committed to promoting and facilitating international arctic science, and is actively working with many international partners to help meet its science objectives.

To provide a logical and useful ecological frame for implementing coordinated, pan-Northern and international research and monitoring of terrestrial ecosystems, CHARS is proposing the implementation of a stnadardized ecological classification and mapping system - the Artic-Subarctic Terrestrial Ecosystem Classification (ASTEC) – the principles of which are well developed at an for forest management in southern Canada, is in the process of being operationalized in the Yukon Territory, and the classification component is presently being coordinated internationally across the circumpolar North.

A knowledge framework that classifies and describes ecological communities so that their species composition, structure and ecological functions can be understood as a direct expression of the environmental drivers and ecological processes that determine their character will help frame research and monitoring studies, and provide a strong foundation for predictive ecosystem modeling. Key principles defining the structure and applications of the ASTEC are being developed and will be available soon (McLennan *et al,* in prep).

In addition to the understanding of community species composition, soil and site properties, habitat values and the ecological processes that control these factors, the terrestrial ecosystem classification is also very useful because ecological units can be mapped at a range of scales to provide an important landscape perspective on the distribution and abundance of the various ecotypes (Figure 7). The maps can also show the spatial relationships among the various ecotypes, and their relationships to local topography and the ecological processes and drivers that operate at a landscape scale such as flooding, snow distributions, elevation, and the effects of aspect. Taken together, the ecosystem maps can be used to interpret the present drivers determining ecosystem pattern and process across the landscape, so that, given predicted changes in drivers with climate change, changes in the landscape mosaic can be understood and predicted. These changes will have important implications for such management issues as changes in the quantity and quality of habitat for ungulates, small mammals, birds, and many other species, changes in net ecosystem carbon flux, and changes in land to atmosphere feedback processes.

Ecotype mapping also permits us to link the terrestrial and freshwater systems within the CHARS ERA, so that important freshwater drivers such as water chemistry and temperature, rates of erosion and sediment delivery, and hydrograph characteristics can be related to changes in terrestrial ecosystem characteristics. These changes may have important consequences for freshwater valued ecosystem components such as long term char and lake trout condition and abundance.

Another key application of the ecosystem maps is the design and implementation of research experiments across the CHARS ERA. Research hypotheses can be developed and tested across the range of ecotypes, or groups of ecotypes, using stratified random or other designs. For the same reasons, the ecosystem maps are also critical for the design and implementation of long term monitoring plots, because of the spatial representation and process understanding, and also because of the standardized

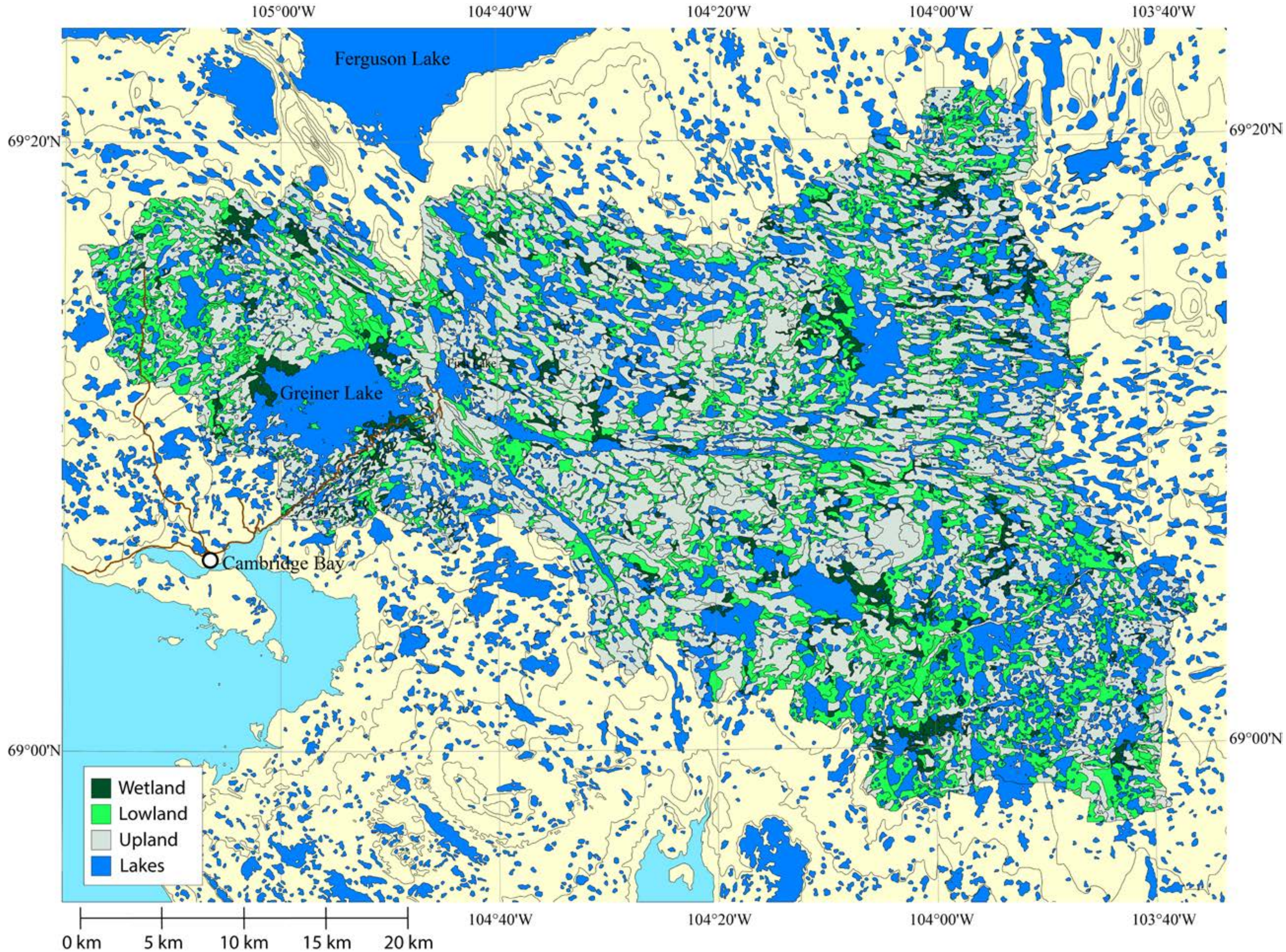

Figure 7. Terrestrial ecosystem map of Cambridge Bay and adjacent regions.

nomenclature for the classification of the plant communities that characterize the ecosites through the CNVC and the AVA classification initiatives. A standardized classification provides the opportunity to plan layouts and link results at CHARS to the network of CHARS monitoring partner sites across the Canadian North (Figure 1), and around the circumpolar area.

The terrestrial ecosystem map presented in Figure 7 is a first approximation of the map products to be developed for the CHARS ERA, and presently depicts groups of ecotypes. This map provides an excellent basis for understanding key habitat distributions and land to air processes such as carbon flux and albedo feedback, and will help us plan development of research infrastructure in the CHARS ERA, e.g., location of experimental watersheds and field cabins. Over the next several years we intend to make much more accurate maps for targeted experimental watersheds within the ERA using aerial drones and other new technologies. Detailed monitoring of ecological change in experimental watersheds will provide a deeper understanding of climate driven ecological changes, and the ecosystem mapping will provide the opportunity to extend this knowledge to broader areas of the landscape.

Vegetation and Ecosystems

Prepared by Del Meidinger[4], Will MacKenzie[5], and Johann Wagner[6]

Arctic Bioclimatic Zonation

The Arctic has been classified by various researchers into bioclimatic regions, varying in number from two to eight (see Table 2 in Walker *et al.*, 2005). In the simplest classification, only Low and High Arctic are characterized (Bliss, 1997). In the most complex, three categories of subarctic (southern, middle, and northern), three categories of arctic (modifiers same as subarctic), and two categories of polar desert (southern, northern) are defined (Alexandrova, 1980). All the zonations attempt to characterize terrestrial ecological variation across the arctic using features such as relative vegetation cover, vertical structure, major plant community types, and floristic diversity, and relate these features to climatic characteristics, such as mean July temperature and overall summer warmth.

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A major project to reconcile Arctic zonation across the circumpolar region was initiated in 1992 and resulted in the Circumpolar Arctic Vegetation Map[7] – CAVM (Walker *et al.*, 2005). In this map, five arctic subzones were defined, A through E, and characterized by their vegetation features and climate. These subzones are based on Yurtsev (1994) and (Elvebakk, 1999). The map also includes mapping of Floristic Provinces based on Yurtsev (1994). Based on the CAVM, the zonation of the lower elevations of SE Victoria Island can be characterized as part of **Subzone D** (Walker *et al.*, 2005) and within **floristic subdivision IV-A (Central Canada) (**Yurtsev, 1994). Much of the mapping team spent time at Cambridge Bay (Gould *et al.*, 2003) so even though we were questioning which subzone SE Victoria Island would be in, we can be assured that the area is mapped correctly to the CAVM subzone (Figure 3).

Subzone D is the northern part of both the Low Arctic (Polunin, 1951; Bliss, 1997) and the Southern Arctic of Tuhkanen (1986). It is equivalent to the Southern Arctic Tundra of Elvebakk (1999), the Northern Hypo-Arctic Tundra of Yurtsev (1994), the Erect Dwarf Shrub zone of Walker *et al.* (2002) and the Southern Arctic Dwarf Shrub zone of Daniëls *et al.* (2000).

Arctic Zonation and the CNVC

The Canadian National Vegetation Classification (CNVC) is developing a hierarchical vegetation classification and a map of vegetation zones for Canada. The map units for this broad-level map are geographic areas where circum-mesic vegetation would be classified within one Macrogroup of the CNVC. A Macrogroup is a mid-level unit of the classification (http://cnvc-cnvc.ca/) that groups lower-level vegetation units (associations, alliances and groups).

The Macrogroups have not yet been determined for the Arctic, as this classification is generally conducted from the 'bottom up', i.e., starting with vegetation associations. However, based on the information we have of Arctic zonation, vegetation patterns, and floristics, the following Macrogroups are proposed:

1. **High Arctic** – Subzones A & B of CAVM. Polar Desert and Arctic Tundra zones of Matveyeva (1998). Sparse to open vegetation communities characterized by cryptogams, forb barrens, and prostrate dwarf shrubs (< 5 cm tall). Flora typically with < 100 vascular plant species. Mean July temperature is from 1–5 ^{o}C.
2. **Mid Arctic** – Subzones C & D of CAVM. Typical Tundra zone of Matveyeva (1998). Moderately open to "interrupted" closed vegetation communities with more upright dwarf shrub

[7] Download at http://www.geobotany.uaf.edu/cavm/

vegetation—so-called 'hemi-prostrate' and erect dwarf shrubs (10–40 cm tall). Flora with 75–250 vascular plant species. Mean July temperatures range from 6–9 ^{o}C.

3. **Low Arctic** – Subzone E of CAVM. Southern Tundra zone of Matveyeva (1998); Arctic Shrub-Tundra zone of Elvebakk (1999). Closed vegetation communities are typical; dwarf-shrubs up to 50 cm tall, along with low-shrub communities with plants up to 80 cm tall. Flora with 200–500 vascular plant species. Mean July temperature from 10–12 ^{o}C.

Terrestrial Ecosystem Classification and Mapping of the CHARS ERA

Ecosystem Sampling and Description (2013 and 2014 Field Seasons)

A selection of terrestrial ecosystems around Cambridge Bay were sampled by a team of specialists (botanists, ecologists, pedologists and geomorphologists) over the 2013 and 2014 field seasons. Data were collected in July and early August in both years following methods and data input forms on site, soil and vegetation outlined in DEIF (2001). The site description forms record information about the general location, geographic coordinates, physical characteristics and vegetation of the site. The soil description forms record detailed information about the soils and surficial geology of the investigated sites, obtained by digging a soil pit. The vegetation forms contain a complete list of vascular and non-vascular plant species growing on the plot, with their percent coverage in different vegetation layers. In addition, general landscape observations were conducted throughout the field program, and many geo-referenced digital photographs were taken to support the mapping and modelling.

These data were not sufficient to create a regional classification and so these field data were appended by historical relevé data for CAVM Subzone D to provide sufficient data and to link the classification to the CNVC national classification. The associations will be integrated into the Canadian National Vegetation Classification (CNVC) and be available on-line at: http://www.cnvc-cnvc.ca/

Terrestrial Ecosystems of the CHARS Experimental and Reference Area - The Greiner Watershed

The CHARS ERA and all elevations below 100m on south-east Victoria Island fall within Subzone D (Figure 3) of the Circumpolar Arctic Vegetation map (Walker *et al.*, 2005). Elevations above 100 m have much lower vegetation cover and could be characterized as part of Subzone C. Both occur within floristic subdivision IV-A (Central Canada) (Yurtsev, 1994). As such, the bioclimate could be coded as D-IV-A and C-IV-A respectively—the combination of these two levels of zonation. Even so, within bioclimate D-IV-A, which occurs over a broader area than SE Victoria Island, there are considerable areas of both base-rich and base-poor bedrock. A complete characterization of the ecosystems of bioclimate D-IV-A would need to encompass both these bedrock conditions. SE Victoria Island only has base-rich bedrock and, therefore has ecosystems of the *Bioclimate D-IV-A over base-rich bedrock*.

The following section provides a provisional classification of ecosystem associations for Bioclimate D-IV-A over base-rich bedrock, and is based on a correlation of the observed and sampled ecosystems around Cambridge Bay with the Arctic Vegetation Classification (Walker 2014). The unit descriptions are from the CNVC descriptions, with further information from the local context where national units exist. Brief descriptions are submitted for proposed new units not currently in the CNVC classification, but sampled in this study.

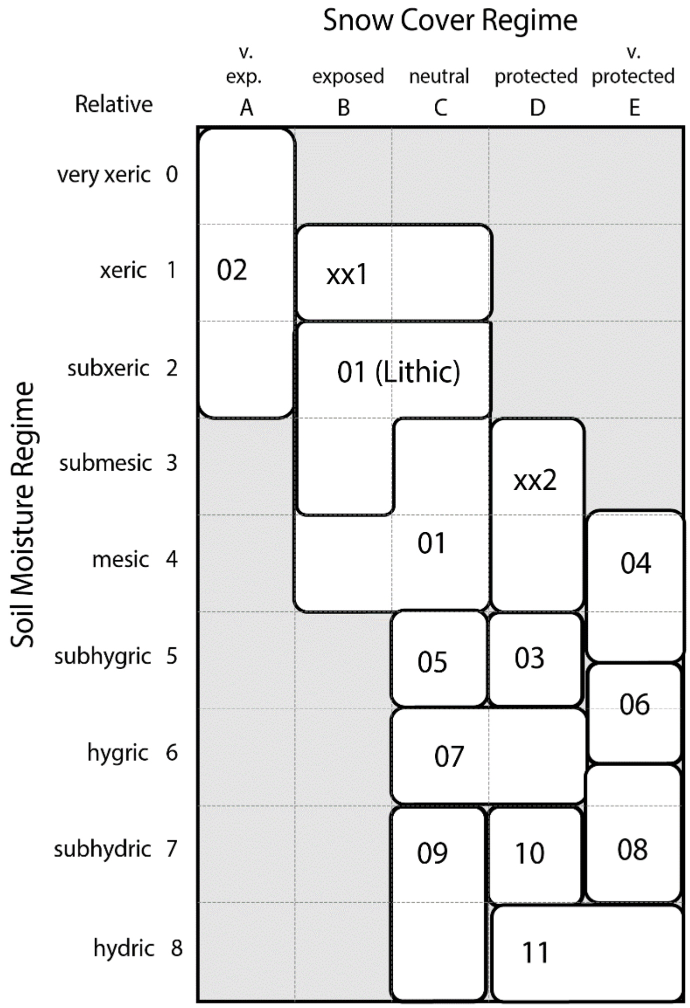
The environmental relationships between these units are presented in Figure 8 as a two-way matrix where the axes are soil moisture regime (from very xeric to hydric) and winter exposure (from highly exposed to highly protected). Within an area of uniform bedrock-soil conditions such as over the CHARS ERA, soil moisture regime and winter exposure are considered to be the 2 major factors controlling the composition, structure and distribution of terrestrial ecosystems across the landscape. A particular soil moisture regime can experience different snow exposures, but generally there is a positive correlation between soil moisture regime and snow exposure, with very dry ecosystems commonly having no winter snow cover, while very wet ones experience relatively deeper snow cover.

At the end of the report, vegetation summary tables for the ecological units are presented in Appendix 1. Vegetation tables are presented for the units using the CNVC dataset, and also from plots from the CHARS area.

Zonal Ecosystem

/01 (ARC041.2) Dryas integrifolia – Saxifraga oppositifolia; Carex rupestris (Mountain Avens – Rock Sedge Ecotype)

ARC041 (Figure 9) is a High and Mid Arctic tundra and barren association that is common on winter-exposed, gravelly, well-drained calcareous soils. A discontinuous mat of entire-leaved mountain avens (*Dryas integrifolia*), the cushion plant purple mountain saxifrage (*Saxifraga oppositifolia*), and the drought tolerant rock sedge (*Carex rupestris*) characterize this dry, sparsely vegetated association. Arctic willow (*Salix arctica*) occurs at very low cover values. A high percentage of unvegetated or crustose



Site Series

01 (Arc041) Mountain-avens - Curly sedge

02 (Arc) Three-toothed Saxifrage - Blackish locoweed

xx1 (Arc) Arctic willow || xx2 Mountain-avens - Oxytropis

03 (Arc) Mountain-avens - Net-veined willow

04 (Arc027) Mountain-heather - Mountain-avens

05 (Arc) Mountain-avens - Water sedge - Arctic willow

06(Arc) xxMountain-avens - Horsetail - Bearberry||Polar willow - Moss

07 (Arc) Arctic willow - Water sedge - Scorpidium

08 (Arc) Richardson's willow - Water sedge

09 (Arc) Water sedge

10 (Arc) Dupontia - Water sedge

11 (Arc) Arctophila fulva

Figure 8. An edatopic grid displaying 11 ecotypes within the CHARS ERA in relation to soil moisture regime and exposure to winter conditions.

lichen cover is common on the typic and barrens subassociation, but higher cover occurs on some *Carex rupestris* sites. This association occurs on elevated strand beaches, pingos, scree slopes, ridges, and gravelly kame and till, often with cryoturbation features such as high-centered polygons, non-sorted circles, and nets. Brunisolic Static Cryosols, Regosolic Turbic and Static Cryosols, and Orthic Turbic Cryosols have all been recorded for this association. Thaw depths are generally less than 35 cm. Four sub-associations are distinguished: ARC041.1 (Typic), ARC041.2 (*Carex rupestris*) ARC041.3 (Barrens), and ARC041.4 (*Carex nardina*).

The ARC041.2 (*Carex rupestris)* subassociation is the zonal common and widespread on SE Victoria Island (Plots CB13004, CB13009, CB13012, CB13015). Based on the Cambridge Bay sampling, this subassociation may be elevated to an association.

In the CHARS ERA, and across Subzone D of SE Victoria Island, this mesic tundra ecosystem is by far the most widespread community. The *Dryas – Carex rupestris* tundra in Subzone D is commonly well vegetated and even-surfaced, but rocky Lithic types occur where cryoturbation is high, vegetation cover is low—some sites are distinctly hummocked. Other species associated with this ecosite locally include *Salix arctica, Oxytropis arctica, Carex scirpoidea* and *Saxifraga oppositifolia.*

Drier and More Exposed Ecosystems

/02 Saxifraga tricuspidata – Oxytropis arctobia (Three Toothed Saxifrage – Blackish Locoweed Ecotype)

This ecosystem is not currently described in the national classification but occurs frequently in the CHARS ERA and across SE Victoria Island on rocky convex ridges, where there is little to no snow in the winter (Figure 10). It is associated with various parent materials—the rapid to well drained materials and exposed landscape positions are the key site factors that result in the sparse to moderately developed vegetation that is characterized by three-toothed saxifrage (*Saxifraga tricuspidata*). Other common species are blackish locoweed (*Oxytropis arctobia*)*,* arctic locoweed (*Oxytropis arctica*)*,* entire-leaved mountain avens (*Dryas integrifolia*)*,* glaucous bluegrass (*Poa glauca*)*,* arctic willow (*Salix arctica*)*,* and Bellard's kobresia (*Kobresia myosuroides*). A "white crust" lichen is commonly found.

Figure 9. Ecosite 01 (ARC41.2).

Figure 10. Ecosite 02 with Saxifraga tricuspidata *in foreground.*

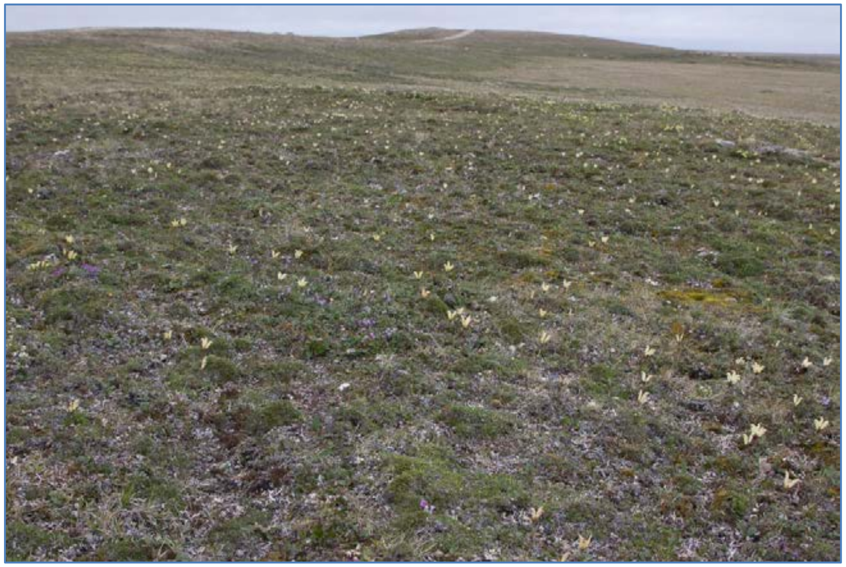


Figure 11. Ecosite 03 with Salix reticulata *and* Dryas integrifolia *being the two most abundant species.*

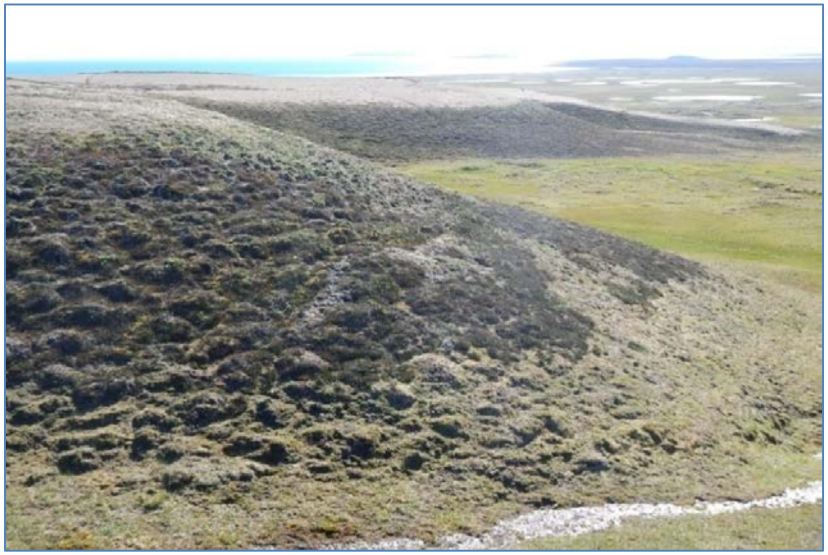


Figure 12. Ecosite 04 (ARC027). The darker band of vegetation in the lee of the slopes is Cassiope tetragona.

Moist Tundra Ecosystems

/03 Dryas integrifolia – Salix reticulate (Mountain avens – Net veined willow Ecotype)

This association and its site conditions are not specifically described in the CNVC classification but similar types exist; they usually have additional species indicators of wetter sites. This is a well-vegetated, tundra ecosystem type that occurs in lee-side nivation hollows, in areas with snow cover and subsequently, a moist soil moisture regime (Figure 11). It sometimes occurs in hummocky areas. Besides the ubiquitous entire-leaved mountain avens (*Dryas integrifolia*) there is a high cover of *Salix reticulata*, the net-veined willow, which prefers moister conditions and longer snow cover. *Arctagrostis latifolia* (polar grass) is also present, in low abundance—*Pedicularis capitata* (capitate lousewort) can be quite frequent. Soils are moderately well-drained, Turbic Cryosols.

/04 (ARC027) Cassiope tetragona – Dryas integrifolia – Salix reticulata (Mountain Heather – Mountain Avens Ecotype)

ARC027 is a widespread Low Arctic association occupying snow accumulation sites at low to high elevations. It is generally common but typically of somewhat restricted areal extent matching the patterns of snowdrift accumulation. The vegetation of the ARC027 is typically dominated by both entire-leaved mountain avens (*Dryas integrifolia*) and four-angled mountain heather (*Cassiope tetragona*) with a higher proportion of mountain-heather favoured on sites with deeper snow packs (Figure 12). The vegetation is often diverse: common associates include net-veined willow (*Salix reticulata*), alpine bilberry (*Vaccinium uliginosum*), and few-flowered lousewort (*Pedicularis capitata*). The lichens *Cetraria nivalis*, *Cetraria cuculata*, and *Dactylina arctica* have a low cover in the inter-hummock areas. Because of high snow accumulations these ecosystems remain moist for some period of the growing season. They occur on a variety of slope positions where snow will accumulate including leeward slopes or even slopes with many concavities where mountain-heather establishes in hollows and mountain avens occurs on wind-affected mounds. Frost heaving and hummocks are common on sites with thinner snowpacks. Four subassociations are recognized: ARC027_1 (Typic), ARC027_2 (Lupine), ARC027_3 (Scrub birch), and ARC027_4 (Bearflower)(see MacKenzie, 2014).

In the CHARS ERA, and across SE Victoria Island**,** the ARC027_1 Typic subassociation occurs (Plots CB13008, CB13016, CB13024) on southern and southeastern slopes of hills, protected by the dominant northwestern winds, where snow accumulates. The parent materials vary. The characteristic and visually distinctive species is four-angled mountain-heather, *Cassiope tetragona,* but *Dryas integrifolia* is often as abundant. The vegetation cover is high—other species, such as arctic willow, net-veined willow*,* or mountain sorrel (*Oxyria digyna*) can occur but are low in cover.

Figure 13. Ecosite 05 (ARC033). Carex aquatilis *is evident;* Dryas integrifolia *is on top of the small hummocks.*

Figure 14. Ecosite 06 (ARC036). The horsetail is evident as the bright green coloured plant.

Figure 15. Ecosite 07 (ARC056). Graminoids often overtop Salix arctica *in the ARC056.*

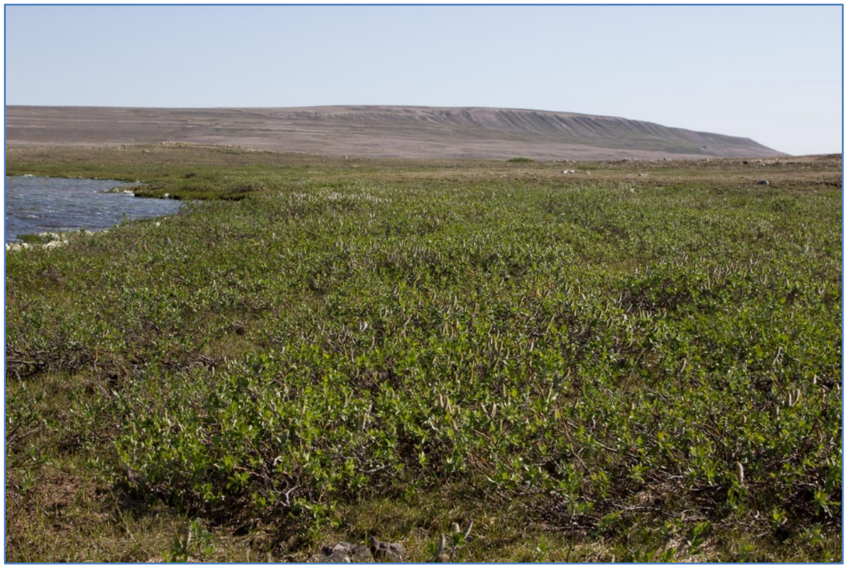


Figure 16. Ecosite 08 (ARC062). Salix richardsonii *is the tallest plant species in the Cambridge Bay area.*

The soils are well drained and usually either Static or Turbic Cryosols—the Brunisolic Eutric subgroup. On one sample site, the soil did not have permafrost, had no evidence of cryoturbation and was well-developed—classed as an Orthic Melanic Brunisol.

/05 (ARC033) *Dryas integrifolia – Carex aquatilis – Salix arctica* (Mountain Avens – Water Sedge – Arctic Willow Ecotype)

ARC033 is a High Arctic association occurring in hummocky snowflush areas that remain wet for much of the short growing season and are protected by a thin snowpack throughout winter (Figure 13). Mats of entire-leaved mountain avens (*Dryas integrifolia*) and arctic willow (*Salix arctica*) are prominent on elevated hummocks, while water sedge (*Carex aquatilis*) and the hummock-forming golden fuzzy fen moss (*Tomenthypnum nitens*) dominate the wetter depressions between the mounds. Other common species include short-leaved sedge (*Carex fuliginosa* ssp. *misandra*) and a diversity of wetland mosses such as artic thread-moss (*Bryum arcticum*), sickle-moss (*Sanionia uncinata*) and golden fuzzy fen moss (*Tomenthypnum nitens*). A film of *Nostoc* algae occurs locally in some sites. Cryoturbated micro topography is prominent. Hummocks may be small or large, up to 1.2 m diameter, and clumped or aligned in distribution in the form of a strangmoor. Hollows may be large or small, deep or shallow, and open or draining. Winter snow depths are moderate. Soils tend to be poorly drained, fine- to medium-grained Gleysolic Turbic Cryosols. Soil pH is neutral to basic.

In the CHARS ERA and across SE Victoria Island, this ecosystem is a transitional one from mesic tundra to wetland. Although observed in other areas, only one site was sampled (Plot CB13007). The soils and geomorphology at this site indicated that the site floods, likely early in the early summer season during snowmelt and run-off. Soils were poorly drained and identified as a Gleysolic Static Cryosol—active layer depth was 34 cm.

/06 (ARC036) *Dryas integrifolia – Equisetum arvense – Arctostaphylos alpina* (Mountain avens – Horsetail – Red Bearberry Ecotype)

ARC036 is a western Low Arctic tundra association occurring on moist solifluction slopes that retain snow or moisture late in the season. Mats of tough-rooted entire-leaved mountain avens (*Dryas integrifolia*), red bearberry (*Arctostaphylos alpina* var. *rubra*), and net-veined willow (*Salix reticulata*) are characteristic of this association. Substantial surface water movement and mobile soils promotes the growth of horsetails (*Equisetum arvense*), and lends a distinct light green cast to the vegetation community (Figure 14). A diversity of other species occur such as arctic willow (*Salix arctica*), Lapland rhododendron (*Rhododendron lapponicum*), alpine bilberry (*Vaccinium uliginosum*), yellow marsh saxifrage (*Saxifraga hirculus*) and muskeg sedge (*Carex lugens*). Moss cover is often high but species data is largely lacking at this time. This plant community commonly occurs at the break between steep, coarse-grained mountain slopes and gradual, fine-grained pediment slopes at their base, but also in other areas receiving upslope seepage. Soils remain saturated for much of the growing season, and typically show evidence of solifluction. Surface topography may take the form of solifluction lobes, terraces, sheets, or stone stripes. Soils are fine-grained, imperfectly to moderately drained, Gleysolic Turbic Cryosols. Buried organic material is a characteristic feature of these soils. The active layer is typically greater than 30 cm.

