Canadian Transect and Mapping
for the Circumpolar Arctic Vegetation Map

W.A. Gould, D.A. Walker, and M. Raynolds

Northern Ecosystem Analysis and Mapping Lab, Institute of Arctic Biology, University of Alaska, Fairbanks, AK, USA 99775-7000

Presented at the National Science Foundation ARCSS LAII Science Workshop, Seattle WA, February 23-26, 2000

Introduction

One of the needs of Arctic science is to maintain an influx of new students and ideas by integrating research and education. A second is to encourage the development of international collaboration needed to conduct research related to global patterns and expected changes in the circumpolar region. We addressed these needs during the summer of 1999 as University students from the United States and Canada joined vegetation scientists from Canada, Germany, Norway, Russia, and the United States (Table 1) in a transect from the northern to southern Canadian Arctic designed to investigate large-scale variation in vegetation related to climate and to involve students in Arctic research. We called this mobile workshop the *1999 Canadian Transect for the Circumpolar Arctic Vegetation Map.*

The field class is *Arctic Field Ecology*, offered by the Itasca Biology Station at the University of Minnesota, and the research is a component of the Circumpolar Arctic Vegetation Map (CAVM) project (Walker and Lillie 1997). The field class and CAVM project were united in an effort to understand patterns of zonation in vegetation of the Canadian Arctic that are related to the climatic gradient in the Canadian Arctic.

Table 1. Students and scientists involved in the 1999 Canadian Transect for the Circumpolar Arctic Vegetation Map.

Students
Dianna Alsup (Texas A&M University)
April Desjarlais (University of Saskatchewan)
Howard Hill (Northeastern Illinois Univ.)
Christine McDaniel Hill (Northeastern Illinois Univ.)
Chris Schadt (Univ. of Colorado)

Researchers, location () and area of expertise
Dr. Fred Daniëls (Germany) Greenland
Dr. Sylvia Edlund (Ottawa, Ontario) High Arctic Canada
Dr. Arve Elvebakk (University of Tromso) Svalbard
Dr. William Gould (Univ. of Minnesota) Canada
Dr. Nadya Matveyeva (Komorov Bot. Inst.) Taimyr Peninsula, Russia
Dr. Boris Yurtsev (Komorov Bot. Inst.) Russia
Dr. Skip Walker (Univ. of Alaska) Alaska

Transect Goals

The 1999 Canadian transect was designed to bring the principle scientists involved in the CAVM to the Canadian Arctic to visit representative sites along the complete north-south climatic gradient in order to:

- discuss zonation concepts in light of our observations and try to develop consensus on zonation terminology for the vegetation map
- better understand vegetation patterns in the least well-documented of the circumpolar regions
- develop a table of major vegetation types along a mesotopographic sequence within the Canadian portion of the Canada-Greenland floristic province
- further interest and research in the Arctic by involving graduate and undergraduate students in the project through a University of Minnesota sponsored field course, *Arctic Field Ecology.*

Acknowledgments

This project was assisted by funding from the Arctic Transitions in the Land-Atmosphere System (ATLAS) project (OPP-9732076), an NSF PFSMETE - postdoctoral fellowship integrating research and field education, and the University of Minnesota Itasca Field Biology Program and Summer Session office. We thank the Polar Continental Shelf Project, Steve Matthews of RWED, George Hakongak, Nunavut Arctic College, and the Hamlet office in Cambridge Bay for assistance with logistics, meetings, and transportation. Special thanks to members of the CAVM project and the students of Arctic Field Ecology.

Figure 2. Color infrared AVHRR image of the Canadian Arctic.