In The CHARS ERA and across SE Victoria Island, this ecosystem is very localized, encountered only on the southwestern slopes of Mount Pelly (Plot CB13021). This is the only location for this associations sampled east of the Yukon, so certain species found only in the Yukon/Alaska arctic are absent from this association (e.g. *Carex lugens*, *Rhododendron lapponicum*). The soil of the single plot is a heavily cryoturbated mix of organics and soil and was classified as a Histic Eutric Turbic Cryosol—active layer 65 cm. It also appears that some solifluction occurs throughout the year.

Wet sites

/07(ARC056) Salix arctica –Carex aquatilis –Scorpidium (Arctic willow – Water Sedge Ecotype)

ARC056 is a wetland association widely distributed in the High and Mid Arctic on wet gradual slopes below snowbeds, drainage channels, and pond margins (Figure 15). It is characterized by the dominance of water sedge (*Carex aquatilis*) with some cover of arctic willow (*Salix arctica*). Fragile sedge (*Carex membranacea*) and narrow-leaved cotton-grass (*Eriophorum angustifolium*) are prominent on some sites. Other common secondary species include polargrass (*Arctagrostis latifolia*), viviparous bistort (*Polygonum viviparum*), and yellow marsh saxifrage (*Saxifraga hirculus*). A well-developed moss cover is typical. Species composition is variable but generally dominated by wetland mosses indicative of relatively high pH such as rusty hook-moss (*Scorpidium revolvens*), arctic cinclidium moss (*Cinclidium arcticum*), golden star-moss (*Campylium stellatum*), *Drepanocladus brevifolius, Orthothecium chryseum*, and others. Lichens are mostly absent. Sites occur from sea level to 300 m elevation, frequently on very gradual, warm aspect slopes but also in well-watered level areas. Soils are subhydric and poorly drained. The soil active layer depth is from 25 to 65 cm deep. Weak ground patterning may be present in the form of polygons or hummocks. Similar to the ARC055 association but the ARC056 occurs on wetter sites. Three subassociations are recognized: typic, *Carex membranacea*, and *Eriophorum angustifolium*. (Plots 13JW001, 13JW002,CB13001, CB13002)

In the CHARS ERA and across SE Victoria Island, this ecosystem is common. *Salix arctica* cover is variable particularly on wetter site with little microtopography. *Eriophorum* spp., *Carex membranacea,* loose-flowered alpine sedge (*C. rariflora*)*,* and dark-brown sedge (*C. atrofusca*) are common local components. The moss *Loeskypnum badium* common in local ARC056 sites. Soils of sample sites are very poorly to poorly drained, with peat of varying thickness. The active layer depth is 10–30 cm and the soils are Fibric Organic Cryosols or Gleysolic Static Cryosols.

/08 (ARC062) Salix richardsonii – Carex aquatilis (Richardson's Willow – Water Sedge Ecotype)

ARC062 is a Low Arctic and Subarctic association occurring on regularly flooded areas along streams, in lowland positions and along the margins of streams and lakes. It is characterized by the dominance of low- to moderate-statured Richardson's willow (*Salix richardsonii*) and water sedge (*Carex aquatilis*), with narrow-leaved cotton-grass (*Eriophorum angustifolium*) also being on most sites but at a much lower cover (Figure 16). Other species that commonly occur include arctic willow (*Salix arctica*), slender-beaked sedge (*Carex athrostachya*), common horsetail (*Equisetum arvense*) and golden star-moss (*Campylium stellatum*). Shrub height can vary from 15 cm to 1.2 m. Sites are commonly flooded for part of the year. Soils are poorly drained with a loamy to sandy texture, and can be Gleysolic Static Cryosols. There is often an organic layer on top of the gleyed C-horizon.

In the CHARS ERA and across SE Victoria Island, this ecosystem is common (Plots CB13003, CB13010) and is the tallest statured vegetation in the Cambridge Bay area. The active layer depth on the site examined was about 25 cm with seepage at 16–18 cm.

/09 (ARC019) Carex aquatilis (Water Sedge Ecotype)

ARC019 is a wetland association widespread in the Low Arctic occurring on a wide range of wet habitats. It is characterized by the dominance of water sedge (*Carex aquatilis*), which forms a nearly continuous cover (Figure 17). Narrow-leaved cotton-grass (*Eriophorum angustifolium*) sometimes occurs as a secondary species. Few shrubs are present but there is often a high cover of mosses, which make up much of the site biomass. Some moss species occurring frequently in this association include: *Sphagnum* species, *Scorpidium* species, golden star-moss (*Campylium stellatum*), giant water-moss (*Calliergon giganteum*) and hook-moss (*Drepanocladus brevifolius*), but the species of mosses varies among sites. Species diversity is often low in ARC019 communities. This association occurs on level wet sites with a high water table that can be flooded for several weeks or more each year. These sites are typically found at low elevations on the margins of ponds, lagoons and streams in areas that do not accumulate sediments at a high rate. Soils are usually gleyed silty loams. There is no relief to the sites or patterning to the vegetation on these sites, due to the negligible influence of permafrost. The association has a very wide range, being found in most areas of the North American Low Arctic, but does not cover a large proportion of the landscape. Four sub-associations are recognized: *Carex aquatilis* (typic), *Carex aquatilis* (*Eriophorum angustifolium*), *Carex aquatilis* (*Sphagnum*) and *Carex aquatilis* (*Drepanocladus*).

In the CHARS ERA and across SE Victoria Island, this ecosystem is uncommon and restricted in extent (Plots CB13006). Marsh ragwort (*Tephroseris palustris*) is a common secondary species. Mosses where they occur will be wetland mosses indicative of base-rich waters, such as *Drepanocladus* spp. and *Scorpidium* spp.

/10 (ARC042) Dupontia fisheri – Carex aquatilis (Fisher's Tundra grass – Water Sedge Ecotype)

ARC042 is a widespread wetland association occurring in shallow freshwater or weakly brackish ponds and low-centered polygonal ground in coastal, lowland locations throughout all but the most northerly Arctic (Figure 18). It is characterized by a high cover of Fisher's tundra grass (*Dupontia fisheri*) and variable lower cover of other sedges such as cotton-grass (*Eriophorum* spp.) and water sedge (*Carex aquatilis*). There is commonly a high cover of "brown" mosses of the *genera Scorpidium, Drepanocladus* or *Campylium*, indicating relatively base-rich conditions. Other plant species may occur peripherally in ARC042 sites including arctic willow (*Salix arctica*), narrow-leaved cotton-grass (*Eriophorum angustifolium*), nodding saxifrage (*Saxifraga cernua*), yellow marsh saxifrage (*Saxifraga hirculus*) and long-stalked starwort (*Stellaria longipes*). Typical sites are level, poorly drained and shallowly flooded; standing water to 20 cm occurs for much of the growing season. The ground may have some patterning, with this association occurring in polygon centres or troughs, or having frost boils or hummocks. Soils can be a variety of textures from sandy to clayey, and are often Gleysolic Static Cryosols or Gleysolic Turbic Cryosols.

In the CHARS ERA and across SE Victoria Island, this ecosystem is not uncommon but of limited extent (Plots CB13006, 13JW003, 13WM001). Soils are peaty Gleysolic Static Cryosols with an active layer depth of 10–20 cm.

/11 (ARC009) Arctophila fulva (Pendant Grass Ecotype)

ARC009 is a widespread Low and Mid Arctic marsh association. This association can be from several square meters to tens of hectares in extent, but is generally limited in extent. It is found primarily at sea level but has been observed in the shallow in-filling lakes at higher elevations. This association also occurs at alpine elevations at lower latitudes. The rhizomatous pendant grass (*Arctophila fulva*) is the dominant and sometimes only plant species, giving the wetland a characteristic red cast (Figure 19). These wetlands are flooded and open shallow water may make up to 50% cover. Other emergents, such as mare's-tail (*Hippuris tetraphylla, H. vulgaris, or H. lanceolata*), Sheuchzer's cotton-grass (*Eriophorum scheuchzeri*) water sedge (*Carex aquatilis*), and marsh ragwort (*Tephroseris palustris*) may be present at low cover. Low cover of aquatic *Ranunculus* spp. or submerged mosses such as *Drepanocladus* spp. may occur.

The ARC009 occurs in deep waters along lake margins and in shallow ponds up to 1.5 m in depth, where the soil profile is completely saturated and permafrost is often very deep. Soils are typically Gleyed Regosols with soft, mucky organic surface horizons. Wave action and water circulation, however limited, limits peat accumulation and results in relatively high nutrient availability. No sub-associations are recognized. This ecotype may occur in slightly brackish waters in coastal locations.

In the CHARS ERA and across SE Victoria Island, this ecosystem was observed in slow flowing streams as well as small ponds. (Plots CB13013, CB13014). In some portions of pond sites, *Hippuris lanceolata* is more abundant than *Arctophila*. Soils are very poorly drained, Rego Humic Gleysols, with soft, mucky surfaces and no permafrost evident.

Marine Shore Ecoystems:

Given its position inland, the CHARS ERA does not include any marine Shore Ecotypes – they are included here to provide a more comprehensive synopsis of terrestrial ecosystems in the CHARS area.

/12(ARC024) Carex subspathacea (Hoppner's Sedge Ecotype)

ARC024 is a widespread circumpolar Low and Mid Arctic association restricted to protected coastal flats and depressions that experience occasional salt water flooding and extensive goose grazing (Figure 20). Hoppner's sedge (*Carex subspathacea*) forms a dense to sparse turf. Common associates include salt marsh starwort (*Stellaria humifusa*) and coast silverweed (*Potentilla anserina*). Other saline tolerant species may occur on some sites, sometimes with significant cover. Some of these species are creeping alkaligrass (*Puccinellia phryganodes*), tussock alkaligrass (*P. vaginata*), Fisher's tundra grass (*Dupontia fisheri*), lesser saltmarsh sedge (*Carex glareosa*), bear sedge (*C. ursina*), scurvy-grass (*Cochlearia groenlandica*), circumpolar reedgrass (*Calamagrostis deschampsioides*), or arctic daisy (*Arctanthemum arcticum*) may occur with lower cover. ARC024 occurs on imperfectly drained, fine textured sediments in saline marshes of estuaries and the margins of brackish lagoons. Sites remain wet throughout the growing season but are flooded only occasionally (description from MacKenzie, 2014).

In the CHARS ERA and across SE Victoria Island, this type occurs in complex with the creeping alkali grass (ARC053), which occurs in lower portions of sites (Plot CB13023, 13WM100)..


Figure 17. Ecosite 09 (ARC019), dominated by Carex aquatilis*.*

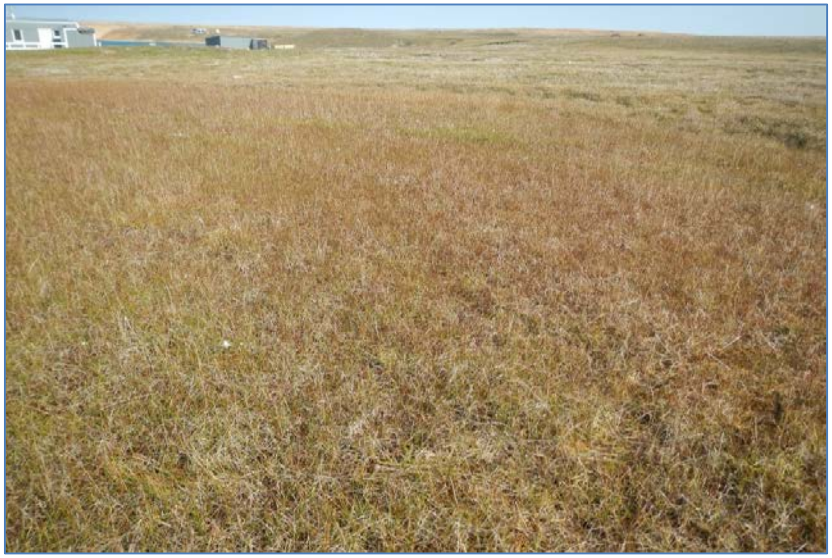


Figure 18. Ecosite 10 (ARC042). Note the slightly rusty colour of Dupontia fisheri *in this ecosystem.*


Figure 19. Ecosite 11 (ARC009), with Arctophila fulva *dominating this example.*


Figure 20. Ecosite 12. Carex subspathacea *is reddish,* Puccinellia phryganodes *green, while* Stellaria humifusa *is the white-flowered herb.*

/13 (ARC049) Leymus mollis (Dune Wildrye Ecotype)

ARC049 is a Low Arctic shorezone association occurring on well-drained supratidal sand and pebble beaches and dunes (Figure 21). Dune wildrye (*Leymus mollis ssp. villosissimus*) occurs with discontinuous cover (mean cover is less than 20%). In more exposed sites few other species will occur but on stabilized sites, tundra species such as arctic willow (*Salix arctica*), three-leaved Saxifrage (*Saxifraga tricuspidata*), arctic lupine (*Lupinus arcticus*), and others may occur. Dune wildrye binds mobile substrates and is tolerant of saltspray and wind. Most exposed ARC049 locations have abundant exposed sand/pebbles and driftwood is common.

On SE Victoria Island, this type is common on gravelly beaches (Plot 13WM104) where secondary species include river beauty (*Chamerion latifolium*) or sea bluebells (*Mertensia maritima*).

/14 (ARC048) Honkeya peploides (Seabeach Sandwort Ecotype)

ARC048 is a circumpolar Low Arctic association occurring on sandy and pebbly beaches exposed to highest tide saltwater flooding and salt spray (Figure 22). Vegetation cover is generally sparse, characterized by patchy clumps of seabeach sandwort (*Honckenya peploides*) sometimes with the scattered presence of other dune or shorezone species such as dune wildrye (*Leymus mollis*) or sea bluebells (*Mertensia maritima*).

On SE Victoria Island, a sandy beach site dominated by *Mertensia maritima* was sampled (13WM105). This type is known from other parts of the arctic but is infrequent and rarely sampled. Currently these communities are included within the ARC048 association as a subassociation but it may represent a distinct association.

Figure 21. Ecosite 13 (ARC049). Note the brightly coloured flowers of Chamenerion latifolium.

Figure 22. Ecosite 14 (ARC048). Mertensia maritima *is the teal-coloured plant in the middle of the photo.*

Figure 23. Chamerion latifolium dominating along stream bank.

Figure 24. Ranunculus gmelinii community.

Other Vegetation Types

Several other types of ecosystem have been observed by data is limited at this time.

Rock outcrops

The driest ecosystem type on the ecogrid, the rocky outcrop type occurs on exposed, continuous bedrock (part of the Felsenmeer geomorphological complex), with very little or no snow cover in the winter, and very little vegetation. Because the carbonate-dominant bedrock of the region is prone to solution weathering and frost-shattering, continuous, exposed bedrock is limited. This ecosystem type is therefore very rare around Cambridge Bay and no plots or national classification currently exist.

(ARC069) Chamerion latifolium – Salix arctica (River Beauty Ecotype)

ARC069 is a High Arctic association occurring on well-watered gravel along small rivulets (Figure 23). Vascular and non-vascular cover is typically low but always dominated by river beauty (*Chamerion latifolium*). Other species common to high arctic tundra such as purple mountain saxifrage (*Saxifraga oppositifolia*) and arctic willow *(Salix arctica*) are common associates. Soils contain gravel-rich fluvial or talus deposits, typically with little fine-grained material. This ecosystem is visually distinctive in the landscape by the stature and colours of the river beauty. It is widespread but generally of very limited extent, occupying only a narrow riparian fringe (description from MacKenzie, 2011).

On SE Victoria Island, this type has not been sampled but was observed on a variety of sandy and gravelly sites such as marine sands and raised beach ridges that are very well drained but have subsurface seepage.

Ranunculus gmelinii riparian community.

This is a riparian ecosystem, occurring on pond and stream shores in seasonally flooded areas (Figure 24). The soil moisture regime and snow exposure conditions are similar to ecosystem /08, but tall vegetation is lacking. Characteristic plants are moss species and Gmelin's water crowfoot, *Ranunculus gmelinii,* a small aquatic buttercup species.

Vascular Plants of Eastern Victoria Island and Adjacent Mainland Nunavut: Results of Field Studies, Summer 2014

Bruce Bennett[8]

Introduction

This report provides an overview of the studies conducted in the summer of 2014 on the vegetation of eastern Victoria Island and adjacent mainland Nunavut. The following studies were conducted to provide an understanding of the ecology of the greater Canadian High Arctic Research Station (CHARS) research area and to set the stage for future work to support research at the CHARS at Cambridge Bay, Nunavut. This report integrates and builds on McLennan et al.'s (2014) findings on the ecology and biodiversity specific to the Cambridge Bay area in an attempt to classify and map the tundra ecological communities over an area covering eastern Victoria Island and adjacent mainland Nunavut, representing a significant portion of the CHARS Greater Ecosystem.

This work involved an integrated team that surveyed the plants, arthropods, gastropods, geology, geomorphology, soils, vegetation and ecosystems. Field work for these surveys utilized ground, helicopter and airplane support on eastern Victoria Island, focusing on Cambridge Bay and the northern mainland Nunavut around Bathurst Inlet and the Kent Peninsula as far east as White Bear Point (Figure 25).

Cambridge Bay is situated on the southern coast on the southeast corner of Victoria Island. During the 2013 field survey (July 12-20), an attempt was made to collect a complete set of all species of vascular plants found in the CHARS ERA and in other accessible areas near Cambridge Bay to form a core collection at the Canadian High Arctic Research Centre (CHARS). McLennan et al. (2014) documents the results including 151 taxa known for the region. Since then the review of collections has added two species not previously reported (*Draba juvenilis*, and *Potentilla tikhomirovii*). In 2014, more far-reaching surveys were completed as part of the Terrestrial Ecosystem Mapping exercise (Figure 25, Figure 26). A total of 274 individual collections (many with duplicates; Table 4) were made from 61 sites over seven days, including 61 taxa not found during the previous work in the vicinity of Cambridge Bay. Newly discovered species and noteworthy records are discussed. No non-native plants were seen. Species of potential conservation concern in Nunavut are discussed.

Preservation of Collections

The Canadian Museum of Nature (CAN) houses many of the existing collections from historical and recent inventories (CMN 2013). Any taxa (species and subspecies) newly discovered have been sent to CAN including any non-vascular plants and lichens. A representative of each species has been retained to be used to initiate a herbarium at the Canadian High Arctic Research Station. Many of the additional duplicates have been retained by B.A. Bennett Herbarium, Yukon (BABY), or sent to herbaria of the University of British Columbia (UBC), University of Alaska, Fairbanks (ALA), and the Department of Agri-food and Agriculture (DAO). Additional specimens were sent to specialists for confirmation including,

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Draba spp. to Dr. G.A. Mulligan (DAO); Brassicaceae to Dr. I.A. Al-Shehbaz, Missouri Botanical Garden (MO); *Carex* spp. to Dr. A.A. Reznicek Michigan State University Herbarium (MICH); *Puccinellia* spp. To

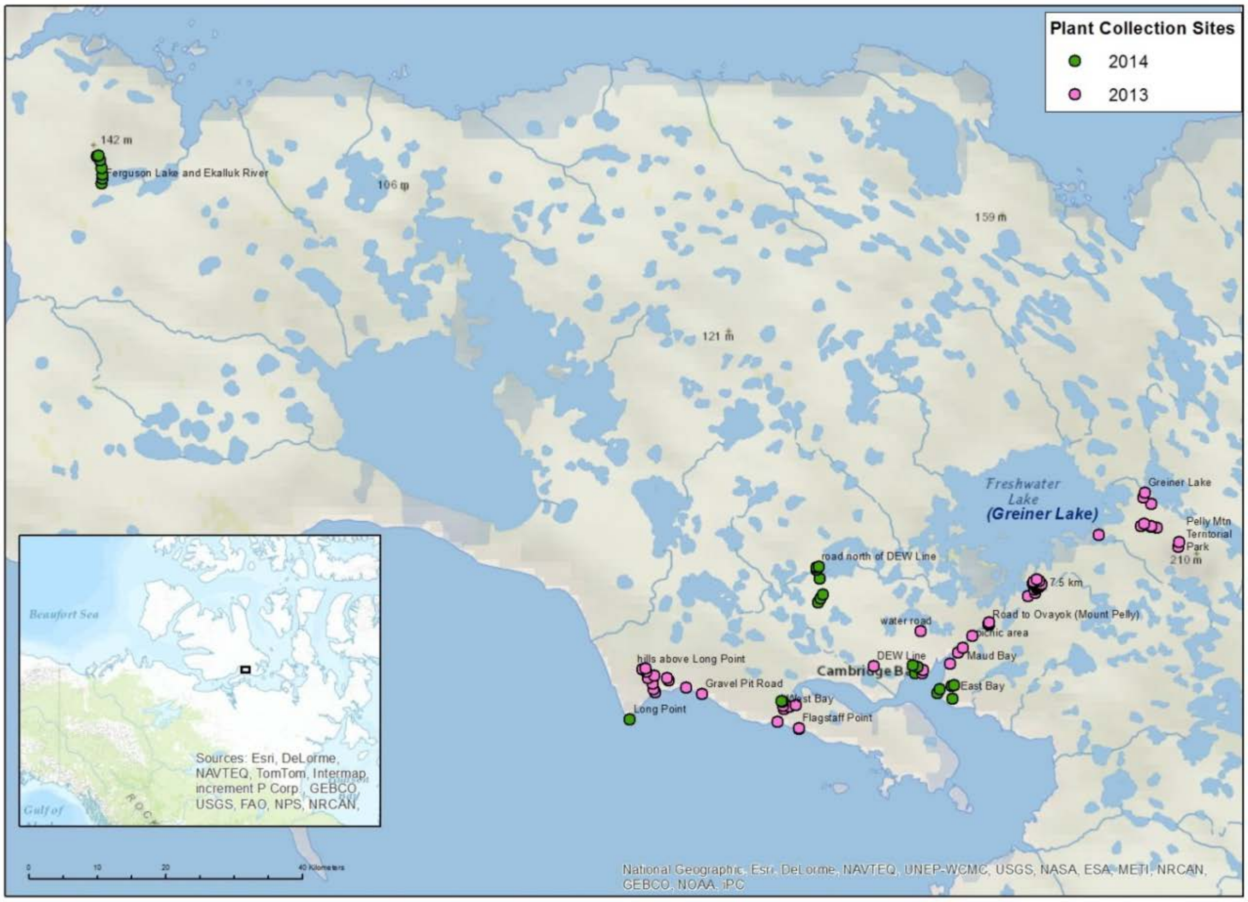

Figure 25. Sites on southeast Victoria Island where plant collections were made or photographed.

Dr. J.M. Saarela (CAN); *Potentilla* spp. Dr. D.F. Murray (ALA); Fabaceae Dr. S.L. Welsh, Brigham Young University (BRY); *Festuca* spp. Dr. M. Dubé, Université de Moncton; and *Castilleja* spp. M. Egger, Washington State University (WTU).

In addition to vascular plants, invertebrate species, including spiders and butterflies, were collected.

Species of Conservation Concern

Nunavut is the only jurisdiction in North America without a Conservation Data Centre or equivalent (http://www.natureserve.org/natureserve-network) and as such it is difficult to get current information on the status of species of conservation concern and their associated territorial status. Every five years since 2000, *Wild Species* reports are produced to provide an overview on which species occur in Canada, in which provinces, territories they occur, and to assess their conservation status (CESCC 2011). Vascular Plants were assessed in their entirety for the first time in 2010.

The following species are considered of conservation concern globally (G or Global rank) that are known or expected within the region. Porsild's Fleabane, *Erigeron porsildii* (G3G4); Pygmy Aster, *Symphyotrichum pygmaeum* (G2G4); Edlund's Fescue, *Festuca edlundiae* (G3G4); High Arctic Fescue, *Festuca hyperborea* (G3G4Q); Soft Fissurewort, *Transberingia bursifolia* (G3?); Drummond's Bluebells, *Mertensia drummondii* (G2G3); Arctic Flase Wallflower, *Parrya arctica* (G3); Hartz's Bluegrass, *Poa hartzii* (G3G4); Banks Island Alkali Grass, *Puccinellia banksiensis* (G1G2). The rank values are as follows: G1 critically imperilled, G2 imperilled, G3 vulnerable, G4 apparently secure, Q questionable taxonomy, ? inexact numeric rank. Additional comments have been added to discuss local abundance.

Non-native and Invasive Species

Many of the new discoveries of plants in northern areas are due to additional survey efforts, however plants and animals are also known to be expanding their range northwards (*e.g*., Beckett, 1959; Carlson and Shephard 2007). During surveys in 2013 and 2014, no plant species that are not native to Canada were found. This is consistent with other recent surveys, which similarly encountered no introduced plants (CMN 2013; Pagacz pers. comm. 2015). Gillespie (pers. comm. 2015) reports that the only introduced species that she has encountered on the arctic islands is Foxtail Barley, *Hordeum jubatum*, which although native throughout most of its range, has been introduced on Baffin Island.

Only 16 non-native plant species have been reported in Nunavut. Besides Foxtail Barley CESCC 2011 reported the following 14 specie (Green Amaranth, *Amaranthus retroflexus*; Wild Caraway, *Carum carvi*; Oxeye Daisy, *Leucanthemum vulgare*; Field Sow Thistle, *Sonchus arvensis*; Common Dandelion, *Taraxacum officinale*; Yellow Rocket, *Barbarea vulgaris*; Shepherd's Purse, *Capsella bursa-pastoris*; Field Pennycress, *Thlaspi arvense*; Tufted Vetch, *Vicia cracca*; Opium Poppy, *Papaver somniferum*; Common Plantain, *Plantago major*; Common Barley, *Hordeum vulgare*; Spreading Alkali Grass, *Puccinellia distans*; Prostrate Knotweed, *Polygonum aviculare*;). In addition, Alfalfa, *Medicago sativa* has been collected from Rankin Inlet on the Kudlulik Peninsula from abandoned settlement grounds of the Keewatin Rehabilitation Centre at Itivia CAN587981 (CMN 2015).

Five of the species listed above were reported from Nunavut only from the most southerly island of Akimiski, in James Bay. These include Wild Caraway, Oxeye Daisy, Field Sow Thistle, Common Dandelion, and Common Plantain (Blaney and Kotanen 2001). Tufted Vetch was reported as occurring on Charlton Island, James Bay - collected by Porsild in July 1929 - with a specimen at CAN77738 (Anions pers. comm. 2015). Prostrate Knotweed has been collected from Rankin Inlet CAN587976 (Saarela pers. comm. 2015; CMN 2015). The presence of Opium Poppy is bases on a single isolated plant on hillside in Iqaluit, just coming into bud, Aiken & McCulloch 89-130, 1989 CAN541800 (CMN 2015). It is unknown if this species still persists. Green Amaranth was reported by Mosyakin and Robertson (2003) for the Flora of North

America treatment, however no collections are known (Anions pers. comm. 2015). The reports of Shepherd's Purse based upon NatureServe (Kartesz 1999) who lists it as present on many NU islands without reference. Yellow Rocket was falsely reported (Kartesz 1999) who cites Scoggan (1978) for Keewatin; however Scoggan only lists "as known from all provinces except SK".

Spreading Alkali Grass has been reported as present in Nunavut (Kartesz 1999) based upon Boivin (1967). However Boivin included Nuttall's Alkali Grass, *Puccinellia nuttalliana* within a broader concept of *P. distans*, so the introduced element may not be currently present.

No introduced species are listed for the Canadian Arctic Archipelago (Aiken et al. 2007) or for the arctic areas of Yukon and Alaska (Bennett 2008; AKEPIC 2014). Introduced species would be expected to originate from other arctic regions (Fridley 2013).

Plant Species Accounts

During the surveys of 2013-2014, 219 taxa have now been identified, an increase of 74 from the previous report. Two species, not seen in the vicinity of the Cambridge Bay road system during the 2013 survey, have been added to the list (i.e., *Silene involucrata*, *Draba juvenilis*). Three sites were visited on Victoria Island outside the vicinity of Cambridge Bay (Figure 2). Eleven species not seen in the vicinity of Cambridge Bay were found on Victoria Island. Most of these were collected near Ferguson Lake and Ekalluk River (Figure 1) where a basaltic intrusion of bedrock allowed for a greater diversity of acidic loving plants and a notable local increase in ericaceous shrubs. The remaining 45 plants newly added to the list were from the seven mainland sites visited which included Bathurst River, White Bear Point, Bicha Lake, Hope Bay, Umingmaktok (Bay Chimo), and two sites on the Kent Peninsula (Figure 2). Most of these were to be expected given the known range of the species, however some range extensions and infills of species distribution are reported.

New Reports

Northern Firmoss, *Huperzia selago* is very rare on Victoria Island and was only seen and collected once on the island near Ferguson Lake and Ekalluk River. The soil here is more acidic than most other sites visited, with ericaceous shrubs more commonly found. This collection is a range extension of almost 200 km ENE of an unnamed lake, ca. 18 km ENE of Johansen Bay airstrip (Thannheiser et al. 2001; CAN 592257, CMN 2013). The only other collection known from Victoria Island is in the vicinity of Holman on the west coast, approximately 500 km to the northwest (Aiken et al. 2007). Aiken et al. (2007) shows the distribution to be apparently more widespread on the mainland. It was only collected at one other site just west of Hope Bay but was also recorded at White Bear Point and Burnside River. This is an infill of the distribution presented by Aiken et al. (2007). However Brouillet et al. (2015) recognize Arctic Firmoss, *Huperzia arctica* (Tolm.) Siplivinsky which may represent some or all of the plants seen.