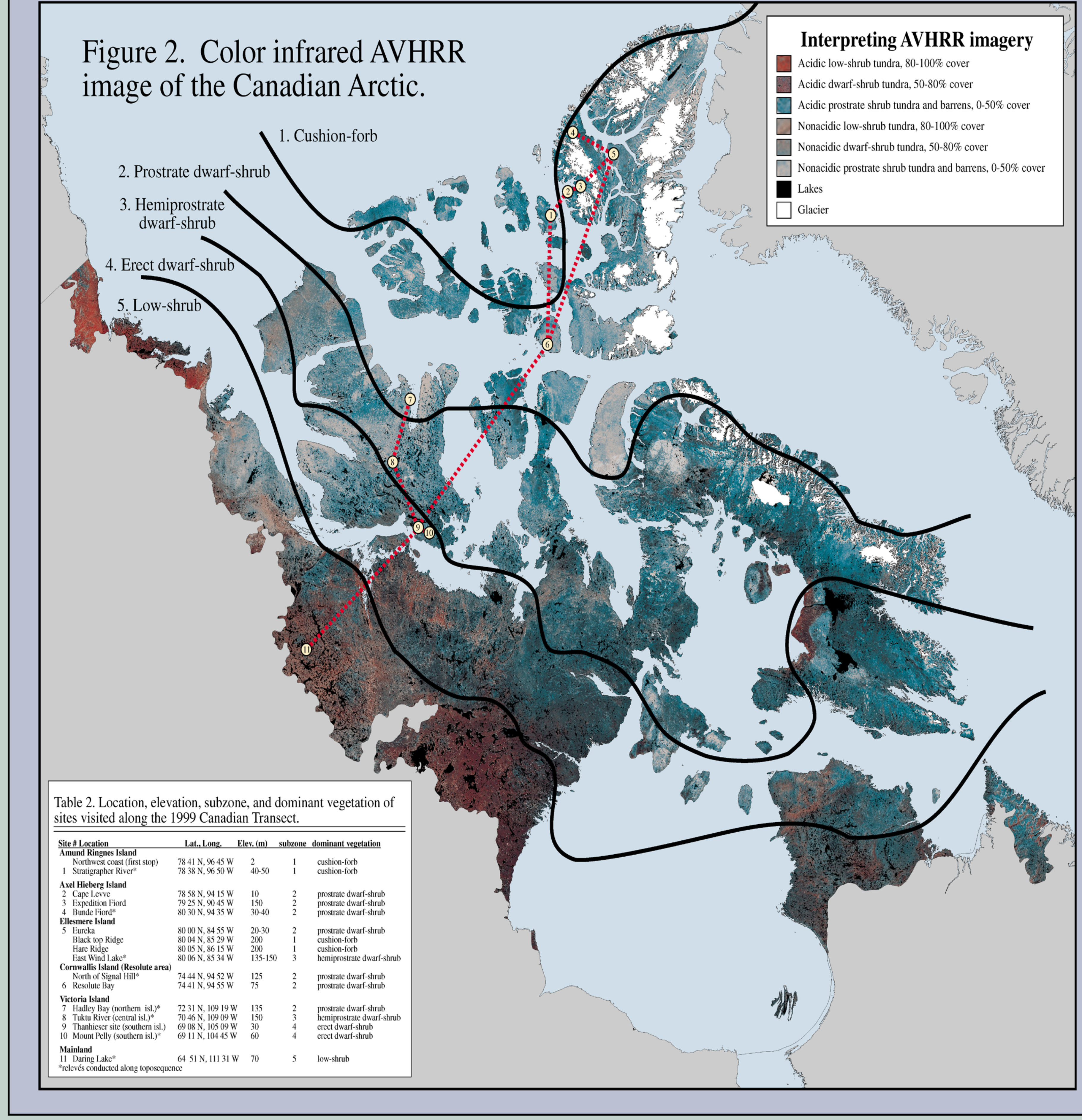


Table 2. Location, elevation, subzone, and dominant vegetation of sites visited along the 1999 Canadian Transect.

Site # Location	Lat., Long.	Elev. (m)	subzone	dominant vegetation
Amund Ringnes Island				
Northwest coast (first stop)	78 41 N, 96 45 W	2	1	cushion-forb
1 Stratigrapher River*	78 38 N, 96 50 W	40-50	1	cushion-forb
Axel Heiberg Island				
2 Cape Levvel	78 58 N, 94 15 W	10	2	prostrate dwarf-shrub
3 Expedition Fiord	79 25 N, 90 45 W	150	2	prostrate dwarf-shrub
4 Bunde Fiord*	80 30 N, 94 35 W	30-40	2	prostrate dwarf-shrub
Ellesmere Island				
5 Eureka	80 00 N, 84 55 W	20-30	2	prostrate dwarf-shrub
Black top Ridge	80 04 N, 85 29 W	200	1	cushion-forb
Hare Ridge	80 05 N, 86 15 W	200	1	cushion-forb
East Wind Lake*	80 06 N, 85 34 W	135-150	3	hemiprostrate dwarf-shrub
Cornwallis Island (Resolute area)				
North of Signal Hill*	74 44 N, 94 52 W	125	2	prostrate dwarf-shrub
6 Resolute Bay	74 41 N, 94 55 W	75	2	prostrate dwarf-shrub
Victoria Island				
7 Hadley Bay (northern isl.)*	72 31 N, 109 19 W	135	2	prostrate dwarf-shrub
8 Tuktu River (central isl.)*	70 46 N, 109 09 W	150	3	hemiprostrate dwarf-shrub
9 Thanksgiving site (southern isl.)	69 08 N, 105 09 W	30	4	erect dwarf-shrub
10 Mount Pelly (southern isl.)*	69 11 N, 104 45 W	60	4	erect dwarf-shrub
Mainland				
11 Daring Lake*	64 51 N, 111 31 W	70	5	low-shrub