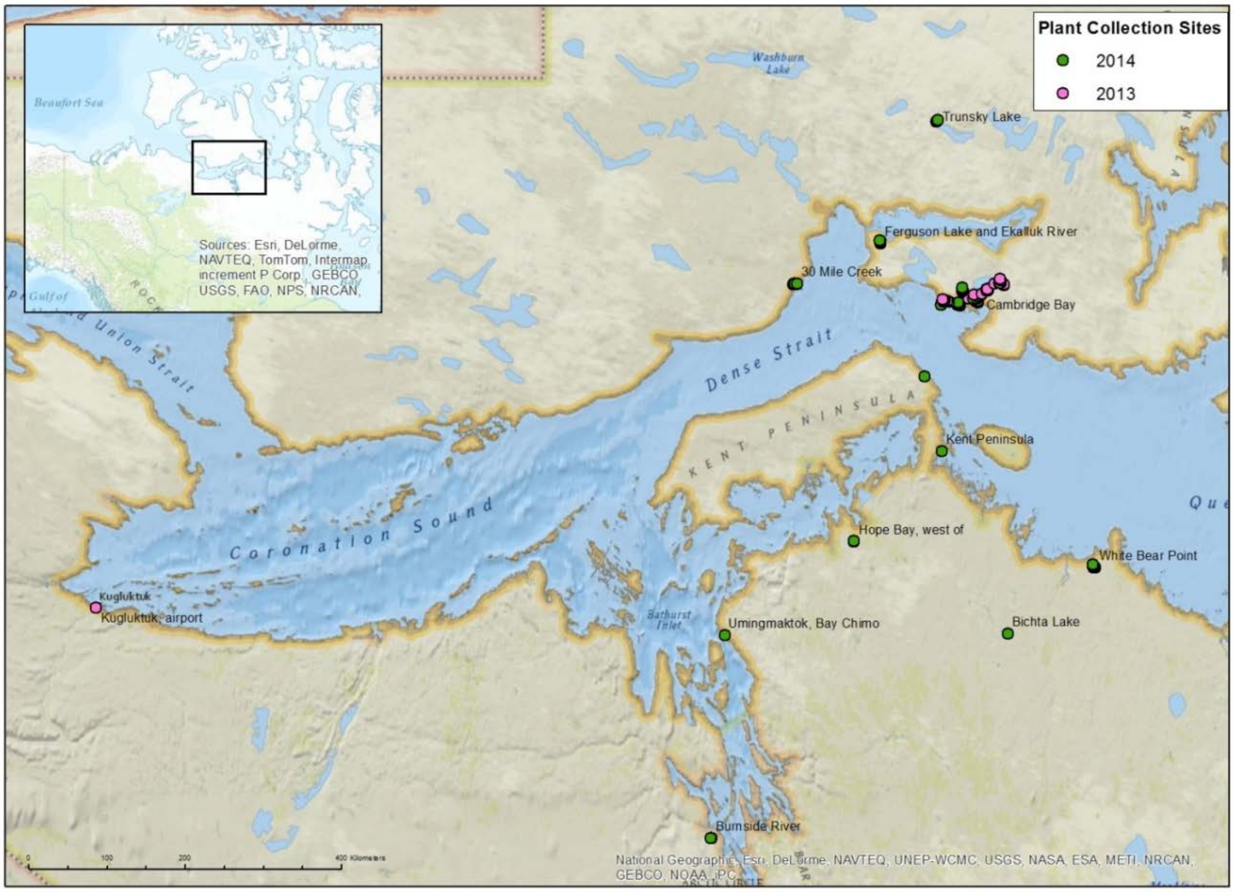

Figure 26. Sites on Victoria Island and adjacent mainland where plant collections were made or photographed.

Fragrant Fern, *Dryopteris fragrans*, was previously reported to have been collected north of Cambridge Bay (Aiken et al. 2007). Though the exact locality of the collection (reported from CAN or DAO) is unknown, it appears to be in the vicinity of Ekalluktok Lake. Additional collections are reported along the south coast in the vicinity of Johansen Bay, Surrey Lake, and Holman (Thannheiser et al. 2001; CMN 2013). This species was not seen on Victoria Island during either surveys, however it was collected west of Hope Bay on the mainland which is a slight range extension of its known distribution (Aiken et al. 2007). It was also seen and collected along the Bathurst River which is well within its known distribution.

Field Horsetail, *Equisetum arvense*, has previously been reported in the vicinity of Cambridge Bay (Thannheiser et al. 2001; Aiken et al. 2007); however it was only seen twice with the largest occurrence near the Angustus Hills adjacent to Long Point. Though it is apparently rare in the vicinity of Cambridge Bay, it is reported to be more common in western Victoria Island (CMN 2013) and was seen and collected from near Ferguson Lake and Ekalluk River and Trunsky Lake but was also found to be common on the mainland and was seen at all sites except White Bear Point.

Seaside Arrowgrass, *Triglochin maritima* was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously in Porsild and Cody (1980). This species is not reported as occurring in the Canadian Arctic Archipelago (Aiken et al. 2007; CMN 2013).

Marsh Arrowgrass, *Triglochin palustris* was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously by Cody et al. (1984). This was at that time a range extension of 400 km eastwards from the east end of Great Bear Lake previously reported in Porsild and Cody (1980) and the only other known locality near to this collection. This species is not reported as occurring in the Canadian Arctic Archipelago (Aiken et al. 2007; CMN 2013).

Alpine Sweet Grass, *Anthoxanthum monticola* subsp. *alpinum* (*Hierochloë alpina* subsp. *alpina*) was seen but not collected near Hope Bay and White Bear Point. These were the only times this species was encountered during the two years of surveys. It was reported from the vicinity of Cambridge Bay (Aiken et al. 2007). The exact locality of the collection (reported from CAN or DAO) is unknown. It has also been reported from the vicinity of Holman (Aiken et al. 2007) and from the vicinity of Johansen Bay (CMN 2013).

Alpine Sweet Grass, *Anthoxanthum monticola* subsp. *monticola* was seen and collected twice from a single site in the vicinity of Ferguson Lake and the Ekalluk River. This is a major range extension; currently the nearest known site for this subspecies is on the eastern side of Hudson Bay (Allred & Barkworth 2007). This subspecies was not reported as occurring in the Canadian Arctic Archipelago (Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013).

Pumpelly's Brome, *Bromus pumpellianus* was seen and collected from Kugluktuk airport and Burnside River; which is at the edge of the species known distribution (Pavlick & Anderton 2007). This species is not reported from the Canadian Arctic Archipelago in (Aiken et al. 2007) and no new collections were reported by CMN (2013); however Pavlick & Anderton (2007) show a single collection on Victoria Island in the vicinity of Cape Baring, NWT at the western end of the Wollaston Peninsula.

Langsdorff’s Reed Grass, *Calamagrostis canadensis* ssp. *langsdorfii*, in the study area, has only been reported from Bathurst Inlet (Porsild & Cody 1980; Aiken et al. 2007) where it was found and collected along the Burnside River.

Lapland Reed Grass, *Calamagrostis lapponica*, has not been reported from Victoria Island (Porsild & Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013). It was seen but not collected from a site west of Hope Bay which is a range extension of about 50 km northeast of sites in Bathurst Inlet (Aiken et al. 2007).

Purple Reed Grass, *Calamagrostis purpurascens* is known from the western portion of Victoria Island, the closest being Victoria Island, West end of Johansen Bay at mouth of Mackenzie Creek (CMN 2013). During the two years of surveys, it was seen and collected only once from the Burnside River in Bathurst Inlet.

Tufted Hair Grass, *Deschampsia caespitosa* was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously by Cody et al. (1984). This was at that time a range extension of 300 km eastwards from the vicinity of Kugluktuk previously reported in Porsild and Cody (1980). This species was not reported from the Canadian Arctic Archipelago (Aiken et al. 2007; CMN 2013) and remains rare in the region.

Alaska Wild Rye, *Elymus alaskanus*, was collected in the vicinity of Cambridge Bay (Aiken et al. 2007). The exact locality of the collection (reported from CAN or DAO) is unknown. The species was frequently collected in southwestern Victoria Island, the closest being in the vicinity of the Sinclair Creek abandoned DEW-line site, approximately 160 km west of Cambridge Bay (CMN 2013). It is also known from the Kent Peninsula on the mainland adjacent, only 35 km SW of Cambridge Bay across Dease Strait, where it was collected in 1926 (CAN 203086; Hore 1512). During the survey it was collected once, at Umingmaktok. It was also photographed but not collected along the Burnside River. This is the first time this species have been reported from Bathurst Inlet, an infill of a scattered distribution.

Richardson's Fescue, *Festuca richardsonii* (*F. rubra* subsp. *arctica*; *F. rubra* subsp. *richardsonii*), was previously reported from Cambridge Bay (Thannheiser et al. 2001; McLennan et al. 2014). It is reported on Victoria Island as far east as the eastern end of Prince Albert Sound and Holman to the west (Aiken et al. 2007). It was collected a number of times from the southwestern coast of Victoria Island (CMN 2013), the closest being in the vicinity of Murray Point on the west side of Wilbank Bay, approximately 220 km WSW of Cambridge Bay. In 2013 it was collected on the Angustus Hills north of Long Point near Cambridge Bay (McLelland et al. 2014). It was collected twice in 2014, again from Long Point, and from the Burnside River in Bathurst Inlet where it has previously been reported by Porsild and Cody (1980). This major race of *Festuca rubra* can be differentiated from other fescue species by its creeping habitat and pubescent lemmas. The correct name as subspecies is undecided. The majority of authors apply subsp. *arctica* (Hack.) Govor. (e.g., Russian authors; Soreng et al. 2003; Darbyshire and Pavlick 2007). For a more complete discussion see Elven (2007). Specimens have been shared with Dr. Marten Dubé for further research.

Alpine Blue Grass, *Poa alpina* has been reported from Victoria Island in the vicinity of Prince Albert Sound (CAN 499520) and from Johansen Bay and Surrey Lake (Thannheiser et al. 2001). It was not collected on recent surveys by botanists with the Canadian Museum of Nature (CMN 2013) and was not seen on Victoria Island in either 2013 or 2014. It was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously by Cody et al. (1984). This was at that time a range extension of 400 km eastwards from the east end of Great Bear Lake previously reported in Porsild and Cody (1980) and the only other known locality near to this collection on the mainland.

Alkali Grass, *Puccinellia* spp. Several species of *Puccinellia* were collected and await further identification. *Puccinellia* is currently the largest Arctic grass genus and have a long history of taxonomic uncertainty and plants that are often difficult to identify. Seven species have been reported from the vicinity of Cambridge Bay (Aiken et al. 2007; CMN 2013), but at the time of this report, only *P. nuttalliana* and *P. phryganodes* have been positively identified. For more discussion on species of Alkali Grass from Cambridge Bay see Consaul et al. (2005).

Two-coloured Sedge, *Carex bicolor*, was not previously reported from Victoria Island, though it is known from Baffin, Coates, and South Hampton islands (Aiken et al. 2007); however there was a collection made at the west end of Johansen Bay at the mouth of Mackenzie Creek (Gillespie et al. CAN592505; CMN 2013) approximately 260 km west of Cambridge Bay. The closest sites are from across Coronation Gulf in Bathurst Inlet area 160 km to the southwest (Aiken et al. 2007). In 2013, it was seen and collected only once from 7.5 km along the road to Ovayok (Mount Pelly). It was growing in a *Carex aquatilis* fen surrounded by *Dryas integrifolia* / *Salix arctica* tundra with *Salix richardsonii, Saxifraga hirculus, Kobresia simpliciuscula*, and *Carex lachenalii*. Specimens were sent to the CAN for confirmation. Plant material was sampled and sent to the Canadian Centre for DNA Barcoding (CCDB) http://ccdb.ca/ to help with confirmation. In 2014, plants were seen and photographed at White Bear Point (Figure 27) a range extension of over 200 kilometres from sites in Bathurst Inlet.

Figure 27. Two-coloured Sedge (Carex bicolor), White Bear Point (photo B. Bennett).

Bigelow's Sedge, *Carex bigelowii* subsp. *bigelowii* was not reported as occurring on Victoria Island by Porsild and Cody (1980) or Aiken et al. (2007); however a single collection of this subspecies has been reported on western Victoria Island, from the head of Minto Inlet (CMN 2013). Thannheiser et al. (2001) reports widespread collections of this species from Holman, Johansen Bay, Hadley Bay, Wellington Bay, and Cambridge Bay. These collections should be reviewed to ensure the same species concept is being applied. Collections from White Bear Point and Bichta Lake have been given this name bearing further research. There remains a lot of disagreement about the arrangement of the *Carex bigelowii* complex which has been separated in the in the Flora of North America Treatment (Strandley et al. 2002) into subspecies bigelowii and subspecies lugens. Elven and Schönswetter note (in Elven 2007) are reluctant to accept a combination of the Atlantic and Beringian regions as the same species or subspecies. Being most familiar with the Beringian races of this complex (i.e., *Carex consimilis, Carex lugens, Carex bigelowii*) I agree that the plants do not closely resemble those taxa, but come closest to the Alaskan *C. bigelowii*. These collections would be a range extension of about 170 km removed from sites in Bathurst Inlet (Porsild and Cody 1980); however are within the distribution given by Aiken et al. (2007).

Creeping Sedge, *Carex chordorrhiza* has been reported twice from Victoria Island, "near lake edge one mile northeast" of Cambridge Bay (CAN 273517) and west end of Tahoe Lake (CAN 127543). Though targeted efforts were made to rediscover this species near Cambridge Bay, this species was not seen again on Victoria Island during the 2013 and 2014 surveys and was no other reports are known (Thannheiser et al. 2001; CMN 2013). Young plants were seen and collected once on the mainland at White Bear Point which is well within the known distribution.

Garber’s Sedge, *Carex garberi* was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously by Cody et al. (1984). This was at that time a range extension of 400 km eastwards from the east end of Great Bear Lake previously reported in Porsild and Cody (1980) and the only other known locality near to this collection. This species was not currently reported from the Canadian Arctic Archipelago (Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013).

Krause's Sedge, *Carex krausei* has been collected on western Victoria Island from the vicinity of Holmen and Minto Inlet (Aiken et al. 2007; CMN 2013). It was collected only once near White Bear Point, which is a range extension of about 220 km northeast of a single collection in Bathurst Inlet (Aiken et al. 2007). It was also seen but not collected at Hope Bay, which would be a range extension of 145 km.

Mackenzie's Sedge, *Carex mackenziei* was seen and collected only once from the Burnside River, close to Bathurst Inlet. This is a major range extension of 1,200 km midway between populations in the Mackenzie Delta and those in Hudson Bay. This species was not currently reported from the Canadian Arctic Archipelago (Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013). It is a species of coastal and estuarine marshes, mostly brackish soils, and seashores. Porsild and Cody (1980) report a site near Arviat, NU and is listed as May Be At Risk for Nunavut (CESCC 2011).

Nard Sedge, *Carex nardina* has previously been reported from western Victoria Island, mainly in Northwest Territories (Porsild & Cody 1980; Aiken et al. 2007; CMN 2013). The collection made near Ferguson Lake and Ekalluk River was a range extension of 220 kilometres from Mount Bumpus on the Wollaston Peninsula. Thannheiser et al. (2001) reports collections of this species in Wellington Bay, Cambridge Bay and Mount Pelly.

Rock Dwelling Sedge, *Carex petricosa,* was previously reported from the far western NWT region of Victoria Island in the vicinity of Holman (Thannheiser et al. 2001) and Berkeley Point (Aiken et al. 2007) and recently near Boot and Minto inlets, and near Fish Lake on the Kuujjua River (CMN 2013) in the same region. So this collection is the first reported from the Nunavut portion of Victoria Island. This is an Amphi-Beringian species so this collection was the furthest east this species has been reported. It matches variety *petricosa*, having three stigmas, and more closely resembles *C. petricosa* than the Beringian *C. franklinii* (of AK, NT, YT) which usually grows in drier habitats. In 2013, it was seen only in the vicinity of Ovayok (Mount Pelly) Territorial Park approximately 15 km east of the community of Cambridge Bay (where it was photographed). In 2014 is was collected at two additional site, 30 Mile River, and near Ferguson Lake and Ekalluk River. Rock Dwelling Sedge was reported as rare in the Canadian Arctic (McJannet et al. 1993).

Beautiful Cottongrass, *Eriophorum callitrix*, has previously been reported from Cambridge Bay (Porsild and Cody 1980; Aiken et al. 2007). It was seen only once and photographed but not collected within Ovayok (Mount Pelly) Territorial Park, on the lower slopes in the center of the circular road near the parking area. It has been collected from several sites throughout the island (Thannheiser et al. 2001; CMN 2013) but is apparently rare in the vicinity of Cambridge Bay. In 2014, it was collected twice more, from 30 Mile River and Trunsky Lake.

Tall Cottongrass, *Eriophorum triste* (*Eriophorum angustifolium* ssp. *triste*) has been recognized as a full species and as a subspecies of angustifolium. It was considered a synonym of *E. angustifolium* by (Aiken et al. 2007); however following Cody (2000) I have recognized this as a full species. I have never seen mixed populations, or integrades. Porsild and Cody (1980) report a collection in the vicinity of Cambridge Bay, however I have been unable to locate any specimens and in the two survey years, I have not found it there. It was seen and collected in 2014 from Trunsky Lake, which is a range extension of about 115 km south of a previous collection from Namaycush Lake (CAN 524325).

Tussock Cottongrass, *Eriophorum vaginatum* ssp. *vaginatum*, has previously been reported from Cambridge Bay (Porsild and Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007). It was seen only once near the Angustus Hills in the vicinity of Long Point. It has been collected from a few sites primarily from western Victoria Island (Thannheiser et al. 2001; CMN 2013) but is apparently rare in the vicinity of Cambridge Bay. In 2014, it was seen but not collected near Ferguson Lake and Ekalluk River as no mature flower heads were found. It was collected from White Bear Point where it was recorded as occasional, again with few plants flowering.

Arctic Rush, *Juncus arcticus*, was seen and photographed but not collected on the west side of town on both sides of Mitik Street near the fish packing plant. It was previously found ~0.25 km west of town on the way to the airport (CAN592323; CMN 2013). Arctic Rush was not reported as occurring on Victoria Island by Porsild and Cody (1980) or Aiken et al. (2007), but was collected at several sites throughout western Victoria Island in both the Nunavut and NWT regions (Thannheiser et al. 2001). It was also photographed by Dr. Johann Wagner (Wagner pers. comm. 2013). In 2014, it was collected in Cambridge Bay, west of town and along 30 Mile River. It was also collected at mainland sites of Kugluktuk airport, Umingmaktok, and Burnside River. All are within the range of the species reported by Aiken et al. (2007).

Chestnut Rush, *Juncus castaneus,* has previously been reported from Cambridge Bay (Porsild and Cody 1980; Aiken et al. 2007). The details of the Porsild and Cody collection are unknown as is the report by Thannheiser et al. (2001); however a collection was made on the west side of the lake behind the D-train at the DEW-line station (CAN 526629). The Canadian Museum of Nature (2013) surveys report collections from Murray Point, on the west side of Wilbank Bay 220 km WSW of Cambridge Bay. This species was only seen once during surveys in 2013 and 2014, from the mainland at the Burnside River.

Arctic Woodrush, *Luzula arctica* (*L. nivalis*), has previously been reported from Cambridge Bay (Porsild and Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007). Several collections have been recently made on the south coast and western portion of Victoria Island (CMN 2013) the closest being near an unnamed lake NE of Johansen Bay, approximately 230 km WSW of Cambridge Bay. Two additional collections were made in 2014 at 30 Mile River and Trunsky Lake. Even with up to 20 sites reported on Victoria Island, this species still in quite uncommon to rare.

Northern Woodrush, *Luzula confusa*, has previously been reported from Cambridge Bay (Porsild and Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007). In 2013, it was seen twice and photographed but not collected within Ovayok (Mount Pelly) Territorial Park, and collected near the Angustus Hills in the vicinity of Long Point. In 2014, it was collected at three addition sites, at the road north of the DEW-line, near Ferguson Lake and Ekalluk River, and at White Bear Point. It is apparently rare in the vicinity of Cambridge Bay but may be more common that Arctic Woodrush.

Northern Tofieldia, *Tofieldia coccinea*, was previously only known from the western portion of Victoria Island near Holman and Winter Bay (Porsild and Cody 1980; Aiken et al. 2007). It is also reported from Minto Inlet and Johansen Bay (Thannheiser et al. 2001). In 2013, basal leaves and stalks with a single stem leaf were found at several sites on the west side of Ovayok, but not collected or photographed.

Small False Asphodel, *Tofieldia pusilla*, was previously only known from the western portion of Victoria Island near Holman and Winter Bay (Porsild and Cody 1980; Aiken et al. 2007). It is also reported from Surrey Lake, Minto Inlet, and Johansen Bay (Thannheiser et al. 2001). It was collected of on Ovayok (Mount Pelly) within the Territorial Park in 2010 (CAN592821; CMN 2013). It was seen but not collected at Mount Pelly in 2013. In 2014, it was seen and collected twice near Ferguson Lake & Ekalluk River, and west of Hope Bay, the first being an infill of its known range on southern Victoria Island and the second being a slight range extension of 75 km northeast of sites in Bathurst Inlet (Porsild and Cody 1980; Aiken et al. 2007).

Blunt-leaved Orchid, *Platanthera obtusata*, is not reported as occurring in the Canadian Arctic Archipelago (Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013). It was seen and collected only once from the Burnside River, in a region where it has previously been reported (Porsild and Cody 1980).

Alaska Willow, *Salix alaxensis*, is known from western and central Victoria Island, but not in the southeast, or in the vicinity of Cambridge Bay Bay (Porsild and Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013) even though this region is in the distribution shown by Argus (2007). It was seen and collected only once during the survey, from the Burnside River (Figure 4), in a region where it has previously been reported (Porsild and Cody 1980).

Alaska Bog Willow, *Salix fuscescens*, is known in the Arctic Islands only on Victoria Island, where it was collected at Long Lake by J.D.H. Lambert on 14 July 1964 (CAN52349; Aiken et al. 2007). The species was not collected during recent Canadian Museum of Nature surveys (CMN 2013). It was only seen on a single mainland site, White Bear Point, in a region where it has previously been reported (Porsild and Cody 1980). The distribution provided by Argus, which includes southern Victoria Island, is not supported by observations, and the Alaska Bog Willow remains a very rare species on the island.

Grey Willow, *Salix glauca* subsp. *stipulifera*, is based on a voucher specimen of *S. glauca* subsp. *callicarpaea* (Thannheiser, personal herbarium) from the vicinity of Cambridge Bay (Aiken et al. 2007). Thannheiser (pers. comm. 2015) reports that he has not seen this species in the vicinity of Cambridge Bay and it was not included in Thannheiser et al. (2001). Several collections have been made on the south coast of Victoria Island (CMN 2013), the closest being near an unnamed lake NE of Johansen Bay, approximately 230 km WSW of Cambridge Bay. Though not seen on Victoria Island during the surveys in 2013 and 2014, it was found and collected three times on the mainland Kugluktuk airport, Bichta Lake, and Burnside River (Figure 4) all are within the range given by Argus (2007).

Snowbed Willow, *Salix herbacea* has not been reported from Victoria Island (Porsild and Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007; Argus 2007; CMN 2013). It was seen and collected twice on the mainland at White Bear Point and Bicha River, both are within the known distribution (Porsild and Cody 1980; Aiken et al. 2007; Argus 2007).

Barrenground Willow, *Salix niphoclada*, is known from Victoria Island where widespread collections have been made to the west of Cambridge Bay (Aiken et al. 2007; CMN 2013), the closest to Cambridge Bay being near an unnamed lake NE of Johansen Bay, approximately 230 km WSW of Cambridge Bay. Though not seen on Victoria Island during the surveys in 2013 and 2014, it was found and collected once on a raised fox den at White Bear Point, which is within the range given by Argus (2007). It is expected to be found on calcareous, gravelly or sandy floodplains, terraces, eskers, and drumlins, or on fine, silty loess deposits. Its habitat may be wet to moderately well-drained.

Tea-leaved Willow, *Salix planifolia* was seen but not collected west of Hope Bay, at White Bear Point and on the Burnside River. These sites are north of the distribution shown in Porsild & Cody (1980), Aiken et al. (2007) and (Argus 2007) which all show the distribution of the willow to only reach the southern end of Bathurst Inlet.

Green Alder, *Alnus viridis* ssp. *crispa*, is not reported as occurring in the Canadian Arctic Archipelago (Porsild and Cody 1980; Furlow 1997; Aiken et al. 2007; CMN 2013). It was seen from the helicopter upriver of the Wilberforce Falls (67.0955 -108.7948) which are on the Hood River, that empties into Bathurst Inlet, Arctic Sound. The mouth of the Hood River is near Banks Peninsula where the most northerly report of species (a collection made by J.P. Kelsall and E.H. McEwen in 1950, CAN202788) is found. Green Alder was found to be common around Bathurst Inlet and was collected on the Burnside River (Figure 4). Bathurst Inlet is on the boundary of both subspecies *crispa* and *fruticosa* (Furlow 1997).

Shrub Birch, *Betula glandulosa*, was reported in the vicinity of Cambridge Bay at Long Lake (Aiken et al. 2007). The closest collection recently made by members of the Canadian Museum of Nature (2013) is near an unnamed lake NE of Johansen Bay, approximately 230 km WSW of Cambridge Bay (CAN593206; CAN 593207) at a site previously reported by Thannheiser et al. (2001). It was not seen during the survey on Victoria Island or on the Kent Peninsula, it was however common at all the other mainland sites but was only collected at White Bear Point. Hope Bay, Bichta Lake, and White Bear Point are all range extensions of 65, 120, 180 km east of previously reported sites, based on the distribution given in Porsild and Cody (1980) and Aiken et al. (2007), but fall within the distribution given in Furlow (1997).

Water Birch, *Betula occidentalis* was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously by Cody et al. (1984). This was at that time a range extension of 400 km eastwards from the east end of Great Bear Lake previously reported in Porsild and Cody (1980) and the only other known locality near to this collection. This is a species has not recently been identified as occurring in Nunavut (CESCC 2011) and although Furlow (1997) does not mention Nunavut in the distribution, the text predates the separation of the territory from the Northwest Territories in 1999. The distribution given in Furlow (1997) does not extend as far north as Bathurst Inlet. This collection confirms it continuing existence in the territory and is a 300 km range extension northwards (Figure 28).

Figure 28. Burnside River with shrubs dominated by Green Alder, Grey Willow, and Alaska Willow. The tall shrub on the right is Water Birch (photo B. Bennett)

Horned Sea-blite, *Suaeda calceoliformis* was not included in the Flora of the Canadian Arctic Archipelago (Aiken et al. 2007). It was however reported from the Richardson Islands on the south coast of Victoria Island by Thannheiser et al. (2001). Several collections have been made on the south coast of Victoria Island and at Boot and Minto Inlets on western Victoria Island (CMN 2013). The closest site to Cambridge Bay was near an unnamed lake NE of Johansen Bay, approximately 230 km to the west southwest. Though not seen on Victoria Island during the surveys in 2013 and 2014, it was found and collected on the mainland at Umingmaktok 320 km east of Rae River where a collection was made by R.E. Miller in 1955 (CAN 241966, Porsild and Cody 1980). Horned Sea-blite was assessed in 2010 as a Sensitive species in Nunavut (CESCC 2011).

Snow Pearlwort, *Sagina nivalis,* was previously reported from Victoria Island as far east as the southeast end of Goldsmith Channel, the eastern end of Prince Albert Sound and Holman to the west (Aiken et al. 2007). This is the first time it has been in the vicinity of Cambridge Bay. It was found and collected from a single site just above the high tide mark in silty sand on flats just at eastern end of inlet that appears to be seasonally flooded, beside a small creek, 50% vegetated with *Armeria scabra, Taraxacum hyparcticum, Potentilla pulcherrima, Braya purpurascens, Salix arctica, Astragalus alpinus, Poa arctica, Juncus biglumis*, and *Carex ursina*. In 2014, it was collected again in the western side of Cambridge Bay, but also at 30 Mile River, and White Bear Point.

Arctic Catchfly, *Silene involucrata* subsp. *involucrata* (*Melandrium affine*), has been collected in the vicinity of Cambridge Bay (Porsild and Cody 1980; Aiken et al. 2007). It was collected by Steve Stephens in 1962 on a ridge beyond the cemetery, along the road 1.5 km east, and from an owl mound (CAN273599; CAN 2713600; CAN 2713601). The species was not seen during the 2013 survey, though these sites were searched. It was also not collected during recent Canadian Museum of Nature surveys in the vicinity of Cambridge Bay but was found commonly to the west (CMN 2013). In 2014, it was found and collected on the road north of the DEW Line and was also collected at 30 Mile River and west of Hope Bay demonstrating a persisting but occasional occurrence.

Taimyr Catchfly, *Silene ostenfeldii*, has been reported near Cambridge Bay (Thannheiser et al. 2001). Additional collections are known from western Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013). This species was not seen on Victoria Island during the 2013 and 2014 surveys, but was photographed west of Hope Bay on the mainland.

Seaside Buttercup, *Ranunculus cymbalaria* (*Halerpestes cymbalaria*) is very rare on Victoria Island with only a single site in the vicinity of Holman being reported by Porsild and Cody (1980). Two additional sites were added in at Oterkvik Point and Johansen Bay (CMN 2013). It was not seen on Victoria Island during surveys in 2013 and 2014, however it was collected once from Umingmaktok, which is a new site in Bathurst Inlet.

Lapland Buttercup, *Ranunculus lapponicus* has not been reported from Victoria Island (Aiken et al. 2007) and was seen and collected only once, west of Hope Bay which is within the distribution or a slight northern range extension from sites within Bathurst Inlet reported in Porsild and Cody (1980).

Arctic Rockcress, *Arabidopsis arenicola*, has not previously reported from Victoria Island. The closest sites are from across Coronation Gulf in Bathurst Inlet area (Aiken 2007). In 2013 a plant that was an incidental collection mixed with *Phippsia algida* and *Braya glabella* subsp. *purpurascens* was collected in the vicinity of Long Point. The plant was glabrous, flowering with petals white-pinkish 4.0 mm and several stem leaves; however the plant was immature, and no fruits were found. So the identification is considered tentative. In 2014, a second collection was made, also in the vicinity of Long Point.

Alpine Draba, *Draba alpina*. The name *Draba alpina* was so misapplied that it was used for any circumpolar or alpine, scapose, yellow-flowered, perennial Draba (Al-Shehbaz et al. 2010). It has been reportedly collected in the vicinity of Cambridge Bay, but also at many sites throughout Victoria Island (Aiken et al. 2007). It is not clear if this species in the strict sense has been collected in the vicinity. The species was also not collected during recent Canadian Museum of Nature surveys (CMN 2013). The taxonomy of this species remains unresolved at the time of this account, however many *Draba* specimens have been sent to Dr. I.A. Al-Shehbaz at the Missouri Botanical Garden for confirmation.

Boreal Draba, *Draba borealis.* Aiken et al. (2007) reported that G.A. Mulligan annotated plants from Ferguson Lake on Victoria Island, 69°25'N and 105°15'W (CAN 561159, CAN 561455), as belonging to this taxon in 1968, and this record is mapped in Porsild and Cody (1980). No other collections of this species are known and the species was also not collected during recent Canadian Museum of Nature surveys (CMN 2013). In 2014, this species was collected at the 30 Mile River and has been sent to Dr. I.A. Al-Shehbaz for confirmation. The only other member of the Arctic Archipelago from which this species is reported is Banks Island. Boreal Draba was not listed as occurring in Nunavut (CESCC 2011).

Long-stalked Draba, *Draba juvenilis* (*D. longipes*) was not reported in the vicinity of Cambridge Bay (Thannheiser et al. 2001; Aiken et al. 2007; CMN 2013); however Porsild and Cody (1980) indicate two sites in the vicinity, which may be collections by Edlund and Argus, between the DEW-line and the village, and in the Angustus Hills (CAN 526652, 526862). Thannheiser et al. (2001) reports a collection from Minto Inlet. Long-stalked Draba was collected once on the road to Mount Pelly in 2013 (identified by G.A. Mulligan, DAO). It is a species ranked as May Be At Risk in Nunavut (CESCC 2011), but is considered globally secure (G5). It is rare on Victoria Island and unknown on the adjacent mainland.

Norwegian Draba, *Draba norvegica* has been reported from the vicinity of Cambridge Bay (Thannheiser et al. 2001), but was not reported as occurring on Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013). It was not collected within the study area, although a specimen from Kugluktuk was identified as this species by G.A. Mulligan (DAO).

Canada Arctic Draba, *Draba oblongata* has been reported as occurring in the vicinity of Cambridge Bay (Thannheiser et al. 2001; Aiken et al. 2007). It was collected twice by botanists with the Canadian Museum of Nature (CMN 2013) in the Colville Hills and near Minto Inlet. Plants resembling this species were collected twice from Cambridge Bay on the road north of the DEW-line. These collections have been sent for confirmation. Though the species is reported as secure (CESCC 2011) it is apparently quite rare on Victoria Island.

Hairy Draba, *Draba pilosa*, has not previously been reported from Victoria Island (Aiken et al. 2007); however several collections have been made by botanists with the Canadian Museum of Nature (CMN 2013) both in the Nunavut and NWT portions of Victoria Island. O. E. Schulz (1927) reduced *Draba pilosa* to a variety of the decaploid *D. alpina* and cited North American collections (Al-Shehbaz et al. 2010). It is likely therefore that a review of *D. alpina* collections will uncover more collections of *D. pilosa*. It was found to be common in *Carex aquatilis / C. rariflora* fens, often growing with *Kobresia simpliciuscula*.

Arctic False Wallflower, *Parrya arctica*, may be a species of conservation concern in Nunavut with a Global Rank of Possibly Vulnerable (G3?). It is endemic to Canadian Arctic Archipelago, south to Great Bear Lake, Northwest Territories (Aiken et al. 2007 – erroneously reported westward). It was found to be occasional in the vicinity of Cambridge Bay and was collected twice in 2013, along the Ovayok Road and near Long Point. In 2014 it was collected an additional seven times, including two sites near Cambridge Bay, 30 Mile River, Trunsky Lake, near Ferguson Lake, and two sites on the mainland on the Kent Peninsula. It has been collected a number of times by members of the Canadian Museum of Nature (CMN 2013) but is currently Not Ranked (SNR) by the NWT or Nunavut (NatureServe 2014). Both white and lavender flowers were found in equal abundance. It is commonly distributed but not abundant when found and is usually represented by dozens or fewer plants.

Rosendahl's Golden-saxifrage, *Chrysosplenium rosendahlii*, may be a species of conservation concern in Nunavut with a Global Rank of Probably Secure (G4), but a Canadian rank of Imperilled (N2). It was not listed by the General Status of Canada (CESCC 2011). Northern Golden Saxifrage was collected in 2008 from adjacent to the airport road, near where the road enters town (CAN592395; CMN 2013). It was collected twice in 2013 along the road to Mount Pelly, in 2014 it was collected along the 30 Mile River and near Ferguson Lake and Ekalluk River. Rosendahl's Golden-saxifrage appears to be restricted in Canada to southern islands of the Canadian Arctic Archipelago and coastal areas of the mainland in northern Nunavut. Alaskan records extend from Beaufort Lagoon west to the vicinity of Prudhoe Bay. It is not known from coastal Yukon, Northwest Territories, or western Nunavut, where suitable habitat exists. Across its range, *C. rosendahlii* may be overlooked because of its similarity to *C. tetrandrum* (Freeman and Levsen 2009). Specimens collected in 2013 were confirmed by Dr. Nick Levsen.

Hawk-leaved Saxifrage, *Micranthes hieraciifolia*, had only a single reported locality on Victoria Island which appears to be in the vicinity of Cambridge Bay, though the exact locality and the collection it is based on were not found. The collection is believed to be housed at DAO (Porsild and Cody 1980; Aiken et al. 2007). In 2013, it was seen and a small collection made for genetic research (see *Contribution to Research*) along the river draining Ferguson Lake approximately 4 km along the Ovayok (Mount Pelly) road. A second patch was found the same year by Dr. Johann Wagner (pers. comm. 2013). In 2014, two additional collections were made, including as site along 30 Mile River and a second near Ferguson Lake and Ekalluk River, which are range extensions of 85 km and 50 km to the west and northwest.

Snow Saxifrage, *Micranthes nivalis* complex (including *M. rufopilosa* and *M. tenuis;* Figure 29). Healy and Gillespie (2004) have shown how *M. nivalis* and *M. tenuis* from arctic Canada differ in both morphology and cpDNA, but unfortunately do not consider *M. rufopilosa*. They did note that the few montane plants from Alaska and the Yukon Territory they treated as *M. tenuis* differed from the arctic specimens by quantitative characters and appeared to be intermediate between *M. nivalis* and *M. tenuis*. These results probably pertain to *M. rufopilosa* that Krause and Beamish (1973) found to have ploidy counts that differed from *M. nivalis* and *M. tenuis*. The plants collected most closely resemble *M. rufopilosa* based on the keys provided in (Brouillet and Elvander 2009). I agree with Healy and Gillespie (2004) that "accurate and consistent identification of North American plants belonging to this complex can be problematic." Plant material was sampled and sent to the Canadian Centre for DNA Barcoding (CCDB http://ccdb.ca/) to help with confirmation. Collections have been made in Cambridge Bay, 30 Mile River and near Ferguson Lake and Ekalluk River on Victoria Island, and White Bear Point on the mainland. All are infills of an otherwise scattered distribution throughout the region.

Marsh Grass-of-Parnassus, *Parnassia palustris* was seen and photographed near the Burnside River and Umingmaktok, which is within the currently known distribution. It is not known from Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013). The related but smaller Kotzebue's Grass-of-Parnassus, *Parnassia kotzebuei* has been reported as a rare species on Victoria Island (Aiken et al. 2007; CMN 2013) where it was collected at the west end of Johansen Bay at mouth of Mackenzie Creek, and from Clauston Bay (CAN592405; 592767).

Figure 29. Snow Saxifrage, Micranthes nivalis *complex (including* M. rufopilosa *and* M. tenuis*) photo B. Bennett).*

Marsh Cinquefoil, *Comarum palustre* (*Potentilla palustris*), has not been reported for Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013) and was not seen on the island during the survey but was collected from White Bear Point which is a slight range extension of 40 kilometres north of the distribution given by the Flora of the Canadian Arctic Archipelago (Aiken et al. 2007) of this otherwise widespread species.

Bluff Cinquefoil, *Potentilla arenosa* ssp. *arenosa*, was reported from a single locality in 2013 (McLennan et al. 2014). In 2014, the subspecies was found to be widespread and was collected from nearly every site visited. In addition, Chamisso's Cinquefoil, *Potentilla arenosa* subsp. *chamissonis*, was reported as occurring in the vicinity of Cambridge Bay (Porsild and Cody, 1980; Aiken *et al.*, 2007). The subspecies was not collected during recent Canadian Museum of Nature surveys (CMN, 2013) and was reported as not collected during the 2013 survey (McLennan 2014); however the re-examination of the collections discovered a single site near Pelly Mountain Territorial Park and on Gravel Pit road. In 2014, additional sites at Hope Bay, 30 Mile River, and Ferguson Lake & Ekalluk River illustrates the taxon is relatively common in the region.

Egede's Silverweed, *Potentilla egedii* (*Argentina egedii*) has previously been reported from a single site on Victoria Island near Holman, NWT (Porsild and Cody 1980; Aiken et al. 2007). It was not seen on Victoria Island on recent surveys (CMN 2013). It was seen and collected only once from the Burnside River near Bathurst Inlet in an area where it has previously been reported (Porsild and Cody 1980; Aiken et al. 2007).

Arctic Cinquefoil, *Potentilla hyparctica* has not been reported from Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013) and was not seen on the island during the 2013 and 2014 surveys. It was collected twice from mainland sites at Bichta Lake and White Bear Point, which are both within the expected distribution of this widespread species.

Yurtsev's Cinquefoil, *Potentilla subgorodkovii* is a species that has traditionally been included within the *Potentilla uniflora* complex (Elven et al. 2014) and as such it is difficult to determine its distribution based on historical accounts. It was however collected during survey of Victoria Island by botanists with the Canadian Museum of Nature near Johansen Bay and Minto Inlet (CMN 2013). It was seen and collected once on Victoria Island near Trunsky Lake (Figure 30)

Figure 30. Yurtsev's Cinquefoil, Potentilla subgorodkovii (photo B. Bennett).

Tikhomirov's Cinquefoil, *Potentilla tikhomirovii* is a species that has traditionally been included within the *Potentilla uniflora* complex (Elven et al. 2014) and as such it is difficult to determine its distribution based on historical accounts. It was not report during survey of Victoria Island by botanists with the Canadian Museum of Nature (CMN 2013). It was seen and collected once in Cambridge Bay at the western end of bay above Flagstaff Point and has been sent to Dr. D.L. Murray for confirmation.

Cloudberry, *Rubus chamaemorus*, was collected in the vicinity of Cambridge Bay, the only locality in the western Arctic Archipelago (Aiken et al. 2007). This collection should be confirmed. The next closest known locality is in the vicinity of Kugluktuk approximately 440 km to the southwest on the mainland. The species was not collected during the 2013 and 2014 survey or during Canadian Museum of Nature surveys of Victoria Island (CMN 2013). In 2014, was seen and collected only once from the Burnside River, close to Bathurst Inlet where it is on the northern edge of the distribution illustrated by the Flora of the Canadian Arctic Archipelago (Aiken et al. 2007) of this otherwise widespread species.

Alpine Sweet-vetch, *Hedysarum alpinum* (*H. americanum*) is an occasional (rare-uncommon) plant on Victoria Island. It was not known on Victoria Island by Porsild and Cody (1980). It was reported from Surrey Lake, Minto Inlet, and Johansen Bay (Thannheiser et al. 2001). Aiken et al. (2007) show four sites, and the Canadian Museum of Nature survey (CMN 2013) added several new sites, particularly along the southwest coast the closest being Lauchlan River near mouth at Byron Bay 150 km to the west. During the 2013 and 2014 surveys, Alpine Sweet-vetch was only collected on the mainland near Hope Bay which was a slight range extension of 75 km east of sites in Bathurst Inlet. Plants identified as Alpine Sainfoin, *Hedysarum hedysaroides*, are sometimes considered synonyms of Alpine Sweet-vetch (Aiken et al. 2007). The flowers are larger, darker blue, and congested, but otherwise similar. Plants resembling Alpine Sainfoin were found in Umingmaktok.

Crowberry, *Empetrum nigrum* was not seen in the vicinity of Cambridge Bay during the 2013 and 2014 surveys, it was however seen but not collected at near Ferguson Lake and Ekalluk River. Aiken et al. (2007) previously only reported near Holman on western Victoria Island. The Canadian Museum of Nature surveys discovered additional sites near Johansen Bay airstrip, and on the west side of Wilbank Bay (CMN 2013). It was also seen but not collected at Bichta Lake, west of Hope Bay, and White Bear Point which is within its previously known distribution where it is a common and widespread species.

One-sided Wintergreen, *Orthilia secunda*, is rare on Victoria Island has been reported previously about four times, the closest being west of Cape Peel, approximately 85 km west of Cambridge Bay (Aiken et al. 2007). However Thannheiser et al. (2001) reports a collection from Cambridge Bay. It was collected only once from the Burnside River, and seen but not collected at Umingmaktok, both in Bathurst Inlet, a region where it had previously been reported.

Arctic Wintergreen, *Pyrola grandiflora*, is apparently uncommon to rare on Victoria Island, though it has previously been collected at a few scattered sites including the vicinity of Cambridge Bay at Long Lake (Aiken et al. 2007). Several collections have been made recently by botanists with the Canadian Museum of Nature (CMN 2013). It was not seen in the vicinity of Cambridge Bay during the surveys in 2013 and 2014, but a single site was found near Ferguson Lake and Ekalluk River. The closest previous collection was from Johansen Bay, 170 km to the west. It was found to be common on the mainland, where it was collected only once at the Burnside River, but was also seen at White Bear Point, west of Hope Bay, and at Umingmaktok, all are within the distribution where it had previously been reported (Aiken et al. 2007).

Alpine Bearberry, *Arctous alpina*, was collected in the vicinity of Cambridge Bay (Aiken et al. 2007). It has not been collected recently (CMN 2013) and was not seen on Victoria Island during the surveys of 2013 and 2014. I was however collected at Kugluktuk airport in 2013 and White Bear Point in 2014, it was also seen but not collected from west of Hope Bay. All these sites are within the expected distribution reported in (Porsild and Cody 1980; Aiken et al. 2007).

Lapland Rosebay, *Rhododendron lapponicum* is apparently rare on Victoria Island. It was only reported from a single site near Holman, NWT by Porsild and Cody (1980). Additional sites were reported in the survey by the Canadian Museum of Nature from the vicinity of Minto Inlet, Oterkvik Point, and Johansen Bay (CMN 2013). It was not seen in the vicinity of Cambridge Bay during the surveys in 2013 and 2014, but sites were found near Ferguson Lake and Ekalluk River. The closest previous collection was from Johansen Bay, 170 km to the west. It was found to be equally uncommon on the mainland, where it was seen and collected only once at the Burnside River, a site where it had previously been reported (Aiken et al. 2007).

Marsh Labrador Tea, *Rhododendron tomentosum* (*Ledum palustre* subsp. *decumbens*), is apparently rare on Victoria Island and though was reported in the vicinity of Cambridge Bay (Aiken et al. 2007), the origin of this report is not known. Cambridge Bay was not included in the distribution given by Porsild and Cody (1980). The other sites on Victoria Island where this species has been noted are in the northwest, the closest being from Johansen Bay (CMN 2013). It was found to be common on the mainland, except was not seen on the Kent Peninsula. It was recorded at Burnside River, Hope Bay, and White Bear Point. Though previously reported from Bathurst Inlet, Hope Bay and White Bear Point sites are range extensions of 75 and 125 km east of distributions shown in the Flora of the Canadian Arctic Archipelago (Aiken et al. 2007) for this widespread species.

Alpine Bilberry, *Vaccinium uliginosum* subsp. *microphyllum*, is apparently rare on Victoria Island. It was previously recorded from the vicinity of Cambridge Bay from collections at Long Lake. It was seen only on two occasions in 2013 (i.e., Pelly Mountain and the Angustus Hills near Long Point). In both cases the plants had been long established but were apparently rare. In 2014, an additional site near Ferguson Lake and Ekalluk River found this species to be locally common and was an infill between the collections in Cambridge Bay and the next closest near the Richardson Island, slight over 200 km to the southwest. This species has previously been collected at fewer than 15 site sites on Victoria Island (Aiken et al. 2007; CMN 2013). It was commonly seen at most mainland sites except Kent Peninsula (which had a calcareous substrate). It was noted but not collected at White Bear Point, Bichta Lake, west of Hope Bay, and Burnside River, Bichta Lake and White Bear Point being range extensions of 65 and 175 km east of distributions shown in the Flora of the Canadian Arctic Archipelago (Aiken et al. 2007) for this widespread species.

Mountain Cranberry, *Vaccinium vitis-idaea* is apparently rare on Victoria Island. It has been collected previously near Cambridge Bay in the vicinity of Long Lake (CAN 529335, 52948) and on other sites including the Sinclair Creek DEW-line site, and Johansen Bay (CMN 2013). It was seen and collected only once on Victoria Island during the 2013 and 2014 survey years, near Ferguson Lake and Ekalluk River. Local stories report crossing Dease Strait in the fall to harvest cranberries on the mainland, indicating the mainland observations are not based on recent range expansions, but lack of inventory in the region. It was commonly seen at all mainland sites except Kent Peninsula (which had a calcareous substrate). It was noted but not collected at White Bear Point, Bichta Lake, Hope Bay, and Burnside River, all of which except Burnside River are range extensions based on distributions shown in the Flora of the Canadian Arctic Archipelago (Aiken et al. 2007).

Pale Paintbrush, *Castilleja pallida* var. *caudata* was not reported from the Canadian Arctic Archipelago by Aiken et al. (2007) or reported during the Canadian Museum of Nature Surveys (CMN 2013). Thannheiser et al. (2001) reports it as occurring at Cambridge Bay, but does not include the more widespread *Castilleja elegans*, so it is possible this report could be based on the pale form of *C. elegans*. Pale Paintbrush was seen and collected only once from along the road north of the Distant Early Warning (DEW-line) station. The collection was confirmed by Mark Egger with Washington State University.

Labrador Lousewort, *Pedicularis labradorica* has not been reported from Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013), and was not found on the island during the 2013 and 2014 survey years. It was found and collected near Bichta Lake which is a range extension of 120 km east of sites within Bathurst Inlet. It was also seen but not collected at the Burnside River.

Lapland Lousewort, *Pedicularis lapponica* has not been reported from Victoria Island (Porsild and Cody 1980; CMN 2013; Aiken et al. 2007), and was not found on the island during the 2013 and 2014 survey years. It was found and collected near Hope Bay, a range extension of 70 km northeast from sites in the vicinity of Umingmaktok.

Common Yarrow, *Achillea millefolium* has not been reported from Victoria Island (Porsild and Cody 1980; Aiken et al. 2007; CMN 2013) and was not found on the island during the survey years. It was found and collected once near White Bear Point, a range extension of 120 km east from sites in the vicinity of Hope Bay.

Fries' Pussytoes, *Antennaria friesiana* subsp. *friesiana*, was seen and collected only once just east of Long Point. This species has previously been collected in the vicinity of Cambridge Bay, but this is the only area on Victoria Island where it has been reported (Porsild and Cody 1980; Aiken et al. 2007). It was collected at a few sites on southwestern Victoria Island, the closest being at sites near Johansen Bay. It was seen and collected twice, once again in the vicinity of Long Point and near White Bear Point. It was also seen and photographed as a site west of Hope Bay. It is apparently rare in this region.

Narrow-leaved Arnica, *Arnica angustifolia* subsp. *angustifolia*, has previously been collected at a number of sites through Victoria Island, north and west of, but also in the vicinity of Cambridge Bay (Aiken et al. 2007). No details of the collection(s) from the vicinity of Cambridge Bay have been found. It was not seen on Victoria Island during either of the 2013 and 2014 survey years, however it was collected from White Bear Point and seen but not collected west of Hope Bay, which is within the previously known range of the species.

Richardson's Wormwood, *Artemisia borealis* subsp. *richardsoniana* was seen and collected once from White Bear Point. This is a range extension of 430 km east of the previously reported range in the vicinity of Dolphin and Union Strait, the closest site on Victoria Island is from Simpson Bay on the southwest coast (Aiken et al. 2007).

Tilesius' Wormwood, *Artemisia tilesii*, has not previously been reported from Victoria Island (Porsild and Cody 1980; Thannheiser et al. 2001; Aiken et al. 2007). It was however collected from Johansen Bay in 2008 (CMN 2013; CAN592268) about 260 km WSW of Cambridge Bay. There it was also reported from a disturbed area adjacent to the main air landing strip. It was previously known to occur in the Canadian Arctic Archipelago from Banks Island, and from the Kent Peninsula on the mainland adjacent, only 35 km SW of Cambridge Bay across Dease Strait (Aiken et al. 2007). As will be discussed further, it is believed this to be a recent introduction (McLennan et al. 2014). The same patch was observed in 2014; plants were also seen at Umingmaktok but not collected.

Low Fleabane, *Erigeron humilis*, was not seen during the 2013 survey but was found approximately 30 km to the west near Starvation Cove by Dr. Johann Wagner (pers. comm. 2013). This may be the vicinity of the only other collection reported for Victoria Island (Aiken et al. 2007). However several collections have been made west of this site (CAN593065, CAN593069, CAN593082; CMN 2013; Saarela pers. comm. 2013). In 2014, it was seen and collected twice, once at 30 Mile River on Victoria Island (an infill) and a second near White Bear Point on the mainland, which is within the known distribution of the species.

One-flowered Fleabane, *Erigeron uniflorus* subsp. *eriocephalus*, was not seen during the 2013 survey but was found approximately 14 km to the west near Long Point by Dr. Johann Wagner (pers. comm. 2013). This may be the vicinity of the other collection reported for Cambridge Bay (Aiken et al. 2007). However several collections have been made north and west of this site (Aiken et al. 2007; CMN 2013). In 2014, it was again not seen on Victoria Island but was collected once, where it was seen in disturbed sites near White Bear Point and not seen elsewhere.

Siberia Aster, *Eurybia sibirica* was seen and collected only once from the Burnside River, close to Bathurst Inlet where it was reported previously by Porsild and Cody (1984). This occurrence is at the eastern edge of the species known distribution. This species is not reported as occurring in the Canadian Arctic Archipelago (Aiken et al. 2007; CMN 2013).

Northern Sweet Coltsfoot, *Petasites frigidus* has previously been collected from a number of sites in the Northwest Territories region of Victoria Island, in the vicinity of Minto Inlet, including 2010 collections by botanists with the Canadian Museum of Nature (CMN 2013). A single site was also reported in the vicinity of, Cambridge Bay (Aiken et al. 2007). No sites were seen during the surveys on Victoria Island in 2013-2014, however Wagner (pers. comm. 2014) found and photographed some plants on the shore of Long Lake (Figure 31). In 2014, it was seen and collected once from the vicinity of White Bear Point is an infill between sites near Hope Bay and sites just west of the Adelaide Peninsula.

Figure 31. Northern Sweet Coltsfoot, Petasites frigidus on the shore of Long Lake, with Salix arctica among others, fertilized by goose droppings 69.150746° -104.652158° (Photo J. Wagner with permission)

Narrow-leaved Saw-wort, *Saussurea angustifolia* subsp. *angustifolia* is not reported as occurring in the Canadian Arctic Archipelago (Aiken et al. 2007; CMN 2013) and was collected near the Burnside River of Bathurst Inlet but was also seen at Umingmaktok but not collected. This is within the currently known range of the species Porsild & Cody 1980).

Horned Dandelion, *Taraxacum ceratophorum*, was collected in the vicinity of Cambridge Bay which is the only site reported for Victoria Island (Aiken et al. 2007). No details of the collection(s) from the vicinity of Cambridge Bay have been found and no plants have been seen on Victoria Island in 2013 and 2014. Two collections were made in 2014 from mainland sites including west of Hope Bay and White Bear Point. Both are major range extensions of about 500 km east of a previously known site near Clifton Point at the western entrance to Dolphin and Union Strait. It was also recorded but not collected from the Kent Peninsula.

Purple-haired Groundsel, *Tephroseris frigida* (*Senecio atropurpureus* ssp. *frigida*), has been collected at a number of sites in western Victoria Island (Aiken et al. 2007; CMN 2013), but also in the vicinity of Cambridge Bay (Porsild and Cody 1980). No details of the collection(s) from the vicinity of Cambridge Bay have been found and no plants have been seen on Victoria Island in 2013 and 2014. Two collections were made in 2014 from mainland sites on the Kent Peninsula and White Bear Point. Both are slight range extensions of about 150 km east of previously known sites in Melville Sound. It was also seen but not collected west of Hope Bay.

Table 4. List of vascular plants seen, collected, reported, and photographed and their estimated abundance.

Family	Common Name	Scientific Name	Cambridge Bay vicinity	Abundance	Mainland	Abundance	Photo
Lycopodiaceae	Northern Firmoss	*Huperzia selago*	collected	R	collected	U	YES
Equisetaceae	Field Horsetail	*Equisetum arvense*	collected	O	collected	U	YES
Equisetaceae	Variegated Horsetail	*Equisetum variegatum* subsp. *variegatum*	collected	U	seen	U	YES
Woodsiaceae	Fragile Fern	*Cystopteris fragilis*	Not seen	R			YES
Woodsiaceae	Fragrant Wood Fern	*Dryopteris fragrans*	Not seen	R	collected	O	YES
Woodsiaceae	Smooth Cliff Fern	*Woodsia glabella*	collected	O	seen	R	YES
Juncaginaceae	Seaside Arrowgrass	*Triglochin maritima*			collected	R	NO
Juncaginaceae	Marsh Arrowgrass	*Triglochin palustris*			collected	R	NO
Poaceae	Alpine Foxtail	*Alopecurus magellanicus*	collected	C	seen	C	YES
Poaceae	Arctic Sweet Grass	*Anthoxanthum arcticum*	collected	C	seen	C	YES
Poaceae	Alpine Sweet Grass	*Anthoxanthum monticola* subsp. *alpinum*	Not seen	U	seen	O	YES
Poaceae	Alpine Sweet Grass	*Anthoxanthum monticola* subsp. *monticola*	collected	R	collected	R	YES
Poaceae	Polar Grass	*Arctagrostis latifolia*	collected	C	seen	C	YES
Poaceae	Pendant Grass	*Arctophila fulva*	collected	U	seen	R	YES
Poaceae	Pumpelly's Brome	*Bromus pumpellianus*			collected	R	NO
Poaceae	Langsdorff's Reed Grass	*Calamagrostis canadensis ssp. langsdorfii*			collected	R	NO
Poaceae	Lapland Reed Grass	*Calamagrostis lapponica*			seen	R	NO
Poaceae	Purple Reed Grass	*Calamagrostis purpurascens*			collected	R	NO
Poaceae	Tufted Hair Grass	*Deschampsia caespitosa*			collected	R	NO

Poaceae	Fisher's Tundra Grass	*Dupontia fisheri*	collected	C	collected	O	YES
Poaceae	Alaska Wild Rye	*Elymus alaskanus*			collected	O	NO
Poaceae	Baffin Fescue	*Festuca baffinensis*	collected	U	collected	C	YES
Poaceae	Short-leaved Fescue	*Festuca brachyphylla*	collected	C	seen	C	YES
Poaceae	Elund's Fescue	*Festuca edlundiae*	?				
Poaceae	Richardson's Fescue	*Festuca richardsonii (rubra* subsp. *arctica)*	collected	R	collected	R	YES
Poaceae	Sea Lyme Grass	*Leymus mollis* subsp. *villosissimus*	collected	U	seen	O	YES
Poaceae	Ice Grass	*Phippsia algida*	collected	R			NO
Poaceae	Sabine's Semaphore Grass	*Pleuropogon sabinei*	collected	O			YES
Poaceae	Northern Blue Grass	*Poa abbreviata*	collected	R			NO
Poaceae	Alpine Blue Grass	*Poa alpina*			collected	R	NO
Poaceae	Arctic Blue Grass	*Poa arctica* subsp. *arctica*	collected	C	seen	U	YES
Poaceae	Arctic Blue Grass	*Poa arctica* subsp. *caespitans*	collected	C			YES
Poaceae	Glaucous Blue Grass	*Poa glauca*	collected	A	collected	C	YES
Poaceae	Hartz's Blue Grass	*Poa hartzii* subsp. *hartzii*	?				?
Poaceae	Kentucky Blue Grass	*Poa pratensis* subsp. *alpigena*	collected	R			NO
Poaceae	Anderson's Alkali Grass	*Puccinellia andersonii*	?				
Poaceae	Northern Alkali Grass	*Puccinellia angustata*	?				
Poaceae	Arctic Alkali Grass	*Puccinellia arctica*	?				
Poaceae	Prince Patrick Alkali Grass	*Puccinellia bruggemannii*	?				
Poaceae	Nuttall's Alkali Grass	*Puccinellia nuttalliana*	collected	C	?	O	YES
Poaceae	Creeping Alkali Grass	*Puccinellia phryganodes*	collected	C	collected	C	YES
Poaceae	Tundra Alkali Grass	*Puccinellia tenella* subsp. *langeana*	?				

Poaceae	Tussock Alkali Grass	*Puccinellia vaginata*	?				
Poaceae	Vahl's Alkali Grass	*Puccinellia vahliana*	?				
Poaceae	Narrow False Oats	*Trisetum spicatum*	collected	O	collected	U	YES
Cyperaceae	Water Sedge	*Carex aquatilis* var. *minor* (subsp. *stans*)	collected	A	seen	A	YES
Cyperaceae	Dark-brown Sedge	*Carex atrofusca*	collected	A	seen	A	YES
Cyperaceae	Two-coloured Sedge	*Carex bicolor*	collected	R	seen	R	NO
Cyperaceae	Bigelow’s Sedge	*Carex bigelowii*			collected	O	NO
Cyperaceae	Hairlike Sedge	*Carex capillaris* subsp. *fuscidula*	collected	C	seen	U	YES
Cyperaceae	Creeping Sedge	*Carex chordorrhiza*			collected	R	NO
Cyperaceae	Short-leaved Sedge	*Carex fuliginosa* subsp. *misandra*	collected	A	seen	C	YES
Cyperaceae	Garber’s Sedge	*Carex garberi*	collected	R	collected	R	NO
Cyperaceae	Arctic Marsh Sedge	*Carex holostoma*	Not seen				
Cyperaceae	Krause's Sedge	*Carex krausei*			collected	O	NO
Cyperaceae	Arctic Hare's-foot Sedge	*Carex lachenalii*	collected	U			YES
Cyperaceae	Mackenzie's Sedge	*Carex mackenziei*			collected	R	NO
Cyperaceae	Sea Sedge	*Carex marina*	collected	C	seen	O	YES
Cyperaceae	Seaside Sedge	*Carex maritima*	collected	C	seen	R	YES
Cyperaceae	Fragile Sedge	*Carex membranacea*	collected	C	seen	U	YES
Cyperaceae	Nard Sedge	*Carex nardina*			collected	R	NO
Cyperaceae	Rock Dwelling Sedge	*Carex petricosa*	new	O	collected	O	YES
Cyperaceae	Loose-flowered Alpine Sedge	*Carex rariflora*	collected	C	collected	C	YES
Cyperaceae	Rock Sedge	*Carex rupestris*	collected	A	seen	C	YES
Cyperaceae	Russet Sedge	*Carex saxatilis*	collected	U	collected	C	YES

Cyperaceae	Spike Sedge	*Carex scirpoidea*	collected	C	Collected	C	YES
Cyperaceae	Hoppner's Sedge	*Carex subspathacea*	collected	C	collected	U	YES
Cyperaceae	Bear Sedge	*Carex ursina*	collected	C	collected	C	YES
Cyperaceae	Sheathed Sedge	*Carex vaginata*	collected	U	seen	C	YES
Cyperaceae	Narrow-leaved Cottongrass	*Eriophorum angustifolium*	collected	C	collected	A	YES
Cyperaceae	Beautiful Cottongrass	*Eriophorum callitrix*	collected	R	collected	O	YES
Cyperaceae	Scheuchzer's Cottongrass	*Eriophorum scheuchzeri subsp. arcticum*	collected	C	collected	C	YES
Cyperaceae	Tall Cottongrass	*Eriophorum triste* (*E. angustifolium subsp. triste*)			collected	U	NO
Cyperaceae	Tussock Cottongrass	*Eriophorum vaginatum*	collected	R	collected	U	YES
Cyperaceae	Bellard's Kobresia	*Kobresia myosuroides*	collected	C	seen	R	YES
Cyperaceae	Siberian Kobresia	*Kobresia sibirica*	collected	C	collected	O	YES
Cyperaceae	Simple Kobresia	*Kobresia simpliciuscula* subsp. *subholarctica*	collected	C	seen	O	NO
Juncaceae	Arctic Rush	*Juncus arcticus* var. *balticus*	seen	R	Collected	U	YES
Juncaceae	Two-flowered Rush	*Juncus biglumis*	collected	U	seen	C	YES
Juncaceae	Chestnut Rush	*Juncus castaneus*			collected	R	NO
Juncaceae	Three-flowered Rush	*Juncus triglumis var. albescens*	collected	O	seen	O	YES
Juncaceae	Arctic Woodrush	*Luzula arctica* (*L. nivalis*)			collected	R	NO
Juncaceae	Northern Woodrush	*Luzula confusa*	collected	O	collected	C	YES
Tofieldiaceae	Northern Tofieldia	*Tofieldia coccinea*	seen				NO
Tofieldiaceae	Small False Asphodel	*Tofieldia pusilla*	collected	R	collected	O	YES
Orchidaceae	Early Coralroot	*Corallorhiza trifida*	not seen				
Orchidaceae	Blunt-leaved Orchid	*Platanthera obtusata*			collected	R	NO

Salicaceae	Alaska Willow	*Salix alaxensis*			collected	R	NO
Salicaceae	Arctic Willow	*Salix arctica*	collected	A	seen	A	YES
Salicaceae	Alaska Bog Willow	*Salix fuscescens*			collected	R	NO
Salicaceae	Gray Willow	*Salix glauca* subsp. *stipulifera*			collected	O	NO
Salicaceae	Snowbed Willow	*Salix herbacea*			collected	O	YES
Salicaceae	Barrenground Willow	*Salix niphoclada*			collected	R	YES
Salicaceae	Polar Willow	*Salix polaris*	collected	O			YES
Salicaceae	Diamond-leaved Willow	*Salix planifolia*			seen	U	YES
Salicaceae	Net-veined Willow	*Salix reticulata*	collected	C	seen	A	YES
Salicaceae	Richardson's Willow	*Salix richardsonii*	collected	C	seen	A	YES
Betulaceae	Green Alder	*Alnus viridis* ssp. *crispa*			collected	R	YES
Betulaceae	Shrub Birch	*Betula glandulosa*	n		collected	C	NO
Betulaceae	Water Birch	*Betula occidentalis*			collected	R	NO
Polygonaceae	Viviparous Bistort	*Bistorta vivipara*	collected	A	seen	A	YES
Polygonaceae	Mountain Sorrel	*Oxyria digyna*	collected	O	seen	C	YES
Chenopodiaceae	Horned Sea-blite	*Suaeda calceoliformis*			collected	R	YES
Caryophyllaceae	Alpine Chickweed	*Cerastium alpinum* var. *alpinum*			?	R	YES
Caryophyllaceae	Bering Sea Chickweed	*Cerastium beeringianum*	collected	C	collected	C	YES
Caryophyllaceae	Regel's Chickweed	*Cerastium regelii* (*gorodkovianum*)	collected	C	Seen	O	YES
Caryophyllaceae	Seabeach Sandwort	*Honckenya peploides*	collected	U	collected	O	YES
Caryophyllaceae	Mountain Stitchwort	*Minuartia biflora*	Not seen				
Caryophyllaceae	Ross' Stitchwort	*Minuartia rossii*	collected	U	collected	O	YES
Caryophyllaceae	Reddish Stitchwort	*Minuartia rubella*	collected	U	collected	U	YES

Caryophyllaceae	Tufted Pearlwort	*Sagina caespitosa*	Not seen				
Caryophyllaceae	Snow Pearlwort	*Sagina nivalis*	new	O	collected	O	YES
Caryophyllaceae	Moss Campion	*Silene acaulis*	collected	U	seen	U	YES
Caryophyllaceae	Arctic Catchfly	*Silene involucrata* subsp. *involucrata*			collected	O	NO
Caryophyllaceae	Taimyr Catchfly	*Silene ostenfeldii*			seen	R	YES
Caryophyllaceae	Nodding Catchfly	*Silene uralensis* subsp. *arctica*	Not seen	O			YES
Caryophyllaceae	Nodding Catchfly	*Silene uralensis* subsp. *uralensis*	collected	C	seen	U	YES
Caryophyllaceae	Fleshy Stitchwort	*Stellaria crassifolia*	Not seen				
Caryophyllaceae	Saltmarsh Starwort	*Stellaria humifusa*	collected	C	collected	O	YES
Caryophyllaceae	Long-stalked Starwort	*Stellaria longipes*	collected	C	collected	U	YES
Caryophyllaceae	One-flowered Starwort	*Stellaria monantha*			collected	C	YES
Ranunculaceae	Small-flowered Anemone	*Anemone parviflora*	collected	O			YES
Ranunculaceae	Prairie Crocus	*Anemone patens* var. *multifida*	Not seen				
Ranunculaceae	Arctic Yellow Marsh Marigold	*Caltha palustris* var. *arctica*			collected	R	YES
Ranunculaceae	Fan-like Yellow Marsh Marigold	*Caltha palustris* var. *flabellifolia*	collected	O	collected	O	YES
Ranunculaceae	White Water Buttercup	*Ranunculus aquatilis* (*subrigidus*)	Not seen	O			YES
Ranunculaceae	Seaside Buttercup	*Ranunculus cymbalaria*			collected	R	YES
Ranunculaceae	Gmelin's Water Buttercup	*Ranunculus gmelinii*	collected	R	seen	R	YES
Ranunculaceae	Far-northern Buttercup	*Ranunculus hyperboreus*	collected	U	collected	O	YES
Ranunculaceae	Lapland Buttercup	*Ranunculus lapponicus*			collected	R	NO
Ranunculaceae	Snow Buttercup	*Ranunculus nivalis*	collected	R	collected	R	YES
Ranunculaceae	Northern Buttercup	*Ranunculus pedatifidus* (*arcticus*)	collected	U	collected	U	YES
Ranunculaceae	Dwarf Buttercup	*Ranunculus pygmaeus*	collected	R	collected	R	YES

Papaveraceae	Polar Poppy	*Papaver dahlianum*	collected	C	collected	O	YES
Papaveraceae	Hulten's Poppy	*Papaver hultenii*	collected	C			YES
Papaveraceae	Lapland Poppy	*Papaver lapponicum*	?		?		
Papaveraceae	Arctic Poppy	*Papaver radicatum*	collected	C	collected	O	YES
Brassicaceae	Arctic Rockcress	*Arabidopsis arenicola*	new	R	collected	R	YES
Brassicaceae	Smooth Braya	*Braya glabella* subsp. *glabella*	collected	C	collected	U	YES
Brassicaceae	Purple Braya	*Braya glabella* subsp. *purpurascens*	collected	O	seen	O	YES
Brassicaceae	Alpine Northern Braya	*Braya humilis*	collected	O	collected	O	YES
Brassicaceae	Richardson's Bittercress	*Cardamine digitata*	collected	C	seen	C	YES
Brassicaceae	Nyman's Bittercress	*Cardamine nymanii*	collected	C			YES
Brassicaceae	Greenland Scurvy-grass	*Cochlearia groenlandica*	collected	C	collected	O	YES
Brassicaceae	Northern Tansy Mustard	*Descurainia sophioides*	collected	C	collected	O	YES
Brassicaceae	Alpine Draba	*Draba alpina*	?		?		
Brassicaceae	Arctic Draba	*Draba arctica*	Not seen				
Brassicaceae	Fellfield Draba	*Draba arctogena*	Not seen				
Brassicaceae	Boreal Draba	*Draba borealis*	Not seen		collected	R	NO
Brassicaceae	Gray-leaved Draba	*Draba cinerea*	collected	A	collected	C	YES
Brassicaceae	Flat-topped Draba	*Draba corymbosa*	collected	C	collected	U	YES
Brassicaceae	Rock Draba	*Draba glabella*	collected	C	collected	A	YES
Brassicaceae	Long-stalked Draba	*Draba juvenilis*	collected	R			YES
Brassicaceae	Milky Draba	*Draba lactea*	collected	U	collected	U	NO
Brassicaceae	Small-flowered Draba	*Draba micropetala*	Not seen				
Brassicaceae	Snow Draba	*Draba nivalis*	collected	U	collected	A	YES

Brassicaceae	Norwegian Draba	*Draba norvegica*	Not seen				
Brassicaceae	Canadian Arctic Draba	*Draba oblongata*	?		?	O	?
Brassicaceae	Hairy Draba	*Draba pilosa*	new	C	collected	U	YES
Brassicaceae	Simmon's Draba	*Draba simmonsii*	?	C	?	O	YES
Brassicaceae	Ellesmere Island Draba	*Draba subcapitata*	collected	U	collected	O	YES
Brassicaceae	Pallas' Wallflower	*Erysimum pallasii*	collected	O	collected	O	YES
Brassicaceae	Edward's Mock Wallflower	*Eutrema edwardsii*	collected	C	seen	U	YES
Brassicaceae	Arctic False Wallflower	*Parrya arctica*	collected	O	collected	C	YES
Brassicaceae	Arctic Bladderpod	*Physaria arctica* (*Lesquerella arctica*)	collected	C	collected	O	YES
Brassicaceae	Soft Fissurewort	*Transberingia bursifolia* (*Halimolobos mollis*)	new	R			YES
Saxifragaceae	Rosendahl's Golden-saxifrage	*Chrysosplenium rosendahlii*	collected	C	collected	O	YES
Saxifragaceae	Northern Golden Saxifrage	*Chrysosplenium tetrandrum*	Not seen				
Saxifragaceae	Hawkweed-leaved Saxifrage	*Micranthes hieraciifolia*	collected	R	collected	O	YES
Saxifragaceae	Snow Saxifrage	*Micranthes nivalis*			collected	C	YES
Saxifragaceae	Red-haired Saxifrage	*Micranthes rufopilosa*	new	O	?		YES
Saxifragaceae	Kotzebue’s Grass-of-Parnassus	*Parnassia kotzebuei*	Not seen				
Saxifragaceae	Marsh Grass-of-Parnassus	*Parnassia palustris*			seen	R	YES
Saxifragaceae	Yellow Mountain Saxifrage	*Saxifraga aizoides*	collected	O	collected	R	YES
Saxifragaceae	Tufted Saxifrage	*Saxifraga caespitosa*	collected	C	collected	O	YES
Saxifragaceae	Nodding Saxifrage	*Saxifraga cernua*	collected	U	collected	C	YES
Saxifragaceae	Yellow Marsh Saxifrage	*Saxifraga hirculus*	collected	C	collected	U	YES
Saxifragaceae	Pygmy Saxifrage	*Saxifraga hyperborea*	Not seen				

Saxifragaceae	Purple Mountain Saxifrage	*Saxifraga oppositifolia*	collected	C	collected	C	YES
Saxifragaceae	Three-toothed Saxifrage	*Saxifraga tricuspidata*	collected	C	collected	A	YES
Rosaceae	Marsh Cinquefoil	*Comarum palustre* (*Potentilla palustris*)			collected	R	NO
Rosaceae	Entire-leaved Mountain Avens	*Dryas integrifolia* subsp. *integrifolia*	collected	A	collected	A	YES
Rosaceae	Entire-leaved Mountain Avens	*Dryas integrifolia* subsp. *sylvatica*	collected	A			YES
Rosaceae	Bluff Cinquefoil	*Potentilla arenosa* subsp. *arenosa*	collected	O	collected	C	YES
Rosaceae	Bluff Cinquefoil	*Potentilla arenosa* subsp. *chamissonis*			collected	U	YES
Rosaceae	Egede's Silverweed	*Potentilla egedii*			collected	U	YES
Rosaceae	Arctic Cinquefoil	*Potentilla hyparctica*			collected	O	YES
Rosaceae	Snow Cinquefoil	*Potentilla nivea*	collected	R			YES
Rosaceae	Pretty Cinquefoil	*Potentilla pulchella*	collected	U	collected	R	YES
Rosaceae	Red-stemmed Cinquefoil	*Potentilla rubricaulis*	collected	R	collected	R	YES
Rosaceae	Yurtsev's Cinquefoil	*Potentilla subgorodkovii*			collected	R	YES
Rosaceae	Tikhomirov's Cinquefoil	*Potentilla tikhomirovii*	collected	O			
Rosaceae	Cloudberry	*Rubus chamaemorus*			collected	R	NO
Fabaceae	Alpine Milk-vetch	*Astragalus alpinus*	collected	C	seen	U	YES
Fabaceae	Richardson's Milk-vetch	*Astragalus richardsonii* (*australis*)	collected	C	collected	U	YES
Fabaceae	Alpine Sweet-vetch	*Hedysarum alpinum*			collected	O	YES
Fabaceae	Northern Sweet-vetch	*Hedysarum boreale* subsp. *mackenziei*	collected	C	seen	U	YES
Fabaceae	Alpine Sainfoin	*Hedysarum hedysaroides*			collected	R	NO
Fabaceae	Arctic Lupine	*Lupinus arcticus*	Not seen				
Fabaceae	Arctic Locoweed	*Oxytropis arctica*	collected	C	collected	U	YES
Fabaceae	Blackish Locoweed	*Oxytropis arctobia* (*nigrescens var.*	collected	C	collected	U	YES

		uniflora)					
Fabaceae	Maydell's Locoweed	*Oxytropis maydelliana*	collected	A	seen	C	YES
Empetraceae	Black Crowberry	*Empetrum nigrum*			seen	C	YES
Onagraceae	River Beauty	*Chamerion latifolium*	collected	C	seen	A	YES
Onagraceae	Arctic Willowherb	*Epilobium arcticum*	collected	O			YES
Hippuridaceae	Lance-leaved Mare's-tail	*Hippuris lanceolata*	collected	C	collected	O	YES
Haloragaceae	Common Mare's-tail	*Hippuris vulgaris*	Not seen				
Haloragaceae	Siberian Water Milfoil	*Myriophyllum sibiricum*	collected	R			YES
Pyrolaceae	One-sided Wintergreen	*Orthilia secunda*			collected	O	NO
Pyrolaceae	Arctic Pyrola	*Pyrola grandiflora*			collected	C	YES
Ericaceae	Alpine Bearberry	*Arctous alpina*	Not seen		collected	U	NO
Ericaceae	Red Bearberry	*Arctous rubra*	collected	O	collected	U	YES
Ericaceae	Four-Angled Mountain Heather	*Cassiope tetragona* subsp. *tetragona*	collected	C	collected	A	YES
Ericaceae	Lapland Rosebay	*Rhododendron lapponicum*			collected	O	YES
Ericaceae	Marsh Labrador Tea	*Rhododendron tomentosum*	Not seen		collected	U	YES
Ericaceae	Alpine Bilberry	*Vaccinium uliginosum*	collected	O	collected	U	YES
Ericaceae	Mountain Cranberry	*Vaccinium vitis-idaea*			collected	U	YES
Primulaceae	Sweet-flowered Fairy-candelabra	*Androsace chamaejasme*	Not seen				
Primulaceae	Northern Fairy-candelabra	*Androsace septentrionalis*	collected	U	collected	O	YES
Plumbaginaceae	Sea Thrift	*Armeria scabra*	collected	O	collected	O	YES
Boraginaceae	Sea Lungwort	*Mertensia maritima* subsp. *tenella*	collected	U			YES
Scrophulariaceae	Elegant Paintbrush	*Castilleja elegans*	collected	O	collected	U	YES
Scrophulariaceae	Pale Paintbrush	*Castilleja pallida var. caudata*			collected	R	NO

Scrophulariaceae	Sudeten Lousewort	*Pedicularis albolabiata* (*sudetica*)	collected	C	collected	C	YES
Scrophulariaceae	Capitate Lousewort	*Pedicularis capitata*	collected	C	seen	U	YES
Scrophulariaceae	Labrador Lousewort	*Pedicularis labradorica*			collected	O	NO
Scrophulariaceae	Woolly Lousewort	*Pedicularis lanata*	collected	C	collected	C	YES
Scrophulariaceae	Langsdorff's Lousewort	*Pedicularis langsdorfii*	collected	C	Seen	O	YES
Scrophulariaceae	Lapland Lousewort	*Pedicularis lapponica*			collected	R	YES
Plantaginaceae	Hairy Plantain	*Plantago canescens*	Johann (new)	R			YES
Asteraceae	Common Yarrow	*Achillea millefolium*			collected	R	YES
Asteraceae	Fries' Pussytoes	*Antennaria friesiana*	collected	R	collected	O	YES
Asteraceae	Narrow-leaved Arnica	*Arnica angustifolia*			collected	O	NO
Asteraceae	Boreal Wormwood	*Artemisia borealis* subsp*. richardsoniana*			collected	R	YES
Asteraceae	Tilesius' Wormwood	*Artemisia tilesii*	new	R	collected	R	YES
Asteraceae	Low Fleabane	*Erigeron humilis*	Johann	R	collected	U	YES
Asteraceae	One-flowered Fleabane	*Erigeron uniflorus* subsp. *eriocephalus*	Johann	R	collected	R	YES
Asteraceae	Siberian Aster	*Eurybia sibirica*			collected	R	NO
Asteraceae	Entire-leaved Daisy	*Hulteniella integrifolia*	collected	C	collected	U	YES
Asteraceae	Northern Sweet Coltsfoot	*Petasites frigidus*			collected	R	YES
Asteraceae	Narrow-leaved Sawwort	*Saussurea angustifolia* subsp*. angustifolia*			collected	O	NO
Asteraceae	Pygmy Aster	*Symphyotrichum pygmaeum*	Johann (new)	R			YES
Asteraceae	Horned Dandelion	*Taraxacum ceratophorum*			collected	U	YES
Asteraceae	Holmen's Dandelion	*Taraxacum holmenianum*	collected	O	seen	O	YES
Asteraceae	High Arctic Dandelion	*Taraxacum hyparcticum* (*hyperarcticum*)	?		?		
Asteraceae	Harp Dandelion	*Taraxacum phymatocarpum*	collected	U	collected	U	YES

Asteraceae	Purple-haired Groundsel	*Tephroseris frigida*			collected	U	YES
Asteraceae	Marsh Ragwort	*Tephroseris palustris* subsp. *congesta*	collected	C	seen	O	YES
Asteraceae	Seashore Chamomile	*Tripleurospermum maritimum* subsp. *phaeocephalum*	collected	C	seen	O	YES

Bird Monitoring Pilot

All work completed and reported by Joachim Obst, ornithologist

Rationale

The wide-ranging impacts of climate change on tundra vegetation, wildlife habitats and breeding bird population trends are poorly understood. Data from ongoing studies on Arctic and Subarctic tundra birds (Obst 2014a and b, 2012a and 2011a) indicate that climate change is causing rapid growth and proliferation of shrubs and vegetation, alteration of nesting habitats and wetlands, and severe weather conditions during the critical nesting period of tundra birds. These impacts are negative in the long term for the stability of the breeding populations for many tundra bird species.

Some Subarctic species of tundra breeding birds are gradually moving north into the Arctic while the populations of certain Subarctic and Arctic bird species are declining including species ranked as "Special Concern" and/or "May Be At Risk" by COSEWIC (Committee on the Status of Endangered Wildlife In Canada). The status of additional breeding birds such as loons, waterfowl, shorebirds and songbirds is largely unknown but of concern in the Arctic. Some of these birds include Valued Ecosystem Components (VECs) such as traditional game birds and birds of cultural importance.

Birds are indicator species of habitat and environmental changes and can be monitored more easily than any other wildlife. Therefore, the proposed long-term monitoring program will record changes of breeding densities, bird communities, and habitats, in order to monitor trends of breeding bird populations and to document the broader effects of climate change on wildlife habitats.

Methods

From June 19–27, 2014, areas beside gravel roads and tracks that were within 2–18 km of Cambridge Bay were scanned with binoculars for seven half-days. Two all-terrain vehicles (ATVs) were used for transporting a team of three along gravel roads. Recorded were the observed numbers and pairs of birds and bird species, as well as evidence of breeding, suspected breeders and types of available nesting habitats. The GPS locations of birds, nest sites and nesting habitats were marked on maps. Observations regarding wildlife, plants, weather, and the activities of local people on the land were noted.

Results

From June 19–27, 2014, a total of 37 bird species were observed in the current CHARS study area at Cambridge Bay, including 18 species of confirmed breeding birds, 12 species of suspected breeders, six summer residents, and a vagrant species outside its range (Table 5). A total of 1,993 birds were recorded during the observation period (Table 6). The most common birds observed, in descending order, were longspurs, eiders, sandpipers, gulls and geese (Table 7).

Conclusions and Recommendations

The available field survey time and logistical support were insufficient with regards to assessing the full potential of the current or preliminary CHARS study area for use as a long-term monitoring site for birds. Based on the observations from roads it appears that relatively undisturbed and potentially suitable study areas and plots are present in distances of 1–2 km from current roads and tracks.

It would be necessary to explore these off-road areas during more extensive field excursion trips in 2015 or 2016 in order to select suitable study plots. When selecting and establishing study plots and monitoring sites, it should be considered that infrastructure and human activities are likely to increase in the future, and that the expected influx of researchers in the field, especially after CHARS is fully operational, will also contribute to additional negative effects on breeding birds even in currently less disturbed areas.

For shorebirds and songbirds, the bird species diversity and the abundance of nesting birds in the current CHARS study area certainly are sufficient for long-term monitoring programs. However, for larger birds such as loons, waterfowl, water birds, raptors and owls, it would be necessary to identify and establish much larger and more distant study areas involving aerial surveys.

The identification of suitable study plots and monitoring sites within the current CHARS study area, identified larger study areas for larger birds, and initial baseline data collections need to be addressed before rigorous protocols can be developed for long-term monitoring programs documenting climate change effects on habitats, breeding densities, reproduction and bird population trends.

Table 5. Breeding status of bird species observed in the CHARS study area, Cambridge Bay, Nunavut, June19–27, 2014.

#	Common Name	Scientific Name	Status Code
1	Red-throated Loon	*Gavia stellata*	b / U
2	Pacific Loon	*Gavia pacifica*	b / C
3	Yellow-billed Loon	*Gavia adamsii*	b / C
4	Tundra Swan	*Cygnus columbianus*	b / C
5	Greater White-fronted Goose	*Anser albifrons*	B / C
6	Lesser Snow Goose	*Anser caerulescens*	sr / M
7	Canada Goose	*Branta canadensis*	B / C
8	Brant	*Branta bernicla*	sr / R
9	Northern Pintail	*Anas acuta*	b / U
10	Long-tailed Duck	*Clangula hyemalis*	b / C
11	King Eider	*Somateria spectabilis*	B / C
12	Common Eider	*Somateria mollissima*	b / U
13	Rough-legged Hawk	*Buteo lagopus*	B / U
14	Sandhill Crane	*Grus canadensis*	b / U
15	Black-bellied Plover	*Pluvialis squatarola*	B / U
16	American Golden Plover	*Pluvialis dominica*	B / U
17	Semipalmated Plover	*Charadrius semipalmatus*	B / U
18	Baird's Sandpiper	*Calidris bairdii*	sr / R
19	Semipalmated Sandpiper	*Calidris pusilla*	B / C
20	Pectoral Sandpiper	*Calidris melanotos*	B / U
21	Stilt Sandpiper	*Calidris himantopus*	b / U
22	Red-necked Phalarope	*Phalaropus lobatus*	B / C
23	Red Phalarope	*Phalaropus fulicarius*	B / C
24	Parasitic Jaeger	*Stercorarius parasiticus*	B / U
25	Long-tailed Jaeger	*Stercorarius longicaudus*	B / C
26	Sabine's Gull	*Xema sabini*	B / C

Table 1: con't

27	Thayer's Gull	*Larus thayeri*	sr / C
28	Glaucous Gull	*Larus hyperboreus*	sr / C
29	Arctic Tern	*Sterna paradisaea*	sr / U
30	Common Raven	*Corvus corax*	B / C
31	Horned Lark	*Eremophila alpestris*	B / C
32	Varied Thrush	*Ixoreus naevius*	V / R
33	American Pipit	*Anthus rubescens*	b / U
34	White-crowned Sparrow	*Zonotrichia leucophrys*	b / U
35	Lapland Longspur	*Calcarius lapponicus*	B / C
36	Snow Bunting	*Plectrophenax nivalis*	B / C
37	Hoary Redpoll	*Carduelis hornemanni*	b / U

Codes: B = confirmed Breeder; b = suspected breeder; sr = summer resident;

V = Vagrant outside range; C = Common; U = Uncommon; R = Rare.

A detailed proposal to develop long term monitoring of all resident and migratory birds in the CHARS area is included in the original report on bird monitoring prepared by Joachim Obst. Some general recommendations to establish a long-term bird monitoring program at CHARS include:

1. explore off-road areas during extensive ground surveys on foot in 2015 or 2016 in order to identify and establish suitable study plots and monitoring sites for birds and nesting habitats in undisturbed areas within 1 - 2 km of current roads and tracks.
2. conduct aerial reconnaissance survey for identifying suitable study areas for larger birds such as loons, waterfowl and raptors in 2015 or 2016.
3. collect initial baseline data on breeding birds and habitats in both the current CHARS study area and in the larger study areas in 2015 and/or 2016.
4. recommended priority target species in descending order are loons, shorebirds, songbirds, and raptors while including all other bird species during studies of these target species.
5. to develop protocols for long-term monitoring programs to document climate change effects on habitats, breeding densities, reproduction and bird population trends, the following need to be in place: appropriate time budget, funding, baseline data, and identified suitable monitoring sites or areas.

Table 6. Daily numbers of birds observed in the CHARS study area, Cambridge Bay, Nunavut, June 19–27, 2014.

#	Common Name (June)	19	20	21	22	23	24	25	25	25	26	Total
1	Red-throated Loon				2							2
2	Pacific Loon	2	8	8				4			8	30
3	Yellow-billed Loon		2	2				4			4	12
4	Tundra Swan	2	8	6				6		4		26
5	Greater White-fronted Goose	40	60	2	2			8	6	20		138
6	Lesser Snow Goose	5	21									26
7	Canada Goose	20	60	2	4	4		12	4	12		118
8	Brant										4	4
9	Northern Pintail			4	1						4	9
10	Long-tailed Duck	8	12		8		2	6		12		48
11	King Eider	30	50	60	8	2	2	30	4	40	2	228
12	Common Eider		8	4								12
13	Rough-legged Hawk		2				1	1		1		5
14	Sandhill Crane	1	2	2	2		4	4		4	1	20
15	Black-bellied Plover	1	4	5				4				14
16	American Golden Plover	2	1		2		6	2		2		15
17	Semipalmated Plover	4	4	4	2	2		1			2	19
18	Baird's Sandpiper			2								2
19	Semipalmated Sandpiper	4	60	50	14	12	4	22		20	12	198
20	Pectoral Sandpiper	2	20	10	2		1	1		1	2	39
21	Stilt Sandpiper	2	1	1				1				5
22	Red-necked Phalarope		1	10				2		2	14	29
23	Red Phalarope		2	13			2	2		4	6	29
24	Parasitic Jaeger	1	6	2	2			6			2	19
25	Long-tailed Jaeger		1	8	3		2					14
26	Sabine's Gull	4	7	12	2			12		2	6	45
27	Thayer's Gull	8	10	20			8	20		5	15	86
28	Glaucous Gull	20	30	40	10	8	6	40		10	25	189
29	Arctic Tern	1	2		2							5
30	Common Raven	1	5		1	1	2	1		1	2	14
31	Horned Lark	1	7	20			4	6	4	20	3	65
32	Varied Thrush						1		1		1	3
33	American Pipit	1	1	1							1	4
34	White-crowned Sparrow	1	2	2	2	2	2		2		2	15
35	Lapland Longspur	17	100	60	12	12	40	40	40	50	12	383
36	Snow Bunting	12	20	20	6	6	10	8	6	8	6	102
37	Hoary Redpoll	2	3	2	2	2	2		4		4	21
Highlights = Locations:												**1993**

- within 1 km SW + W of CHARS house (light grey)
- within 200m S of CHARS house (dark grey)
- road - hamlet to Mount Pelly/Greiner Lk. (yellow)
- road - hamlet to Long Point Beach (orange)
- at #2 slug site (green)
- DEW Line road (blue)

Table 7. Daily numbers of birds, sorted in descending order, observed in the CHARS study area, Cambridge Bay, Nunavut, June 19–27, 2014.

#	Common Name June	19	20	21	22	23	24	25	25	25	26	Total
1	Red-throated Loon				2							2
18	Baird's Sandpiper			2								2
32	Varied Thrush						1		1		1	3
8	Brant										4	4
33	American Pipit	1	1	1							1	4
13	Rough-legged Hawk		2				1	1		1		5
21	Stilt Sandpiper	2	1	1				1				5
29	Arctic Tern	1	2		2							5
9	Northern Pintail			4	1						4	9
3	Yellow-billed Loon		2	2				4			4	12
12	Common Eider		8	4								12
15	Black-bellied Plover	1	4	5				4				14
25	Long-tailed Jaeger		1	8	3		2					14
30	Common Raven	1	5		1	1	2	1		1	2	14
16	American Golden Plover	2	1		2		6	2		2		15
34	White-crowned Sparrow	1	2	2	2	2	2		2		2	15
17	Semipalmated Plover	4	4	4	2	2		1			2	19
24	Parasitic Jaeger	1	6	2	2			6			2	19
14	Sandhill Crane	1	2	2	2		4	4		4	1	20
37	Hoary Redpoll	2	3	2	2	2	2		4		4	21
4	Tundra Swan	2	8	6				6		4		26
6	Lesser Snow Goose	5	21									26
22	Red-necked Phalarope		1	10				2		2	14	29
23	Red Phalarope		2	13			2	2		4	6	29
2	Pacific Loon	2	8	8				4			8	30
20	Pectoral Sandpiper	2	20	10	2		1	1		1	2	39
26	Sabine's Gull	4	7	12	2			12		2	6	45
10	Long-tailed Duck	8	12		8		2	6		12		48
31	Horned Lark	1	7	20			4	6	4	20	3	65
27	Thayer's Gull	8	10	20			8	20		5	15	86
36	Snow Bunting	12	20	20	6	6	10	8	6	8	6	102
7	Canada Goose	20	60	2	4	4		12	4	12		118
5	Greater White-fronted Goose	40	60	2	2			8	6	20		138
28	Glaucous Gull	20	30	40	10	8	6	40		10	25	189
19	Semipalmated Sandpiper	4	60	50	14	12	4	22		20	12	198
11	King Eider	30	50	60	8	2	2	30	4	40	2	228
35	Lapland Longspur	17	100	60	12	12	40	40	40	50	12	383
Highlights = Locations:												1993
within 1 km SW + W of CHARS house		road - hamlet to Mount Pelly/Greiner Lk.						at #2 slug site				
within 200m S of CHARS house		road - hamlet to Long Point Beach						DEW Line road				

Going Forward

For all of the reasons discussed here, annual and comprehensive monitoring of birds in the CHARS area will make up an important component of the CHARS monitoring program. Bird monitoring methodologies that will be explored in 2015 will include:

- Standard 10 minute point count protocols
- Breeding Bird Surveys along roads and
- Mountain Bird Monitoring Protocols

It will be evaluated which one of these protocols are most suitable for Arctic bird monitoring under various circumstances with the aim to have standardized and quantifiable approaches. As for other pilots, the approach will be to integrate bird monitoring and bird research with the whole of ecosystem monitoring proposed for selected areas in the Greiner Watershed. As recommend in this report, the ecosystem classification and mapping of terrestrial ecosystems will be used to identify key songbird and shorebird habitats so that data on habitat change can be correlated with changes in bird populations. Much broader areas are required to effectively monitor change in wider ranging species such as raptors and waterfowl. In some cases it may be decided to invest in the monitoring of certain focal species, such as yellow-billed loons, which can be linked to ecosystem processes in lake systems and have important conservation status. Work in future years will address these issues so that a comprehensive and cost-effective approach to bird monitoring can be implemented by 2018–2019.

Arthropod Biodiversity Monitoring Pilot

Chris Buddle[9]

Introduction

There are thousands of species of arthropods (insects, spiders and their relatives) occurring in the Canadian Arctic, and these animals perform numerous key ecological functions, from pollination to acting as key food for vertebrates. A recent project on Arctic arthropods (NSERC Strategic Grant, titled **Ecological Structure of Northern Arthropods: Adaptation to a Changing Environment**) included Cambridge Bay as a key study site, and field teams collected arthropods during a field visit in 2011. Additional collections were done in 2013, in collaboration with Donald McLennan (Canadian High Arctic Research Station). This report serves to provide preliminary findings from these collections, to highlight aspects of arthropod diversity on Victoria Island.

Results

Spiders (*Araneae*)

Twenty-two species of spiders are known from Cambridge Bay (Table 8); this was the original number of species known after field collections in 2011 (as reported by Loboda, 2013) and no additional species were discovered in 2013. This is a drop in the number of species on the mainland; for example, we have documented 35 species in Kugluktuk, and parts of the Yukon are known to have over 130 spider species. In general, the spider fauna from Cambridge bay is dominated by Lycosidae (wolf spiders) in terms of abundance and biomass (Figure 32), but the Linyphiidae (micro-sheet webs spiders) dominate the diversity. Our collections in Cambridge Bay documented the first occurrence of long-jawed orb-web (Tetragnathidae) species *Pachygnatha clerckii* in Nunavut.

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Figure 32. Wolf Spiders (Lycosidae).

Table 8. Spider species known from Cambridge Bay.

Family	Species
Linyphiidae	*Agyneta olivacea* (Simon)
	Baryphyma kulczynskii (Eskov)
	Diplocephalus barbiger (Roewer)
	Hilaira vexatrix (O.P.-Cambridge)
	Meioneta amersaxatilis (Saaristo & Koponen)
	Tarsiphantes latithorax (Strand)
	Walckenaeria karpinskii (O.P.-Cambridge)
	Hilaira proletaria (L.Koch)
	Hybauchenidium aquilonare (L.Koch)
	Masikia indistincta (Kulczynski)
	Meioneta maritima (Emerton)
	Semljicola beringianus (Eskov)
	Silometopoides pampia (Chamberlin)
	Agyneta olivacea (Simon)
	Erigone arctica (White)

	Erigone psychrophila (Thorell)
	Baryphyma groenlandicum (Holm)
Tetragnathidae	*Pachygnatha clerckii* (Sundevall)*
Dictynidae	*Emblyna borealis* (O.P.-Cambridge)
Lycosidae	*Alopecosa exasperans* (O.P.-Cambridge)
	Alopecosa hirtipes (Kulczynski)
	Pardosa algens (Kulczynski)
Thomisidae	*Xysticus deichmanni* (Sorensen)

*denotes a new Territorial record

Beetles (Coleoptera)

Beetles are among the most diverse animals on the planet, and there are certainly many species known from Arctic Canada. Beetles collected from field sampling in 2011 have been partially sorted and identified, and we believe about 10 or more species of beetles should occur in the vicinity of Cambridge Bay. To date, the following Carabidae (ground beetles) are identified from Cambridge Bay: *Agonum exerratum*, *Amara alpina, Pterostichus brevicornis, Pterostichus caribou*, and *Pterostichus vermiculosus*. The weevil (Curculionidae) *Lepyrus nordenskioeldi* also occurs in the region. Latridiidae and Staphylinidae have not yet been identified, and some additional unsorted material will surely yield additional species. For example, Ernst and Buddle (2013) have reported 50 species in Kugluktuk, and 11 of those species were new Territorial records.

Black Flies (Diptera, Simuliidae)

Collections of black flies in 2013 were productive as the following species were sampled from local streams and rivers:

Cnephia eremites
Metacnephia borealis
Simulium baffinense
Simulium gigantium
Simulium tuberosum complex
Simulium venustum/verecundum complex (including, minimally, *S. rostratum*)

Of interest, only two of these species (*C. eremites* and *M. borealis*) were previously known from Victoria Island. Of the aforementioned species, *S. giganteum, S. tuberosum* and *S. venustum/verecundum* are all known as blood-feeders, and thus it is of interest to the local human population that these black flies are present in the vicinity of Cambridge Bay.

Other flies

Other families of flies are dominant in the Arctic, but many are taxonomically difficult to identify. To date, MSc student Meagan Blair identified 10 species of flies in the family in the Scathophagidae family (Blair, 2013). Ongoing research at the Lyman Entomological Museum will eventually produce species inventories for many other families including, for example, the Muscidae, Chloropidae, and the Piophilidae. MSc student Patrick Schaefer will also eventually report on the mosquitoes from Cambridge Bay (Culicidae).

Parasitoid Wasps (Hymenoptera, various families)

Parasitoid wasps are species that use other insects as hosts, and they show high diversity in northern regions. These wasps, globally, are considered one of the true 'hyper-diverse' taxa, and numerous additional species will be uncovered as additional sampling occurs in and around Cambridge Bay. To date, 15 taxa are known, but many of these cannot be identified to species, in general because of poor taxonomic knowledge (Table 9).

Table 9. Parasitoid wasps from Cambrdige Bay.

Family or sub-family	**Genus (if known)**	**Species (if known)**
Adelognathinae	*Adelognathus*	*sp.*
Banchinae	*Glypta*	*sp(p).*
Banchinae	*Lissonota*	*sp.*
Campopleginae	.	.
Cryptinae	.	.
Ctenopelmatinae	.	.
Diplazontinae	*Homotropus*	*alaskensis*
Diplazontinae	*Sussaba*	*rugipleuris*
Diplazontinae	*Tymmophorus*	*gelidus*
Ichneumoninae	*Ichneumon*	*sp(p).*
Metopiinae	*Exochus*	*pullatus*
Orthocentrinae	*Orthocentrus*	*sp(p).*
Orthocentrinae	*Stenomacrus*	*sp.*
Pimplinae	*Delomerista*	*laevis*

Tryphoninae	*Ctenochira*	*sp,*

Other taxa

To date, specimen sorting and identifications continue. Results to come include species-level identification of additional *Diptera* families, and bumble bees (*Hymenoptera*).

Summary

With relatively little sampling, this preliminary report documents over 50 taxa of arthropods are reported from Cambridge Bay. Additional sampling, sorting and monitoring efforts will vastly increase this number, although it is expected that most of the species of black fly, spider, and beetle species are now known from Cambridge Bay.

Acknowledgements

Many colleagues and students have been involved in specimen sorting and identifications. The following individuals are thanked for offering preliminary results for this report: Doug Currie, Cyrstal Ernst, Meagan Blair, Sarah Loboda, Laura Timms, Anna Solecki, Terry Wheeler, and others.

Summary of Research on the Health of Muskoxen in the CHARS ERA and Southern Victoria Island

Introduction

Muskoxen are undergoing substantial declines in the area of the CHARS ERA, on southern Victoria Island, and in other regions of the Canadian Arctic archipelago. Surveys of the two largest populations in 2014, those on Banks and Victoria Islands, demonstrated more than a 50% decline since previous surveys (2010 Banks Island, 1999 Victoria Island) (M. Branigan and L. Leclerc, pers. comm.). Several unusual mortality events and emergence of new diseases have been observed on both these islands since 2010. These include (i) multiple severe, acute and widespread mid-summer mortality events on Banks and Victoria Islands (Northwest Territories and Nunavut) associated with *Erysipelothrix rhusiopathiae*, a bacterium not previously reported in muskoxen, nor in the Arctic (Kutz et al, in press), (ii) emergence and rapid range expansion of two protostrongylid lungworms (*Umingmakstrongylus pallikuukensis* and *Varestrongylus* sp.) on Victoria Island, and, (iii) the emergence of severe contagious ecthyma, or 'orf'-like lesions (M. Tomaselli and F. Van der Meer, unpubl. data). The disease events of different etiologies suggest changes in ecological conditions and cumulative stressors culminating in disease and mortality with substantial population level impacts. Muskoxen are exquisitely well adapted for the arctic environment, which makes them particularly susceptible to new environmental stressors, such as ongoing and increasing climate change and invasion of new pathogens.

A number of projects are ongoing to begin to answer some of these important questions around the changes in muskoxen health and abundance in and around Cambridge Bay and the CHARS ERA. These are summarized below for four ongoing projects.

Project 1: Non-invasive tools for assessing health and guiding conservation of muskoxen in a changing Arctic

Nora Navarro, Post-Doctoral Researcher – University of Calgary

This research aims to develop robust indicators and predictors of muskox health that can be incorporated into community-based surveillance programs. To do this, we will evaluate the health status of several muskox populations on different population trajectories and determine if hair glucocorticoids can be used as an index of individual and population health. Glucocorticoids are produced in response to stress and incorporated into hair and feathers, and have been used as retrospective markers of stress in bears and prospective markers of survival in birds. For muskoxen, the thick undercoat (qiviut) that is produced and shed annually may provide measures of seasonal summer stress, whereas guard hairs are produced throughout the lifetime and rarely shed, thus providing a long-term stress measure.

Specifically this project will:

1. Evaluate the use of qiviut glucocorticoids as indicator of individual health in muskoxen.
2. Detect differences in glucocorticoids in guard hairs between populations differing in their trajectory.

Methods

The Kutz Research Group has developed a standardized sampling kit for muskoxen, which includes those variables most important to health assessment. These are: filter paper blood (for assessing exposure to diseases), hair (for measures of stress), feces (for parasite detection and quantification), the metatarsus and the depth of the back fat (as measures of size and body condition). In 2014, the muskox population around Cambridge Bay has been sampled in August–September and October–November, and a total of 49 sampling kits have been received. The collection of samples has been done mainly in collaboration with a sport hunt outfitter and the guides, but also with individual hunters. Cortisol and corticosterone in prepared hair extractions have been determined by liquid chromatography – tandem mass spectrometry as described previously (Koren et al, 2012). Likewise, 30 kits have been sent to the wildlife office in Kugluktuk and samples are expected to be shipped soon to the University of Calgary.

Preliminary Results

The methodology (liquid chromatography- tandem mass spectrometry) for the quantification of glucocoirticoids in qiviut has been validated. Preliminary results show higher cortisol levels in populations that have undergone mortality events due to *E. rhusiopathiae* and extensive declines (Navarro-Gonzalez et al, 2014). The distribution of emerging lungworms is being documented, and a serological assay for *E. rhusiopathiae* has been validated. The identification of gastrointestinal parasites is ongoing.

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Project 2: Tracking and Predicting the Distribution and Range Expansion of muskox lungworms of the Canadian Arctic in relation to climate warming.

Pratap Kafle, MSc. Student - University of Calgary

Muskoxen (*Ovibos moschatus*) are an integral part of the arctic ecosystem with cultural, economic and ecological value (Gunn et al., 1990). Recently, two species of protostrongylid lungworms, *Umingmakstrongylus pallikuukensis* and *Varestrongylus eleguneniensis* were detected in muskoxen on Victoria Island, Nunavut (Figure 33). These two pathogenic lungworms, historically limited to the Canadian Arctic mainland, emerged on Victoria Island in 2008 and 2010, respectively (Hoberg et al., 1995; Kutz et al., 2013; Verocai et al., 2014). Since first detected on the southwestern part of the island, *U. pallikuukensis* has substantially expanded its range to the eastern and northern areas of Victoria Island in relatively short period of time. The geographic distribution of *V. eleguneniensis* on the island, is not well established, however, prevalence and intensity near the community of Cambridge Bay increased from 2010 (3.7%) to 2012(31%) (Kutz et. al., 2013). The invasion, establishment, and ongoing range expansion of *U. pallikuukensis*, and probably *V. eleguneniensis*, are thought to at least in part be associated with a warming climate that has become permissive for these parasites to complete the lifecycle on the island (Kutz et. al., 2013). Moreover, Isolating individual larva and sequencing ITS-2 gene has been the only method of larva identification that has underlying technical complexity and also enabling fewer larvae to be tested. It is, therefore, important to develop more robust and efficient method of larval identification to better diagnose the mixed infection and also understand where and how rapidly they are expanding. Anticipating areas of potential establishment will be key for successful management strategies

In 2014, we collected fecal samples from different areas of Victoria Island, focusing on areas east and north to areas previously sampled. Our team (myself, Dr. Kutz and two guides) were involved in field sampling in south East area of Victoria Island (Mount Pelly to Jayco Lake) and successfully collected 20 fecal samples. Another team lead by Lisa-Marie, regional biologist at Kugluktuk, sampled central and northern areas of Victoria Island, collecting over 150 fecal samples.

Objectives

The objectives of my project are: 1). to be able to differentiate first stage lungworm larvae based on larval morphology. 2). to determine the current range of muskox lungworms in the Canadian Arctic and 3). to use the degree-day modelling approach to understand the impact of climate warming in the observed range expansion and predict the future range of lungworms in climate warming scenarios.

Methodology

Detailed morphological and morphometric analysis of 25 larvae of each of *U. pallikuukensis* and *V. elegune*niensis was done which was confirmed by DNA analysis to find the morphological keys. These differences were consistent to each species thus established as keys for identification. Testing the larvae from different sources and confirming them with the established molecular methods was done for the validation of the keys.

To determine the geographic distribution fecal samples collected in the field were analyzed using the beaker Baermann technique for extraction of (L1) (Forrester & Lankester, 1997) and L1 was identified to the species level based on morphology keys developed.

Degree-days model using available satellite based temperature data is being used to generate historical, current and projected maps describing the potential range of these parasites under ongoing climate change.

Preliminary Results and Future Direction

A laboratory guide was prepared for differentiation of L1 of these lungworms (Manuscript submitted for publication).

Fecal samples collected in 2013 and 2014 were analysed. All samples from Banks Island (n=42), Melville (n=11), Axel Heiberg (n=12) and Ellesmere (n = 76) were negative, but samples analysed from Victoria Island to date shows overall high prevalence of L1 and prevalence and intensity of infection follows a southwest-northeast gradient. The relatively low prevalence and intensity (Larvae per gram) at the northern and eastern extremities suggests recent invasion.

Historical, current, and future distribution of lungworms is being modeled using established empirically based degree–day models for development of *U. pallikuukensis* in gastropod intermediate hosts and satellite-based temperature data from history to projected future. Aanlysis to date shows that, since the discovery of *U. pallikuukensis* in 1988 on the (western mainland of Nunavut), the geographic range has expanded substantially to the north and east. These observations are consistent with the predictions of the model suggesting the effect of climate warming in expanding range. This work is in progress and currently, I am working on predicted lungworms distribution in future under climate warming scenarios.

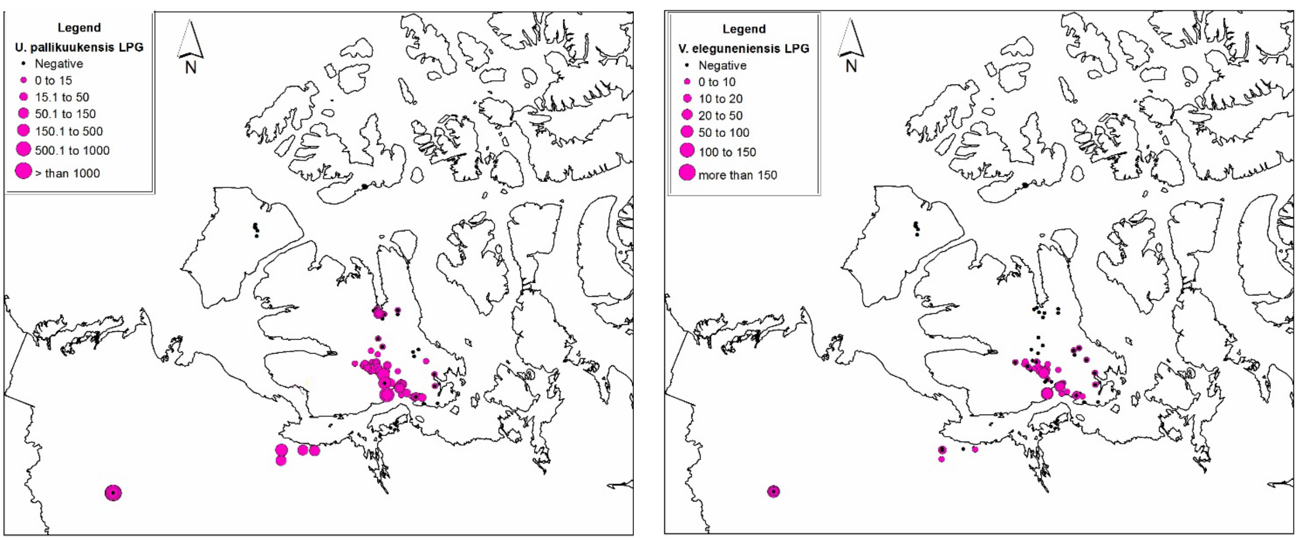

Figure 33. Distribution and infection intensities of Umingmakstrongylus pallikuukensis *and* Varestrongylus eleguniensis *in the Canadian Arctic (2013-2014).*

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Project 3: Diversity and Distribution of Gastropod Intermediate Hosts on South-eastern Victoria Island

Josh Sullivan, MSc. Student – University of Calgary

Introduction

Two species of protostrongylid lungworms recently emerged on Victoria Island, Nunavut. These are common lung-dwelling parasites of mainland muskoxen which can also infect caribou and moose (Kutz, Ducrocq et al. 2012). They have an indirect lifecycle and require a gastropod intermediate host for development and transmission (Figure 34). At high infection intensities lungworms can cause significant lung pathology, likely reducing lung capacity and potentially making the host more susceptible to predation (Kutz, Ducrocq et al. 2012). Muskoxen are a significant source of cultural, social, physical and economical health and welfare for northern people (Meakin and Kurvits 2009, Kutz, Checkley et al. 2013). Thus, it is critical to understand the patterns of invasion and transmission dynamics of these parasites.

In 2014, we resampled a series of sites from the previous field season, focusing on the habitats that produced gastropods in 2013 and using the technique that was successful in capturing gastropods (objective 1). We also sampled five locations spanning a latitudinal transect on Victoria Island to better understand the distribution of terrestrial gastropods (objective 2).

Figure 34. The terrestrial slug Deroceras laeve *that acts as an intermediate host for the muskoxen lungworm.*

Methods

Objective 1

Sampling locations: We sampled at five sites near the hamlet of Cambridge Bay. Four of the sites we sampled were sites that we also used in summer 2013.

Habitats: We sampled only fen, shrub-sedge and moist upland habitats as no gastropods were found in mesic habitats during the 2013 surveys and these were not characteristic gastropod habitats (Sturm, Pearce et al. 2006).

Sampling techniques: We used a dampened mat technique (Figure 35) in which sheets of quilting fabric (30 x 30cm) were soaked in pond water and laid out on the tundra for a 3.5 hour period in the late afternoon or early evening (Krull and Mapes 1974, Sturm, Pearce et al. 2006).

Sampling methodology: We did five sampling periods, one every two weeks between early July and early September. During each sampling period we sampled each of the locations twice over six days to account for any weather variations between days. At each location we sampled the three habitats using fifty mats spaced 2m apart from one another in 8 x 18m plots.

Figure 35. Layout of the dampened mat technique.

Objective 2

***Sampling locations**:* We selected five locations across a latitudinal transect on Victoria Island based on lungworm prevalence, climate maps (average summer temperature and precipitation) and logistical feasibility. Each location was sampled for a minimum of two nights.

Habitats: We sampled two suitable habitat types at each location: fen and shrub-sedge meadows.

Sampling techniques: Along with the dampened mat technique we used in objective 1 we also used a turf flooding technique (Kralka 1986). The dampened mat technique was used to detect gastropod presence and the turf flooding technique was used to determine abundance (Hawkins, Lankester et al. 1998, Oggier, Zschokke et al. 1998). Each mat was soaked with water from nearby ponds and then baited with 10mL of grape juice to attract gastropods.

Sampling methodology: Fifty mats and fifty pails were set up side-by-side and spaced 2m apart in an 18 x 8m plot in both habitats on the first evening. Mats were checked after 3.5 hours. On day two, mats from each plot were moved to a new site and were reset. In addition, another fifty mats per habitat were set out in a separate site and pails received a flooding. In the afternoon/evening all mats were checked and reset one mat width to the side of the original plot. Pails received a final flooding on the second night and all mats were checked and cleaned up. On the second and final morning all pails were checked and cleaned up.

Results

Objective 1: We found one species of terrestrial slug, *Deroceras laeve*, in low numbers at all sites near Cambridge Bay. We captured a total of 182 slugs in the three habitats sampled. The highest number of slugs per mat was in moist upland habitat (0.50 slugs/mat) followed by fen (0.19 slugs/mat) and shrub-sedge meadows (0.15 slugs/mat). Slugs were highly aggregated within habitats.

Objective 2: Both surveying techniques were successful in capturing the terrestrial slug, *D. laeve*, at two of the most southern sites we sampled in 2014. Data from the turf flooding technique indicate an abundance of 4.62 gastropods/m^2 at Byron Bay and an abundance of 1.30 gastropods/m^2 at Surrey Lake.

Discussion

During the sampling around Cambridge Bay we found that moist upland held the highest number of slugs per mat. Due to prolonged flooding in fen and shrub-sedge meadows during the spring it was expected that gastropods would move to higher grounds of moist upland habitat. However, we also found that fen habitats produced gastropods during each sampling period whereas other habitats were inconsistent. This suggests that although fen meadows did not produce the highest number of gastropods there still may be a preference for this habitat. Because *D. laeve* was the only species of gastropod recovered we believe that this is the main intermediate host for these parasites near Cambridge Bay. Thus, it is important to monitor the gastropod populations annually to detect increases in abundance, possible establishment of new species and to understand the seasonal phenology of *D. laeve* slugs in the Arctic.

During our remote sampling we found gastropods at the two southernmost sampling locations. All gastropods recovered were *D. laeve* slugs indicating that these are the key intermediate hosts for lungworm transmission in these regions. Relative abundance at these sites, measured using dampened mat data, was higher than the sampling locations near Cambridge Bay. This may suggest that living conditions are better at these locations or that Cambridge Bay was colonized more recently and slug populations are still becoming established. Due to the patchiness of terrestrial gastropods we cannot be sure that gastropods were not present at the more northern sampling locations.

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Project 4: Inuit Knowledge on muskoxen and caribou in the community of Ikaluktutiak, Victoria Island, Nunavut.

Matilde Tomaselli, MSc. Student – University of Calgary

Introduction

Muskoxen and caribou are two important species for ecosystem health in the Arctic. They are also an essential source of food for Arctic people and central to community well being, cultural heritage and identity (Giroux et al., 2012). Recent anecdotal and scientific evidence suggests that muskox population have declined around the community of Ikaluktutiak on Victoria Island (Nunavut, Canada) (Leclerc, 2014); moreover, mid-summer die-offs of muskoxen have been reported on both Bank Island and Victoria Islands (Northwest Territories and Nunavut, Canada) (Kutz et al., 2015). To gather baseline information on the health status of wild muskoxen, we designed a project in the community of Ikaluktutiak combining qualitative and quantitative research methods. Early on during the research we documented people observations and concerns also about caribou in the same area. We therefore implemented the project to gather baseline information on both wild ungulate species.

Participatory methods, originally developed in pastoral communities of Africa, were adapted to our context to gather Inuit ethno-veterinary knowledge about the wildlife that the local community depends on for subsistence (Mariner et al., 2000; Jost et al., 2007). During summer 2014, individuals were interviewed in the community of Ikaluktutiak to compile baseline information on local muskox and caribou abundance, distribution, health and changes over time (objective 1). The data gathered were then used to design the small-group interviews that were conducted in winter 2014 in the same community in order to quantify participants' perceptions of population abundance over time, changes in body condition status, relative prevalence of diseases, and observations of endemic and emergent diseases within the studied wildlife populations (objective 2).

Methods

Objective 1:

Semi-structured individual interviews conducted from July to September 2014 (N=30) (Figure 36). Purposeful sampling in collaboration with the local Hunters and Trappers Organization and the Kitikmeot Inuit Association. Thematic saturation approach to define the sample size, and thematic content analysis applied for data analysis (Daudt et al., 2013).

Figure 36. Moments captured during the interview process: mapping exercise (A) and proportional piling exercise (B).

Objective 2:

Small groups interviews (N=7) with 19 community members, conducted from November to December 2014 (Figure 37). Recruitment through purposeful sampling. Participatory exercises (mapping, proportional piling, drawing exercises, seasonal calendar) were applied during the interviews (Mariner et al., 2000).

Figure 37. Moments captured during the interview process: mapping exercise (A) and proportional piling exercise (B).

Results

Results will be available after community consultation for final validation of the findings.

Conclusion

The methods applied in the present study underline the importance of combined qualitative and participatory methods in the context of wildlife health surveillance in particular, and the value of community based participatory approaches for generating the kind of ethno-veterinary knowledge that is useful for wildlife disease monitoring in general. We believe that participatory methods could be a valuable tool to integrate Inuit knowledge in the context of wildlife health surveillance and monitoring with a perspective towards co-management.

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Studies of Freshwater Lakes and Streams in the CHARS ERA

Milla Rautio[10], Michael Power[11], Joseph Culp[12] and Fred Wrona[13]

The four researchers listed above have completed a first exploratory year of studies on freshwater systems in the CHARS ERA in summer 2014. They are all members of the CAFF CBMP Freshwater Expert Monitoring group and the intention is to conduct baseline studies in freshwater ecosystems in the CHARS ERA that will support the establishment of a freshwater monitoring program, linked through CAFF to freshwater monitoring across the circumpolar Arctic.

Project 1: First inventory of lakes and rivers on Victoria Island: 2014 field season trip report – Lead: Milla Rautio

The Canadian High Arctic Research Station (CHARS) at Cambridge Bay, Nunavut, will strengthen Canada's role as a leader in Arctic science and will allow for research that until now has not been possible or has been difficult to carry out in the North due to logistic constraints. The lack of state-of-art research facilities and common methodology to measure and monitor many environmental processes has hampered the ability to develop conceptual frameworks that could integrate how changes to Arctic landscapes are likely to be linked to the biodiversity and productivity of these systems.

As an initial step in addressing the knowledge shortfall a sampling campaign of freshwater ecosystems the Greiner Lake watershed near Cambridge Bay was carried out in the summer of 2014. Sampling of 20 lakes, rivers and their immediate watersheds was carried out to provide a baseline description of the ecological variability of water quality, phyto- and zooplankton biodiversity and biomass, trophic structure and carbon fluxes.

The sampling contributes also to the Circumpolar Biodiversity Monitoring Program (CBMP) that has been created in collaboration with all the 8 circumpolar countries. Each country aims to follow the same sampling protocol with the aim to provide high quality and comparable information of different environments in the Arctic and their biodiversity.

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The results described below are based on the analyses at the Laboratory of Aquatic Sciences (LASA) of UQAC. Additional analyses from the sampling campaign are being conducted at University of Waterloo (stable isotopes) and Environment Canada (macroinvertebrates).

Sampling

The sampling took place between August 30 and September 3, 2014. Twenty sites (Figure 38) in the Greiner Lake watershed were visited with a helicopter. Sixteen of the sites (CBL 1-16) were connected to other lakes with streams or rivers and are considered lakes. Four sites (CBL 17-20) were shallow ponds without inlets or outlets. The lakes were sampled from the outlet that integrates the information from the lake water column; the ponds were sampled from several locations along the shore. Each site was visited for about an hour during which the site was sampled for about 8 L of water, small amounts of benthic material (< 5 cm^2) and zooplankton. Zooplankton was sampled with plankton nets from a water volume of some hundreds of liters (Figure 39). Terrestrial vegetation and soils around the sites were sampled (about 50 g per site). The samples were brought to the Arctic College laboratory in Cambridge Bay where water was preserved for nutrient analyses and filtered for carbon characterization, fatty acids, stable isotopes and chlorophyll. A small aliquot (100 mL) was preserved with Lugol's solution for phytoplankton identification and counts. Zooplankton were a) preserved with formaldehyde for taxonomy and counts and b) sorted alive for fatty acid and stable isotope analyses and frozen. Benthic organic material and terrestrial vegetation were frozen for chlorophyll, stable isotopes and fatty acids.

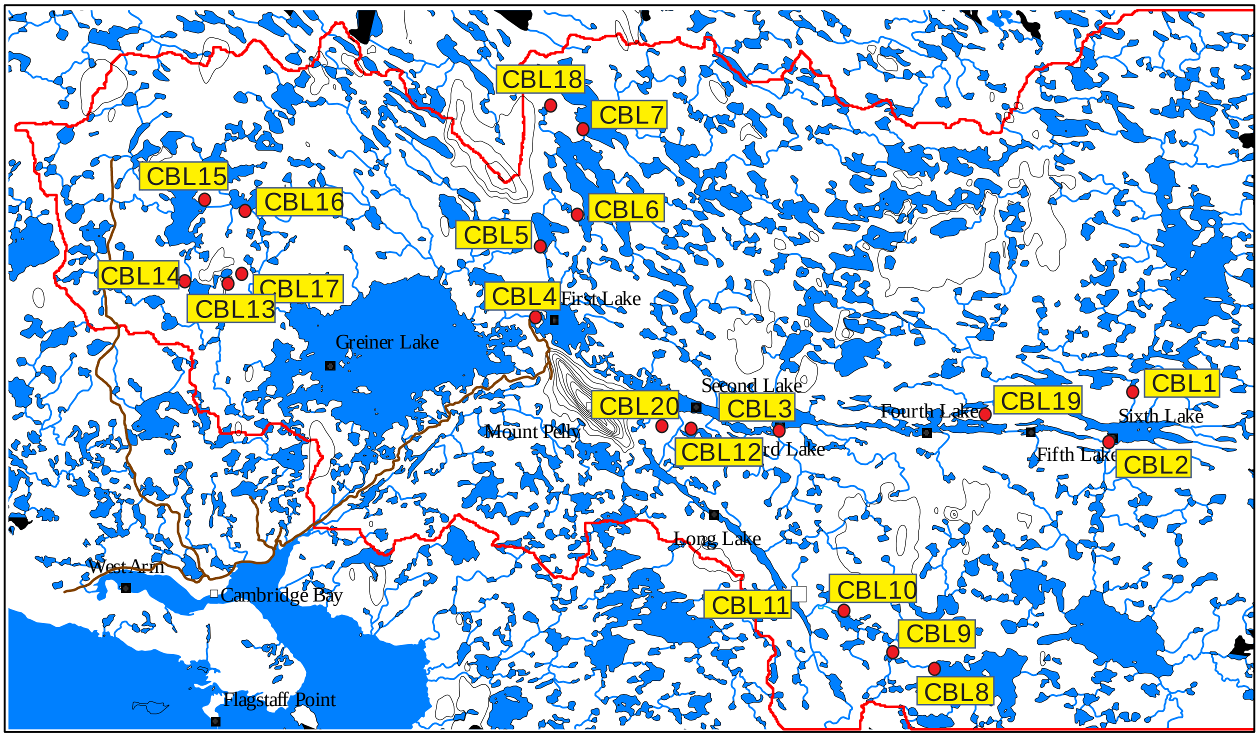

Figure 38. Map showing the location of the 16 lakes (CBL 1-16) and ponds (CBL 17-20) that were sampled between August 30 and September 3, 2014.

The samples and analyses were based on recommendations outlined in the Arctic Freshwater Biodiversity Monitoring Plan for circumpolar Arctic freshwater biodiversity assessment to be carried out for all Arctic countries in five-year intervals. Each analysis has been pointed out as a key variable indicating the environmental status of a given water body (Table 10).

Preliminary results

Because of the limestone bedrock, the lakes on Victoria Island are highly alkaline with pH ranging from 8.0 to 8.6. They are also characterized with high conductivity (mean 390 µS cm^{-2}), which partly results from relatively high nutrient conditions in these systems. Total phosphorus (TP) ranged from 8.1 to 18.7 mg L^{-1}. The lakes (CBL 1-16) were in general characterized with more diluted waters than the ponds (CBL 17-20) with a magnitude of order higher values in conductivity, total and dissolved nitrogen, and seston dry weight (Table 11). The higher amount of organic material in the water column of the ponds, as was indicated by the seston DW, was also reflected in the light attenuation (K_d PAR) of these waters. All lakes could be characterized as highly transparent with light penetrating to more than 20 m in the water

Table 10. Focal Ecosystem Components (FEC).

Analysis	Justification as important Focal Ecosystem Component (FEC)
Phytoplankton	High importance because they are the base of the food web, sensitive to change, diagnostic of certain types of change, metrics have been developed to identify stressor effects, low variance within a system; some long term monitoring data available.
Benthic algae	High importance because they are the base of the food web, sensitive to change; data availability generally low, samples sporadic spatially, chl a used as a measure of periphyton production; high feasibility due to high ease of sampling and low cost, potential for archival analysis
Zooplankton	Food for higher trophic levels, important consumers and secondary producers in the food web; community structure reflects environmental changes; easy to sample and fairly easy to identify; some long term monitoring data available.
Lipids and their fatty acids/energy flow	Important for community function and biodiversity, useful to detect changes within and among systems, useful for assessment of targeted species to identify energy flow (benthic vs. pelagic); few data exist.
Seston dry weight, DOC/CDOM*	High importance because indicators of overall productivity of the system, strong relationship with biodiversity; high feasibility of sampling due to ease of sample collection and low cost; data are spatially and temporally extensive

*DOC= Dissolved organic carbon, CDOM = Chromophoric dissolved organic matter

Figure 39. Sampling CBL lakes. Photo on the left shows zooplankton sampling with a plankton net, in the photo on the right Lugol's solution is added to a phytoplankton sample.

column. Light in the ponds attenuated twice as fast as in the lakes. The shallow depth of the ponds compensated for this higher light attenuation.

The high transparency of the lakes and ponds meant that there was enough light for photosynthesis even in the bottom. The bottoms of these lakes were covered with benthic algae often forming a layer of organic material that is several mm thick (Figure 40). Phytoplankton biomass was low and made of highly variable taxa (Figure 41).

The number of species and the biomass of zooplankton were high, especially in the ponds that are too shallow to harbour fish that are the main predators of zooplankton. The zooplankton were also highly pigmented, possibly as a response to ozone depletion and high solar ultraviolet exposure in these transparent waters (Figure 42).

Figure 40. Underwater photo of bottom of ponds showing the thick layers of benthic algae growing on rocsk and soft sediment. Notice also the red zooplankton.

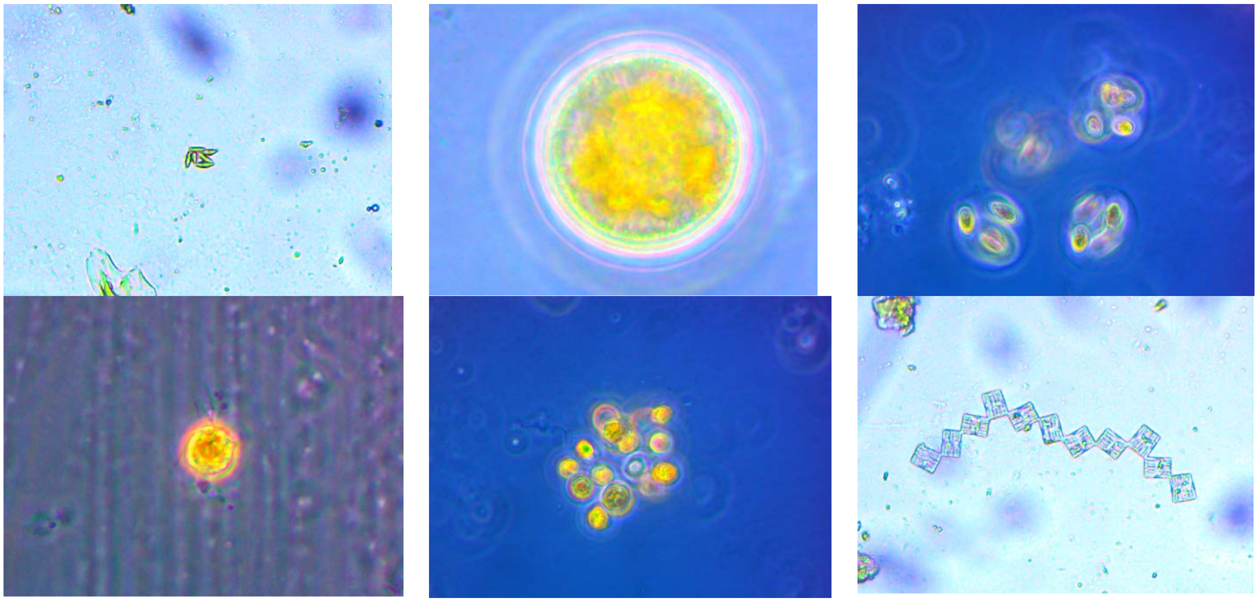

Figure 41. Examples of phytoplankton found in the sampled lakes on Victoria Island. From top left to bottom right: Chilomonas, Cyclotella, Oocystis, unknown flagelates, Sphaerocystis, Tabellaria.

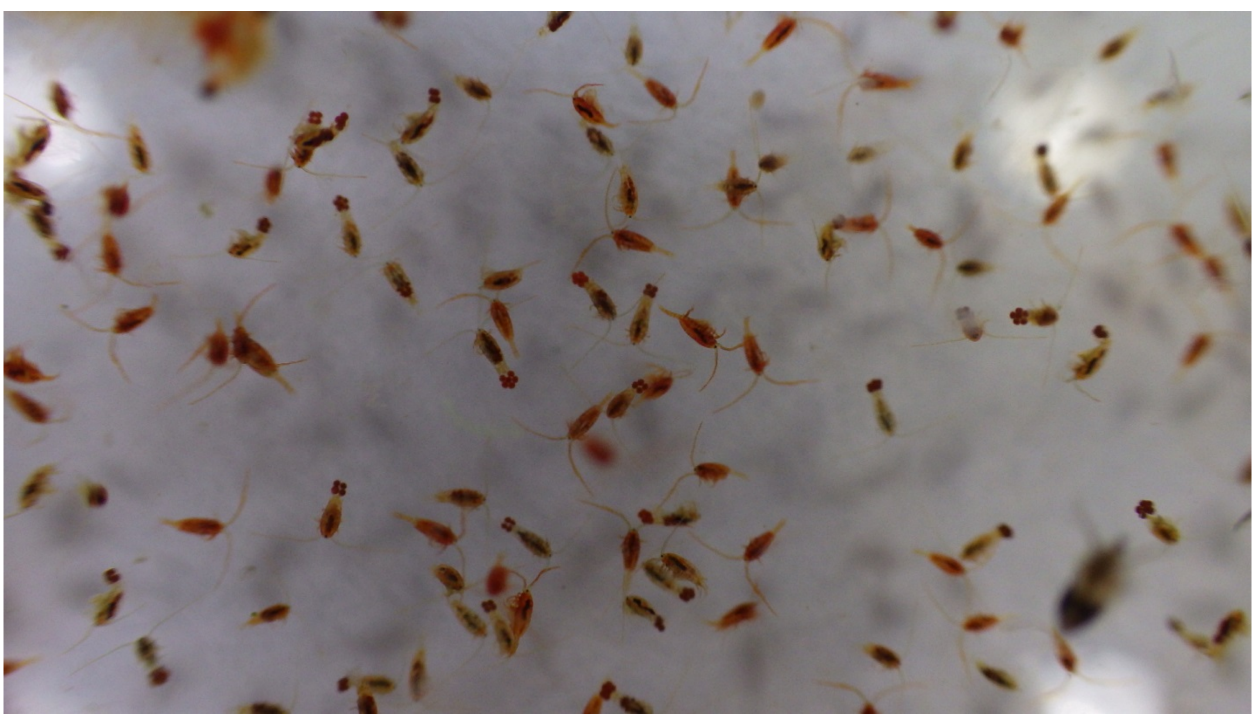

Figure 42. Calanoid copepods carrying eggs. The red colour comes from photoprotective astaxanthin pigment.

We also made estimations of the nutritional quality of aquatic foods based on their lipid and fatty acid composition which can be used as indicators of trophic relationships as well as of the quality of aquatic food sources for human use.

Lipids and their fatty acids were sampled from zooplankton, seston, benthos, terrestrial vegetation and soils. The results show that zooplankton has the highest percentage of lipids per unit mass, followed by seston, benthos, terrestrial vegetation and soils (Figure 43a). The percentage of polyunsaturated fatty acids (PUFA) was, however, highest in the catchment vegetation and soils (Figure 43b). These results will be combined with stable isotope signatures of the samples and carbon quality in each source habitat to estimate food web structure and diet sources of zooplankton and other aquatic organisms. The preliminary results of carbon quality (high values of SUVA and CDOM: indicators of the presence of terrestrial carbon in lakes) (Table 11) show that the land-lake coupling is stronger in ponds with terrestrial carbon sources likely playing an important role in aquatic food web ecology.

Aquatic animals, including different taxa of zooplankton, benthic invertebrates, mysids and stickle backs were also in more detailed compared in their lipid quantity and quality. Most of these organisms are putative diet sources for arctic charr, lake trout and other valuable fish. Our results show that copepods, mysids and benthic invertebrates contain the highest amount of lipids (Figure 44a) but according to the PUFA content the mysids make the best fish food, followed by stickle backs and benthic invertebrates (Figure 44b).

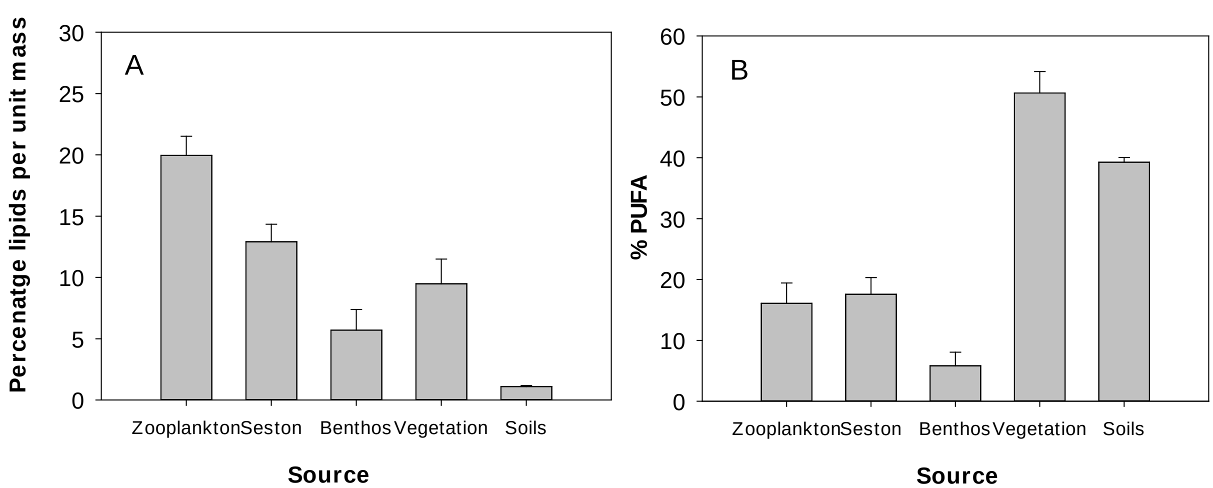

Figure 43. Lipids in zooplankton, seston, benthos, terrestrial vegetation and soils. A) The ranking of percentage lipids per unit mass and B) percentage of PUFA in different sources of lipids.

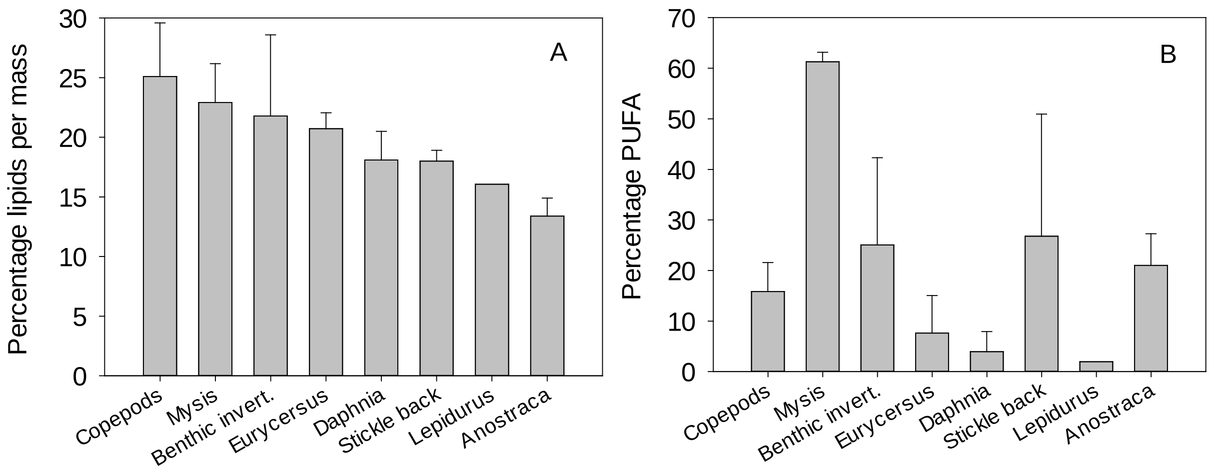

Figure 44. Amount of lipids in the putative diet sources of arctic charr and other fish. A) The ranking of percentage lipids per unit mass and B) percentage of PUFA in different sources of lipids.

Summary and sampling plan for 2015

The monitoring for 2015 will build on the work by our team in 2014 that addressed the knowledge shortfall of freshwater ecosystems on Victoria Island in the Greiner Lake watershed. The samples have been processed, and some of the results have been included in a research paper that will be submitted shortly. Two video podcasts were made of the sampling campaign to inform Northerners and the broader public of our work. The project will also be described in AANDC Publications by the writer Janet Hunter in 2015. A full use of this initial dataset will be implemented as part of the proposed monitoring for 2015 with a large number of additional samples and measurements.

Table 11. Limnological characteristics of the sampled sites. The measured variables include temperature (Temp), conductivity (Cond), pH, lights attenuation coefficient for photosynthetically available radiation (Kd PAR), total nitrogen (TN), total dissolved nitrogen (TN diss), total phosphorus (TP), seston dry weight (DW), seston cholorophyll-a (Chl-water), benthic chlorophyll-a (Chl-benthic), dissolved organic carbon (DOC), specific UV absorbance (SUVA) and chromophoric dissolved organic carbon (CDOM).

Site	Date	Lat	Lon	Temp	Cond	pH	K_d PAR	TN	TN diss	TP	DW	Chl-water	Chl-benthos	DOC	SUVA	CDOM
				Celcius	µScm		m^{-1}	mg/L	mg/L	mg/L	µg/L	µg/L	mg/m^{-2}	mg/L	A254	a320
CBL1	30.8.2014	69.17674	104.1467	8.5	450	8.1	0.81	0.73	0.39	96.3	1.36	0.55	28.9	6.4	1.3	7.6
CBL2	30.8.2014	69.15665	104.1709	8.4	280	8.6	1.89	0.50	0.25	16.6	1.40	0.89	16.1	4.4	1.0	5.4
CBL3	30.8.2014	69.16155	104.5164	8.2	295	8.6	0.43	0.46	0.23	15.3	1.37	2.37	16.8	4.2	1.1	9.6
CBL4	31.8.2014	69.20183	104.7682	7.6	258	8	0.30	0.48	0.23	18.7	1.30	1.61	11.2	4.1	0.9	4.4
CBL5	31.8.2014	69.22874	104.7591	7.4	242	8	2.34	0.36	0.18	13.5	1.08	1.71	17.1	3.3	0.6	2.1
CBL6	31.8.2014	69.2416	104.7171	10	244	8.2	1.37	0.41	0.18	14.0	1.62	1.37	6.9	3.1	0.8	7.5
CBL7	31.8.2014	69.2729	104.7161	7.5	246	8.3	1.82	0.41	0.20	14.2	1.09	1.37	7.0	3.5	0.6	2.6
CBL8	1.9.2014	69.07447	104.3584	7.2	258	8.1	3.57	0.47	0.22	14.0	1.01	1.16	13.8	4.8	0.7	3.3
CBL9	1.9.2014	69.07729	104.4011	7.2	258	8.2	3.93	0.43	0.22	10.6	0.85	0.39	21.3	4.2	0.9	8.0
CBL10	1.9.2014	69.09504	104.4028	7.3	331	8.2	2.55	0.56	0.29	13.8	1.45	1.36	25.6	4.9	1.1	6.1
CBL11	1.9.2014	69.14977	104.6388	9	294	8	1.84	0.42	0.20	11.9	1.18	1.80	21.9	3.9	1.0	6.0
CBL12	1.9.2014	69.16284	104.6168	8.4	702	8.1	2.41	0.94	0.47	15.4	2.67	1.04	25.3	7.7	1.4	6.8
CBL13	1.9.2014	69.2203	105.0958	8	423	8.5	0.15	0.41	0.22	10.4	0.56	0.57	7.9	3.4	0.5	0.9
CBL14	2.9.2014	69.21848	105.1273	7.5	353	8.4	0.47	0.44	0.23	8.1	0.92	0.64	6.7	3.9	0.6	1.7
CBL15	2.9.2014	69.24606	105.111	8.2	214	8.4	0.78	0.45	0.23	15.3	4.47	1.05	28.7	4.1	0.9	3.9
CBL16	2.9.2014	69.24506	105.0667	8.5	292	8.6	0.31	0.58	0.31	12.1	0.82	0.67	19.3	5.5	1.0	4.7
CBL17	3.9.2014	69.22258	105.0772	9.9	774	8.4	3.66	1.44	0.74	9.7	1.67	0.42	22.2	14.6	3.2	21.3
CBL18	3.9.2014	69.28286	104.7585	10	694	8.5	2.36	1.34	0.72	11.4	1.88	0.82	13.8	12.8	2.0	12.2
CBL19	3.9.2014	69.16594	104.2891	10.5	596	8.6	1.77	1.24	0.68	11.6	4.66	0.34	16.6	13.7	3.5	24.7
CBL20	3.9.2014	69.16554	104.6296	10.2	594	8.5	1.54	1.46	0.77	21.0	1.59	0.10	10.5	14.2	2.8	13.2
Mean	Lakes (CBL 1-16)			8.1	321	8.3	1.6	0.5	0.3	18.8	1.4	1.2	17.2	4.5	0.9	5.0
	Ponds (CBL17-20)			10.2	665	8.5	2.3	1.4	0.7	13.4	2.5	0.4	15.8	13.8	2.9	17.9

Project 2: Inventory of Rivers Near Cambridge Bay, Nunavut: 2014 Field Report

Lead: Fred Wrona

Overview

As a first step in developing a freshwater monitoring program at the Canadian High Arctic Research Station (CHARS), a biomonitoring inventory of rivers near Cambridge Bay, Nunavut, was conducted in August 2015. This work intends to establish long-term monitoring sites that can be used to observe the cumulative effects of multiple stressors (related to climate change and northern development) on the biotic and abiotic environmental conditions of these rivers. The project applies tools and indicators generated under the International Polar Year project (Arctic-BioNet) and the **C**anadian **A**quatic **BI**omonitoring **N**etwork (CABIN-EC). The focal ecosystem component for study is the benthic invertebrate assemblage as they are ideal indicators of freshwater ecosystem health and can provide early warning of ecological impairment (and ultimately sustainability) within terrestrial catchments.

Results will provide unique baseline information and contribute to the development and validation of predictive models to facilitate management decisions directed to resource development and climate change in these regions. The study will examine how biological diversity is associated with environmental drivers (natural and human-induced) across regional gradients of temperature, nutrients, metals and ion concentration, and sediment load. These abiotic drivers of ecological condition are predicted to be most related to the effects of resource development (e.g., mining) and climate change (e.g., permafrost degradation). Benthic communities along this gradient will be evaluated using biological and ecological metrics that describe structural and functional aspects of biological composition. Regional reference models will be developed and used to determine the most important drivers of biological composition, examine disturbance-response patterns associated with resource development and climate variability and estimate related biological response thresholds. Identification of thresholds is the first step in creating disturbance-related criteria to protect the ecological condition of rivers across the broader geographical region.

Sampling

Seventeen sites near Cambridge Bay were visited by helicopter over the period of August 24-28, 2014. Samples included collection of fish species present, water chemistry (i.e., major ions, metals, and nutrients), current velocity, streambed substrate composition, pH, dissolved oxygen, temperature and conductivity. Benthic invertebrate samples were collected using the 3-min traveling kick net (400 µm mesh) method following Environment Canada's CABIN protocol (Environment Canada 2012). Sampling at each site took approximately one hour. All water chemistry samples will be processed by Environment Canada's National Laboratory for Environmental Testing (NLET) using their published rates, standard operating protocols and QA/QC procedures. Benthic invertebrate samples will be processed following EC-CABIN protocols (Environment Canada 2014). The detailed methods for NLET and CABIN protocol are available through Environment Canada's website. Other field sampling and laboratory protocol will follow those detailed in the "Arctic Freshwater Biodiversity Plan" (Culp et al. 2012a, b). Water chemistry and benthic invertebrate samples are currently being processed.

Potential sampling in 2015

A submission entitled, "*Effects of Changing Lake and River Ice on Arctic Freshwater Ecology and Resource Transportation Networks*", was submitted to the recent CHARS Call for Proposals. If funded, this proposal will build on the 2014 work.

Acknowledgements

We thank W. Goedkoop (Swedish University of Agricultural Sciences) and P. diCenzo (Environment Canada) for field assistance, and D. McLennan and J. Wagner (CHARS) for arranging helicopter and local transportation.

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First inventory of streams and lakes in the Greater Lake Greiner watershed, Victoria Island: 2014 field season trip report.

Michael Power, U Waterloo

The following reports on sampling completed under the auspices of the Canadian High Arctic Research Station (CHARS), Cambridge Bay, Nunavut, as part of the completion of a larger baseline monitoring program designed to describe and inventory the range of aquatic habitats available for juvenile fish within the watershed. Sampling was to focused on: [1] determination of fish community diversity within the watershed lakes; [2] assessment of juvenile Arctic char stream habitats following standardized methods as described in the literature for the International Polar Year (i.e., Sinnatamby et al., 2012); and [3] selection of suitable long-term monitoring sites encompassing the range of variation found in Lake Greiner tributary systems.

Sampling

The sampling of fish took place between August 23 and August 29, 2014 at 17 sites as listed in Table 13. Fourteen of the selected sites were located within the confines of the Lake Greiner watershed. Three of the selected sites were located within the confines of the Nauyak Lake watershed, Kent Peninsula. Sampling was to consist of standardized electro-fishing to determine densities using the three-pass Zippin method for estimating population size (Seber & LeCren 1967; Seber & Whale 1970). Owing to equipment shipment issues, the Smith-Root LR-24 electro-fisher (Smith-Root Inc., Vancouver, WA, USA) was not available for sampling and density estimates were not obtained. Characterization of stream habitats was, therefore, confined to obtaining random (n=5) water velocity measurements taken 1 cm above the substrate using a Marsh-McBirney Flow-mate 2000 (Hach Company Inc., Loveland, CO, USA) and sampling of filamentous algae for stable isotope analysis. Further assessment of stream reaches was completed with randomized dipnet sampling to identify stream resident fishes.

A single overnight set of n=2 gillnets (one each 1.5 and 2.5 inch mesh) was completed in sixth lake (69°09.890, 104°09.359) back in the chain of tributary lake systems entering Lake Greiner from the northeast as a means of assessing community composition. Sets were for a 12-hour period. Capture results are reported in Table 12. No other fisheries related work was completed.

Table 12. Biological characteristics of fish captured in test gillnet sets completed in the sixth tributary Lake.

Species	N	Length (mm)	Comments
Coregonus sardinella	6	305	Dead in net
Coregonus sardinella		300	Dead in net
Coregonus sardinella		265	Dead in net
Coregonus sardinella		180	Dead in net
Coregonus sardinella		165	Dead in net
Coregonus sardinella		250	Dead in net
Salvelinus alpinus	2	430	Dead in net
Salvelinus alpinus		397	Dead in net
Salvelinus namaycush	6		Not measured, released alive

References

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of Animal Ecology 36: 631–643.

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Table 13. Stream site locations, mean velocity (n=5), dissolved oxygen (DO%, DO mg/L), temperature (°C), conductivity (S/cm) and presence (Y) of algae, nine-spine stickelbacks (Pungitius pungitius) and other fish species (Cisco = Coregonus sardinella, A. charr = Salvelinus alpinus).

Site	Latitude	Longitude	Velocity cm/s	DO %	DO mg/L	Temperature ° C	Conductivity :S/cm	Algae	Sticklebacks	Other Species
CBR-1	69°09.370	104°10.269	31.3	107.8	11.6	12.0	303	Y	Y	Cisco
CBR-2	69°09.370	104°10.269	13.1	116.0	13.4	9.2	285	Y	Y	
CBR-3	69°09.890	104°09.359	12.6	106.7	11.2	13.1	469	Y	Y	
CBR-4	68°25.042	107°41.853	6.3	95.8	11.3	8.7	681	Y	Y	
CBR-5	68°23.990	107°39.515	5.8	98.0	11.3	9.3	655	Y	Y	A. charr
CBR-6	68°39.083	107°23.979	16.9	98.8	11.2	9.7	390	Y	Y	
CBR-7	69°10.837	104°18.845	8.2	103.0	12.1	8.2	262	Y	Y	
CBR-8	69°10.485	104°15.380	11.3	95.6	11.9	5.6	419	Y	Y	
CBR-9	69°11.777	104°19.183	32.3	95.3	11.9	5.9	525		Y	
CBR-10	69°04.496	104°22.945	9.3	100.9	12.7	5.5	270	Y	Y	
CBR-11	69°05.751	104°28.927	49.0	97.1	12.1	6.1	346	Y	Y	
CBR-12	69°14.626	105°03.674	17.4	100.8	12.5	6.1	303	Y	Y	
CBR-13	69°15.393	105°10.924	18.1	108.7	13.1		336		Y	
CBR-14	69°14.683	104°45.553	7.3	106.4	12.9	6.9	260	Y		
CBR-15	69°12.320	104°46.652	11.5	102.1	12.2	7.6	270	Y	Y	A. Charr
CBR-16	69°07.729	104°59.655	10.4	93.8	11.5	6.5	405	Y		
CBR-17	69°07.916	104°59.407	14.8	95.7	11.7	6.8	253	Y	Y	

Assessing the occurrence of wastewater contaminants in Cambridge Bay, Nunavut

Luis Chaves-Barquero[14,15], Kim, Luong[16], Charles Knapp[17], CJ Mundy[14], Mark Hanson[14], Charles Wong[14, 16]

Introduction

Cambridge Bay is a community in the Canadian Arctic, and home to the Canadian High Arctic Research Station (CHARS). With a population of approximately 1400, its wastewater treatment system is managed by the local municipality. The facility consists of a lagoon-tundra wetland system that is discharged into the bay (Figure 45). This project aimed to examine the lagoon effluent along the wastewater path, with special interest in nutrients (total phosphorus and nitrogen), pharmaceuticals (Figure 46), and antibiotic resistance genes (ARGs).

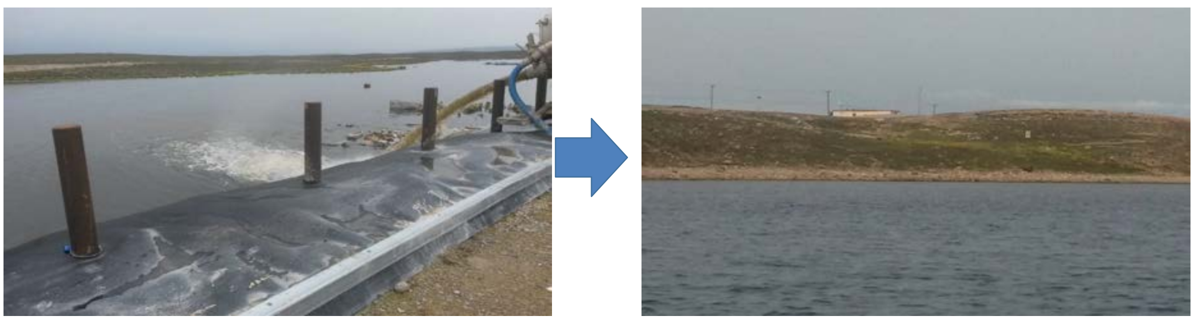
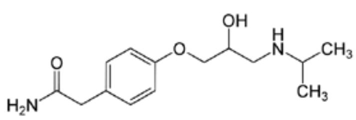
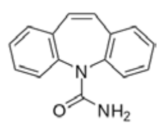


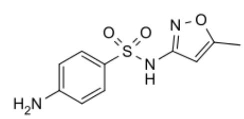
Figure 45. Wastewater in Cambridge Bay is treated in a lagoon-tundra wetland system, and then discharged into the bay.



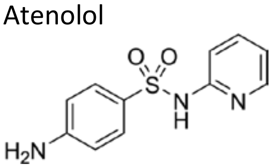
Atenolol



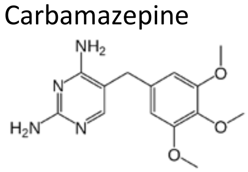
Carbamazepine



Sulfamethoxazole



Sulfapyridine



Trimethoprim

Figure 46. Pharmaceuticals commonly found in wastewaters

Objective

Understand the efficacy of wastewater treatment under arctic conditions, by assessing the occurrence of wastewater contaminants attenuation and release from a facility in Cambridge Bay in Nunavut, Canada.

[14] University of Manitoba, Department of Environment and Geography
[15] Costa Rica Institute of Technology, Department of Chemistry.
[16] The University of Winnipeg, Richardson College for the Environment
[17] University of Strathclyde, Department of Civil and Environmental Engineering

Method

- Samples were collected before and during lagoon discharge in the locations presented in Figure 47.
- Grab samples were collected to measure nutrients and antibiotic resistance genes using quantitative real time polymerase chain reaction (qPCR).
- Polar Organic Chemical Integrative Samplers (POCIS) were deployed to passively collect pharmaceuticals, analyzed by LC-MS/MS.
- Two sites in the main lagoon, one site in the wetland downstream and three offshore locations were selected for sampling.

*Figure 47. Sampling locations: **1 – Lagoon input 1 (LI 1):** dumping point; **2 – Lagoon input 2 (LI 2):** older dumping point; **3 – Wetland:** natural wetland downstream; **4 – Outfall:** approx. 100 m away from the primary discharge point to the bay; **5 – CHARS:** seawater intake for CHARS studies; **6 – Finger Bay:** possible secondary discharge point.*

Results

- Non-detectable (ND) levels for pharmaceuticals in most locations off shore (Figure 48). ND concentrations are below the limits of detection (LOD) in each case.
- Concentrations within lagoon sites varied, which indicates that the two sites are not getting exactly the same amount of material (Figure 48).
- Significant removal of pharmaceuticals and nutrients during discharge through the natural wetland, which is hydrologically isolated from the lagoon (Figure 48, Figure 49).
- Higher presence of tetracycline resistant genes in the main lagoon compared to other locations downstream (Figure 50).

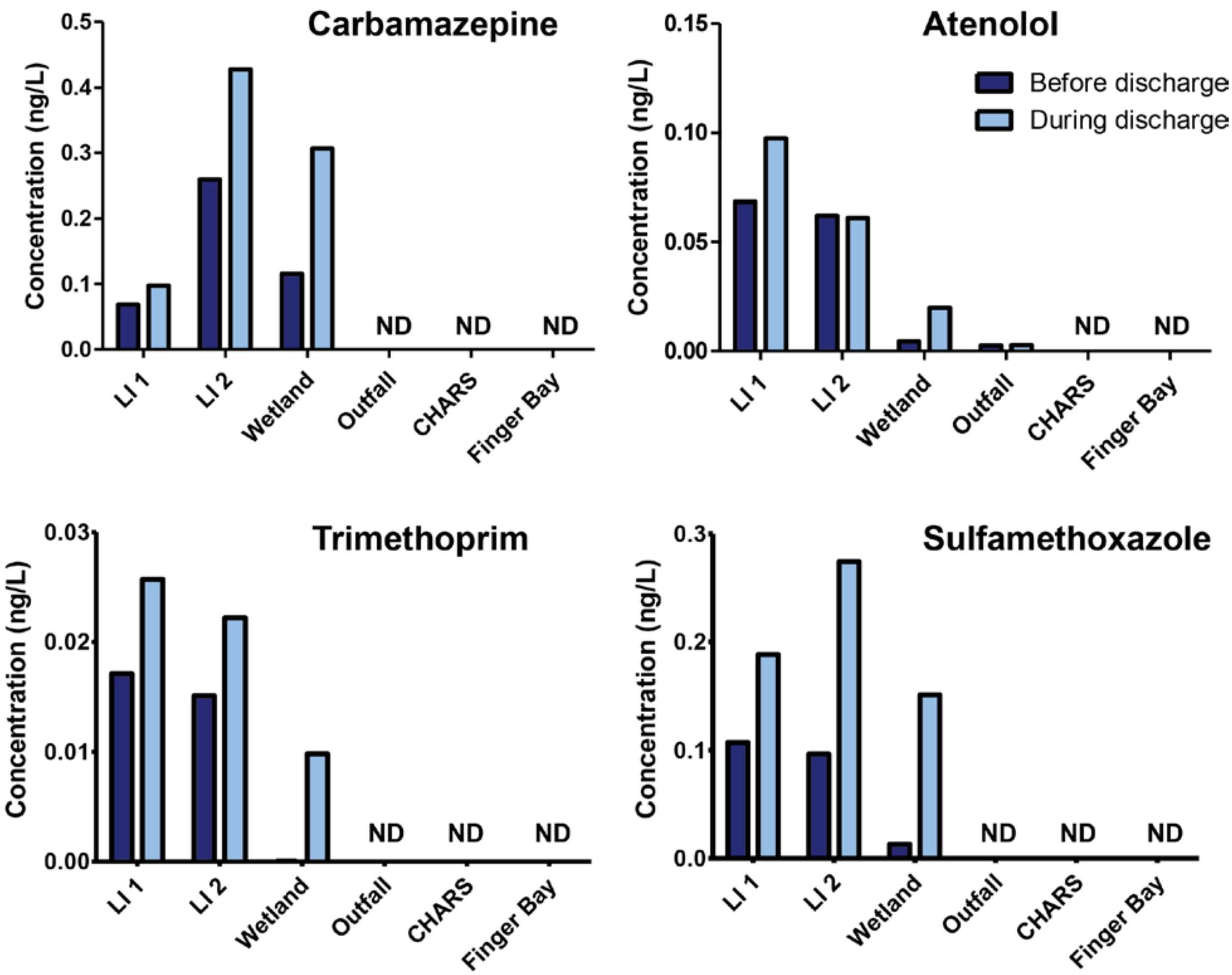


Figure 48. Pharmaceuticals levels at 6 sampled locations in Cambridge Bay, Nunavut.

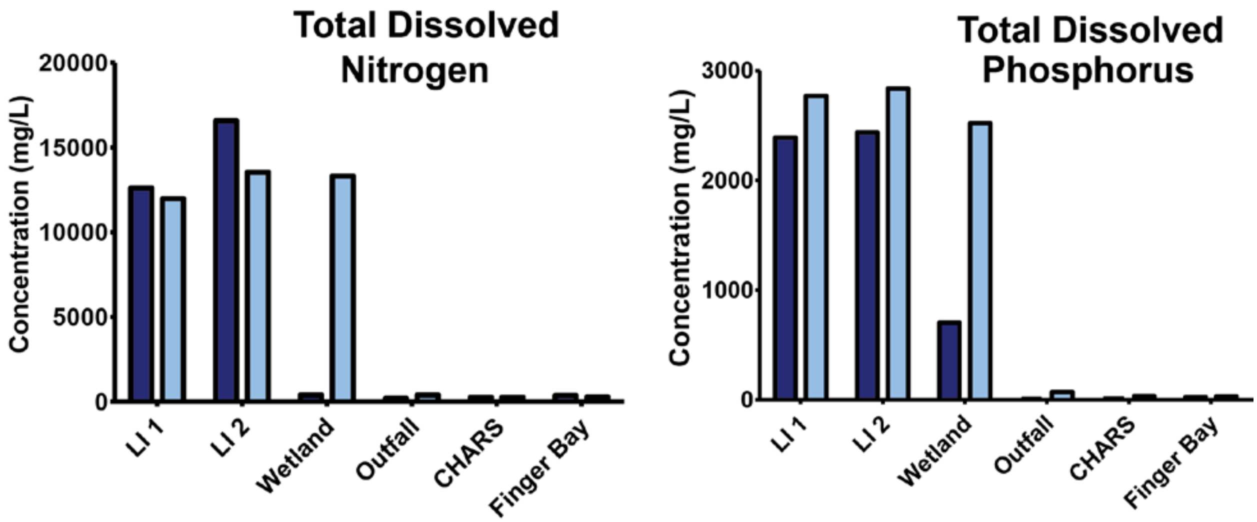


Figure 49. Nutrient levels at 6 sampled locations in Cambridge Bay, Nunavut.

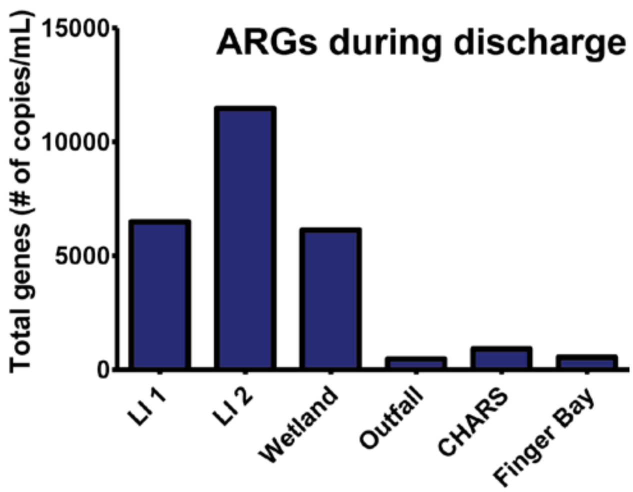


Figure 50. Antibiotic resistance genes (ARG) in bacteria at 6 sampled locations in Cambridge Bay, Nunavut.

Conclusions and future work

- Data obtained suggests that attenuation mechanisms for pharmaceuticals and nutrients are in place along the wastewater path.
- ARGs are present in greater concentrations in the lagoon input 2, which suggests the presence of antibiotic resistant bacteria.
- This system will be assessed again during the summer of 2015.

Plans for Summer 2015

The following projects are planned for summer 2015 at Cambridge Bay.

Terrestrial Ecosystem Classification and Mapping (TEM)

The following TEM studies will be conducted in the CHARS ERA

- additional full ecosystem description plots for each of the ecotypes – a target of 10 plots/ classification unit will support the CNVC/AVA classification
- first approximations of flooding duration and ecotype landscape distributions
- drone photography and mapping in selected areas – pilot runs and training
- more detailed mapping and modelling

Elu Inlet High Value Ecosystem Component Inventory

Under the direction of Martin Raillard, Chief Scientist of CHARS, this project will be conducted in an area of 100 km radius around Elu Inlet lodge, southeastern Kent Peninsula. This area has a high development potential and a number of mineral claims exist here. Discussions have been held with TMAC Resources, a company that will undertake geological surveys at the same location this field season. The CHARS team will conduct biological and archeological inventory work at same time and refine the methodology in preparation of extensive future work in cooperation with the NRCAN GEMS program in future years. The aim is to train field crews that will then be able to accompany geological surveys to conduct biological and archeological inventories. More specifically, CHARS teams will undertake the following:

- Vegetation mapping: following the same protocols as for TEM (see above).
- Bird surveys: A number of bird inventory methods will be used and compared: Spot checks, Breeding Bird Surveys, PRISM surveys and simple check lists. The method ideally suited to transects and fly camps in the High Arctic will be determined.
- Wildlife Surveys: All wildlife species will be counted and locations recorded on flights and along transects

Geomapping for Energy and Minerals (GEM) project cooperation

Natural Resources Canada and Polar Knowledge Canada are exploring cooperation with their 100 M GEM project that has considerable overlap with CHARS's Baseline Information Preparedness for Development (BPID) mandate. Because of this overlap, the possibility arises of having joint field crews, or of GEM crews doing some sampling for CHARS as they conduct geological surveys in remote locations of the High Arctic over the next 7 years. In conclusion, at CHARS we will prepare our field methodology, so we can easily join their team, and will also provide them with GPS-enabled digital cameras, so they can take pictures with our standardized protocols as they do geological exploration in remote area.

The long-term vision of this cooperation is that CHARS's Pan-Arctic vegetation map and inventory of sensitive areas will be overlapping GEM's GIS map of areas of high mineral potential.

Arthropod Monitoring:

- Elyssa Cameron of McGill University will be conducting arthropod monitoring training July 9–12
- We will carry on this work over the summer, with Angut Pedersen leading the students
- Insect sorting to gross taxonomic levels will be a key part of this work

Freshwater studies

Under the direction of the CBMP Freshwater EMG (Milla Rautio, Mike Power, Joseph Culp and Kristina Brown) we will conduct the following work in freshwater systems:

- inventory survey of lakes by lake classes (deep, connected ocean-going char lakes, connected mod deep (2–4m), and shallow (<2m) unconnected/connect lakes); measures will include benthic invertebrates and microbiology, nanoplankton, phytoplankton, zooplankton, small to medium fish, morphometry, temperature, water chemistry; Milla will train Johann Wagner to conduct this sampling and he will lead it with students
- sediment cores: Milla Rautio and Connie Lovejoy will get sediment cores form a number o basins through the ice (June 8-20) to look at basin history, sedimentation and microbiology
- river sampling: continue monitoring of chemistry and isotopes through weekly sampling at Freshwater Creek gauge and other locations tbd—led by Kristina Brown, Woods Hole
- char studies: tbd – we are talking with Mike Power (University of Waterloo) and Les Harris (Department of Fisheries and Oceans)
- stream invertebrates: tbd with Joseph Culp

Marine studies:

- Under the direction of Eddy Carmack, Bill Williams and CJ Mundy we are discussing implementation of a very modest marine baseline studies and monitoring program—probably in the Cam Bay - Dease Strait area—objective is to deploy 1 or 2 fixed moorings, some benthic work, and a series of CTD surveys
- We are also discussing the continuation of the sewage studies with Charles Wong – Angut Pedersen and Johann Wagner know how to deploy the samplers and would add to last year's work

List of baseline data available by 2017

CHARS has an agreement in place with Polar Data Catalogue (PDC; https://www.polardata.ca/) for storage and management of data produced by scientific research performed through CHARS. By 2017, the following baseline data will be available on PDC:

- Terrestrial ecosystem data from the Central Canadian Arctic (GPS waypoints, geo-referenced digital photographs, geo-referenced high-definition videos, ground plots with soil, ecosystem and vegetation data).
- Data on the flora and plant species of the Central Canadian Arctic (checklists and plant collections).
- Data on arthropods and insects in southeastern Victoria Island (quantitative and qualitative data, arthropod collections).
- Data on muskoxen parasites and their intermediate hosts (gastropods).
- Data on migratory birds from Cambridge Bay and Elu Inlet area.
- Wildlife data from Elu Inlet area.
- Bathymetry of the east end of Cambridge Bay.
- Freshwater data from lakes and streams in the Greiner Lake Watershed.
- Marine sampling data, including CTD, from CHARS ERA.
- Baseline oceanographic data from Dease Strait and western Queen Maud Gulf
- SPOT5 and SPOT6 panchromatic and multispectral satellite imagery of the Cambridge Bay area and eastern Kent Peninsula.
- Data related to renewable energy in Cambridge Bay (wind and solar).
- Contaminant data from Cambridge Bay's water treatment system

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Appendix 1: Vegetation Tables for the CHARS ERA Ecotypes in CAVM Subzone D

Table 14. Dryas *Summary Vegetatoin table - Cambridge Bay plots only.*

Life Form	Ecotype / Number of plots	/02	/01.2	/03	/04	/06	Common name
	Number of plots	3	6	2	3	1	
	Shrubs						**Shrubs**
04	*Vaccinium uliginosum*				□□□		alpine bilberry
	Herbs						**Herbs**
07	*Saxifraga tricuspidata*	■■■■	□		*		three-toothed saxifrage
12	*Dryas* spp.	■■■	■■■■■	■■■■■	■■■■■	■■■■■	mountain avens
12	*Salix arctica*	■■	■	■	■■	■■■	arctic willow
07	*Oxytropis* spp.	■■	■	■	□□	■	locoweeds
06	*Poa glauca*	■■	*				glaucous bluegrass
06	*Carex rupestris*	□	■■■		*	■	rock sedge
07	*Saxifraga oppositifolia*	■	■■	□	■		purple mountain saxifrage
07	*Pedicularis* spp.	*	■	■■	■	■	louseworts
07	*Bistorta vivipara*	*	■	■	■	■	alpine bistort
07	*Lesquerella arctica*	*	■				arctic bladderpod
12	*Salix reticulata*		*	■■■■■	■■	■■■■	net-veined willow
12	*Cassiope tetragona*				■■■■■		four-angled mountain-heather
05	*Equisetum arvense*					■■■■	common horsetail
12	*Arctous* spp.				*	■■	bearberry
06	*Eriophorum angustifolium*					■■	narrow-leaved cotton-grass
06	*Carex scirpoidea*		■	□	■■	■	single-spike sedge

06	*Carex fuliginosa*		▒	▒	▒▒	■	short-leaved sedge
06	*Arctagrostis latifolia*			■■■	**	■	polargrass
06	*Carex membranacea*			▒	**	■	fragile sedge
	Mosses/lichens						**Mosses/lichens**
09	*Pohlia* spp.	▒▒	■■	■■■		■■■	nodding-cap moss
11	*Thamnolia vermicularis*	■■	■■		▒▒	■	the whiteworm
11	*Lecanora epibyron*	▒▒	■■■	▒▒▒▒	■■■		“white crust”
11	*Cetraria* spp.	*	▒▒	▒	■■	■	Iceland lichens
09	*Tomentypnum nitens*			▒▒▒▒	****	■■■	golden fuzzy fen moss

Lifeforms: 00—genus-level and mixed; 01—coniferous tree; 02—broad-leaved tree; 03—evergreen shrub; 04—decidious shrub; 05—fern or fern-ally; 06—graminoid; 07—forb; 08—parasite or saprophyte; 09—moss; 10—hepatic; 11—lichen; 12—dwarf woody plant; 13—macro alga

Frequency	25-50% *	50-70% ▒	70-100% ■		
Mean Cover	<1% ■	1-3%■■	3-10%■■■	10-25%■■■■	>25% ■■■■■

Table 15. Dryas *Summary Vegetation Table - national plots.*

Life Form	Ecotype / Number of plots	/02 Saxitri	/01.1 ARC041_1	/01 ARC041_2	/03	/04 ARC027_3	/06 ARC036	Common name
	Number of plots	11	53	40	10	25	29	
	Shrubs							**Shrubs**
00	*Salix* spp.						***	willow
04	*Vaccinium uliginosum*				□□□	***	□□	alpine bilberry
	Herbs							**Herbs**
07	*Saxifraga tricuspidata*	■■■			*			trident-leaved saxifrage
12	*Dryas* spp.	□□	■■■■	■■■■■	■■■■	■■■■■	■■■■	mountain-avens
07	*Oxytropis* spp.	□□		□□	■■	**	*	locoweeds
07	*Saxifraga oppositifolia*	□	■■■	■■		*		purple mountain saxifrage
12	*Salix arctica*	**	■■■	□□	□□		■■■	arctic willow
06	*Carex fuliginosa*		□□□					short-leaved sedge
06	*Carex rupestris*			■■■■				rock sedge
07	*Pedicularis* spp.		*	■	□	■	□	lousewort
12	*Salix reticulata*				■■■■	■■■	■■■	net-veined willow
06	*Carex scirpoidea*			***		□□□		single-spike sedge
12	*Cassiope tetragona*					■■■■■	***	four-angled mountain-heather
05	*Equisetum arvense*						■■■■	common horsetail
12	*Arctous* spp.						■■■	bearberry
12	*Rhododendron lapponicum*						□□□	Lapland rosebay
06	*Carex lugens*						□□□	muskeg sedge

07	*Hedysarum*						□□	sweet-vetch
	Mosses/lichens							**Mosses/lichens**
11	*Cetraria* sp.	**		□□	□□□	■■■		Iceland lichens
11	*Cladonia* sp.			*		■■		clad lichens
11	*Thamnolia vermicularis*	□	**	■■		□□		the whiteworm
11	*Lecanora epibyron*		***	□□□		***		“white crust”
09	*Hylcomium splendens*					□□□		step moss
11	*Cetraria islandica*					□□□		icelandmoss
09	*Moss species*						□□□□□	mosses

Lifeforms: 00—genus-level and mixed; 01—coniferous tree; 02—broad-leaved tree; 03—evergreen shrub; 04—decidious shrub; 05—fern or fern-ally; 06—graminoid; 07—forb; 08—parasite or saprophyte; 09—moss; 10—hepatic; 11—lichen; 12—dwarf woody plant; 13—macro alga

Frequency	25-50% *	50-70% □	70-100% ■		
Mean Cover	<1% ■	1-3%■■	3-10%■■■	10-25%■■■■	>25% ■■■■■

Table 16. Carex aquatilis *Summary Vegetation Table - Cambridge Bay plots only.*

Life Form	**Ecotype** / **Number of plots**	/05 1	/08 2	/07 4	/09 1	/10 2	/11 2	**Common name**
	Shrubs							**Shrubs**
04	*Salix richardsonii*	■■	■■■■■	□□				Richardson's willow
	Herbs							**Herbs**
12	*Salix reticulata*	■■■	□□					net-veined willow
06	*Alopecurus magellanicus*	■■	□□			□		alpine meadow-foxtail
12	*Dryas* spp.	■■■■■	■■■	■■				mountainavens
12	*Salix arctica*	■■■■	□□□□	■■■		□□□□		arctic willow
06	*Carex membranacea*	■■■	□□□	□□□		□□		fragile sedge
06	*Carex aquatilis*	■■■■■	■■■■■	■■■■■	■■■■■	■■■		water sedge
06	*Eriophorum angustifolium*	■	□□	■■		■■■■		narrow-leaved cotton-grass
07	*Pedicularis* spp.	■	■	■		■■		lousewort
07	*Saxifraga* spp.	■	□	■		□		wet site saxifrages
06	*Arctagrostis latifolia*	■	■	■	■■			polargrass
06	*Carex rariflora*	■	□	□□□				loose-flowered alpine sedge
06	*Carex atrofusca*		□□	□□□□				dark-brown sedge
06	*Dupontia fisheri*	■	□□		■■■	■■■■■	□	Fisher's tundra grass
07	*Tephroseris palustris*				■■■			marsh ragwort
07	*Hippuris* spp.				■		■■■■	mare's-tail
06	*Arctophila fulva*						■■■	Pendant grass
07	*Ranunculus* spp.						□□	buttercup

07	*Caltha palustris*						■	yellow marsh-marigold
	Mosses/lichens							**Mosses/lichens**
09	*Drepanocladus* spp.	■■■■	■■■■					
09	*Tomentypnum nitens*	■■■■		■■		■■■		golden fuzzy fen moss
09	*Pohlia* spp.	■■■	■■■■	■■■				nodding-cap moss
09	*Campylium stellatum*	■■	■■■■■	■■■				golden star-moss
09	*Pseudocalliergon turgescens*	■■	■					turgid scorpion-moss
09	*Loeskypnum badium*		■■■■	■■■■				
09	*Cinclidium subrotundum*		■■■			■■		
09	*Distichlis* spp.		■■■					

Lifeforms: 00—genus-level and mixed; 01—coniferous tree; 02—broad-leaved tree; 03—evergreen shrub; 04—decidious shrub; 05—fern or fern-ally; 06—graminoid; 07—forb; 08—parasite or saprophyte; 09—moss; 10—hepatic; 11—lichen; 12—dwarf woody plant; 13—macro alga

Frequency	25-50% *	50-70% ■	70-100% ■		
Mean Cover	<1% ■	1-3%■■	3-10%■■■	10-25%■■■■	>25% ■■■■■

Table 17. Carex aquatilis *Summary Vegetation Table - National plots.*

Life Form	**Ecotype** / **Number of plots**	/05 ARC033 7	/07 ARC056 89	/08 ARC062 26	/09 ARC019 106	/10 ARC04 69	/11 ARC009 52	**Common name**
	Shrubs							**Shrubs**
04	*Salix richardsonii*			■■■■■				Richardson's willow
	Herbs							**Herbs**
12	*Dryas* spp.	■■■■		□□□				mountain avens
06	*Carex fuliginosa*	□□□						short-leaved sedge
07	*Pedicularis* spp.	■■	□□	**				lousewort
06	*Arctagrostis latifolia*		□□	**				polargrass
12	*Salix arctica*	■■■■	■■■■			□□□		arctic willow
06	*Carex aquatilis*	■■■■■	■■■■■	■■■■■	■■■■■	□□□□		water sedge
06	*Eriophorum angustifolium*		■■■	■■■	□□□□	***		narrow-leaved cotton-grass
06	*Dupontia fisheri*					■■■■■		Fisher's tundra grass
06	*Arctophila fulva*						■■■■■	pendantgrass
07	*Bistorta vivipara*		□□	*				alpine bistort
07	*Saxifraga* spp.		□□			□□		wet site saxifrages
	Mosses/lichens	*****						**Mosses/lichens**
09	*Tomentypnum nitens*	□□□□	□□□□□					golden fuzzy fen moss
09	*Drepanocladus* spp.							

Lifeforms: 00—genus-level and mixed; 01—coniferous tree; 02—broad-leaved tree; 03—evergreen shrub; 04—decidious shrub; 05—fern or fern-ally; 06—graminoid; 07—forb; 08—parasite or saprophyte; 09—moss; 10—hepatic; 11—lichen; 12—dwarf woody plant; 13—macro alga

Frequency	25-50% *	50-70% □	70-100% ■		
Mean Cover	<1% ■	1-3%■■	3-10%■■■	10-25%■■■■	>25% ■■■■■

Table 18. Shore zone Summary Vegetation Table - Cambridge Bay plots only.

Life Form	Ecotype / Number of plots	/12	/13	/14	Common name
	Number of plots	2	1	1	
	Herbs				**Herbs**
06	*Carex ursina*	■■■■■			bear sedge
06	*Carex subspathecea*	■■■■			Hoppner's sedge
06	*Puccinellia phryganodes*	■■■■			creeping alkali grass
07	*Stellaria humifusa*	■■■	■		salt marsh starwort
12	*Salix arctica*	■	■	■	arctic willow
06	*Leymus mollis*		■■■■	■■	dune wildrye
07	*Mertensia maritima*		■	■■■■	sea bluebells
07	*Saxifraga tricuspidata*		■	■■	three-toothed saxifrage
07	*Tripleurospermum maritimum*		■	■■	seashore camomile
07	*Androsace septentrionalis*		■	■	northern fairy-candelabra
07	*Honckenya peploides*		■	■	seabeach sandwort
07	*Papaver* spp.		■	■	arctic poppies
07	*Tephroseris palustris*		■	■	marsh ragwort
06	*Festuca baffinensis*		■		Baffin fescue
07	*Astragalus* spp.		■		milk-vetches
07	*Epilobium latifolium*		■		broad-leaved willowherb
07	*Oxyria digyna*		■		mountain sorrel
07	*Oxytropis* spp.		■		locoweeds
07	*Sagina nivalis*		■		snow pearlwort

07	*Saxifraga* spp.		■		wet site saxifrages
12	*Dryas* spp.		■		mountain avens

Lifeforms: 00—genus-level and mixed; 01—coniferous tree; 02—broad-leaved tree; 03—evergreen shrub; 04—decidious shrub; 05—fern or fern-ally; 06—graminoid; 07—forb; 08—parasite or saprophyte; 09—moss; 10—hepatic; 11—lichen; 12—dwarf woody plant; 13—macro alga

Frequency	25-50% *	50-70% ■	70-100% ■		
Mean Cover	<1% ■	1-3%■■	3-10%■■■	10-25%■■■■	>25% ■■■■■

Table 19. Shore zone Summary Vegetation Table - National Plots.

Life Form	**Ecotype**	/12 ARC024	/12 ARC053	/13 ARC049	/14 ARC048	ARC069	
	Number of plots	27	36	28	22	7	**Common name**
	Herbs						**Herbs**
07	*Stellaria humifusa*	**	***				salt marsh starwort
06	*Carex subspathecea*	■■■■■					Hoppner's sedge
06	*Puccinellia phryganodes*		■■■■■				creeping alkali grass
06	*Leymus mollis*			■■■■■	■■		dune wildrye
07	*Epilobium latifolium*					■■■	broad-leaved willowherb
07	*Honckenya peploides*				■■■■		seabeach sandwort
07	*Androsace septentrionalis*			*	**		northern fairy-candelabra
07	*Mertensia maritima*			*	***		sea bluebells
07	*Plantago maritima*		***				sea plantain
07	*Saxifraga oppositifolia*					***	purple mountain saxifrage
12	*Salix arctica*					■■■ (grey)	arctic willow

Lifeforms: 00—genus-level and mixed; 01—coniferous tree; 02—broad-leaved tree; 03—evergreen shrub; 04—deciduous shrub; 05—fern or fern-ally; 06—graminoid; 07—forb; 08—parasite or saprophyte; 09—moss; 10—hepatic; 11—lichen; 12—dwarf woody plant; 13—macro alga

Frequency	25-50% *	50-70% ■ (grey)	70-100% ■		
Mean Cover	<1% ■	1-3%■■	3-10%■■■	10-25%■■■■	>25% ■■■■■

Table 20. Vegetation properties in each bioclimate subzone.

Subzone	Mean July Temp[1] (°C)	Summer warmth index[2] (°C)	Vertical structure of plant cover[3]	Horizontal structure of plant cover[3]	Major plant growth forms[4]	Dominant vegetation unit (see Detailed Vegetation Descriptions for species)	Total phyto-mass[5] ($t\ ha^{-1}$)	Net annual production[6] ($t\ ha^{-1}\ yr^{-1}$)	Number of vascular plant species in local floras[7]
A	0-3	<6	Mostly barren. In favorable microsites, 1 lichen or moss layer <2 cm tall, very scattered vascular plants hardly exceeding the moss layer	<5% cover of vascular plants, up to 40% cover by mosses and lichens	b, g, r, cf, of, ol, c	B1, G1	<3	<0.3	<50
B	3-5	6-9	2 layers, moss layer 1-3 cm thick and herbaceous layer, 5-10 cm tall, prostrate dwarf shrubs <5 cm tall	5-25% cover of vascular plants, up to 60% cover of cryptogams	npds, dpds, b, r, ns, cf, of, ol	P1, G1	5-20	0.2-1.9	50-100
C	5-7	9-12	2 layers, moss layer 3-5 cm thick and herbaceous layer 5-10 cm tall, prostrate and hemi-prostrate dwarf shrubs <15 cm tall	5-50% cover of vascular plants, open patchy vegetation	npds, dpds, b, ns, cf, of, ol, ehds* * in acidic areas	G2, P2	10-30	1.7-2.9	75-150
D	7-9	12-20	2 layers, moss layer 5-10 cm thick and herbaceous and dwarf-shrub layer 10-40 cm tall	50-80% cover of vascular plants, interrupted closed vegetation	ns, nb, npds, dpds, deds, neds, cf, of, ol, b	G3, S1	30-60	2.7-3.9	125-250
E	9-12	20-35	2-3 layers, moss layer 5-10 cm thick, herbaceous/ dwarf-shrub layer 20-50 cm tall, sometimes with low-shrub layer to 80 cm	80-100% cover of vascular plants, closed canopy	dls, ts*, ns, deds, neds, sb, nb, rl, ol *in Beringia	G4, S1, S2	50-100	3.3-4.3	200 to 500

[1] based on Edlund (1996) and Matveyeva (1998).
[2] Sum of mean monthly temperatures greater than 0°C, modified from Young (1971).
[3] Chernov and Matveyeva (1997).
[4] b - barren; c - cryptogam; cf - cushion or rosette forb; deds - deciduous erect dwarf shrub; dls - deciduous low shrub; dpds - deciduous prostrate dwarf shrub; g - grass; ehds - evergreen hemiprostrate dwarf shrub; nb - nonsphagnoid bryophyte; neds - nondeciduous erect dwarf shrub; npds - nondeciduous prostrate dwarf shrub; ns - nontussock sedge; of - other forb; ol - other lichen; r - rush; rl - reindeer lichen; sb - sphagnoid bryophyte; ts - tussock sedge. Underlined codes are dominant.
[5] Based on Bazilevich, Tishkov and Vilcheck (1997), aboveground + belowground, live + dead.
[6] Based on Bazilevich, Tishkov and Vilcheck (1997), aboveground + belowground.
[7] Number of vascular species in local floras based mainly on Young (1971).