*relevés conducted along toposequence

Canadian Vegetation Mapping

The CAVM map integrates information on soils, bedrock and surficial geology, hydrology, remotely-sensed vegetation classifications, previous vegetation studies, and regional expertise of the mapping scientists. This information is used to define polygons drawn using photo-interpretation of a 1:4 million scale AVHRR basemap of Canada (Fig. 2). The final CAVM map will unify and standardize information from regional maps and legends derived from many years of vegetation study in all the circumpolar countries. It will be useful for creating an international framework and common language for the study of arctic vegetation, modeling vegetation change at the circumpolar scale, educational purposes, interpreting large-scale patterns of wildlife distribution and migration, and regional or larger-scale land management.

The scale at which the circumpolar map is being developed will capture variation in vegetation related to climate (latitudinal variation, phytogeographic subzones), substrate, topography, and longitudinal floristic variation. This will link large scale phytogeographic patterns with landscape units visible in AVHRR satellite imagery (Fig. 2) (Walker and Lillie 1997).

Transect sampling

We visited sixteen locations along the 2000 km transect (Table 1, Fig. 2). Sites were selected using the following criteria: 1) they should be located in each of Yurtsev's (1994) five phytogeographic subzones, 2) they should be logistically accessible, 3) each site should have a range of accessible undisturbed habitats (topographic positions and moisture conditions), and 4) each site should be representative of regional climatic and substrate conditions. Sampling areas were selected using air photos and topographic and vegetation maps when available. Sampling was designed to supplement existing knowledge of vegetation in the region and to provide a springboard for discussion of the concepts of zonal vegetation in the Canadian Arctic and the circumpolar region.

Our transect included a set of four stops with logistic support (Daring Lake, Cambridge Bay, Resolute, and Eureka) with day travel to our sampling areas. Vascular, lichen, and bryophyte floristic surveys were conducted at each of the sixteen sites. Sampling at eight intensive sites involved conducting relevés along a complete mesotopographic gradient (Fig. 3) with the goal of describing the range of representative vegetation and soils in 1) dry, 2) mesic-zonal, 3) wet, 4a) early snowbed, 4b) late snowbed, and 5) riparian environments.

Data from each intensive site include location, general site description, site photographs, site vascular species list, relevé vegetation data including presence and abundance of vascular, bryophyte, and lichen species, relevé soils data including depth of horizons, active layer depth, USGS classification, a "B" horizon soil sample for data on texture, pH, mineral analysis (Ca, N, P, K, Na), volumetric/gravimetric soil moisture, color, and % organic matter.

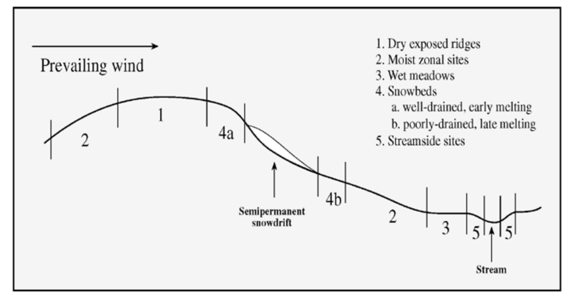


Figure 3. Diagram indicating relative locations of habitats sampled along mesotopographic gradient.

Zonation

Subzone 1: Cushion-forb

Characterized by the absence of woody plants and sedges and the dominance of herbaceous dicots, grasses, rushes, and bryophytes. Equivalent to the Russian polar desert region. It is restricted to the low lying northern Queen Elizabeth Islands and the northern and western most edges of Ellesmere and Axel Hieberg Islands. This region is primarily within the permanent polar ice pack and has frequent summer fogs, reducing insolation and summer temperatures. Average vegetation cover is < 5 % but regions with suitable substrate can have up to 100% cover. Mean July temperatures range from 0-3°C.

Subzone 2: Prostrate dwarf-shrub

Restricted to the Arctic Islands and characterized by prostrate dwarf-shrub vegetation including *Salix arctica* on more acidic sites and *S. arctica* and *Dryas integrifolia* (*Carici-Dryadetum integrifoliae*) on nonacidic sites. There are large areas with scant vegetation cover on the strongly calcareous substrates of Cornwallis, Devon, Somerset, and parts of Baffin Island. The sedge *Carex aquatilis* var. *stans* occurs in wet areas. The mesic-zonal vegetation is similar throughout both subzone 2 and 3 on the strongly calcareous substrates found in the Canadian Arctic but variation does occur in the wet, riparian, and snowbed habitats. Vegetation cover averages 5-50%. Mean July temperatures range from 3-5°C.

Subzone 3: Hemiprostrate dwarf-shrub

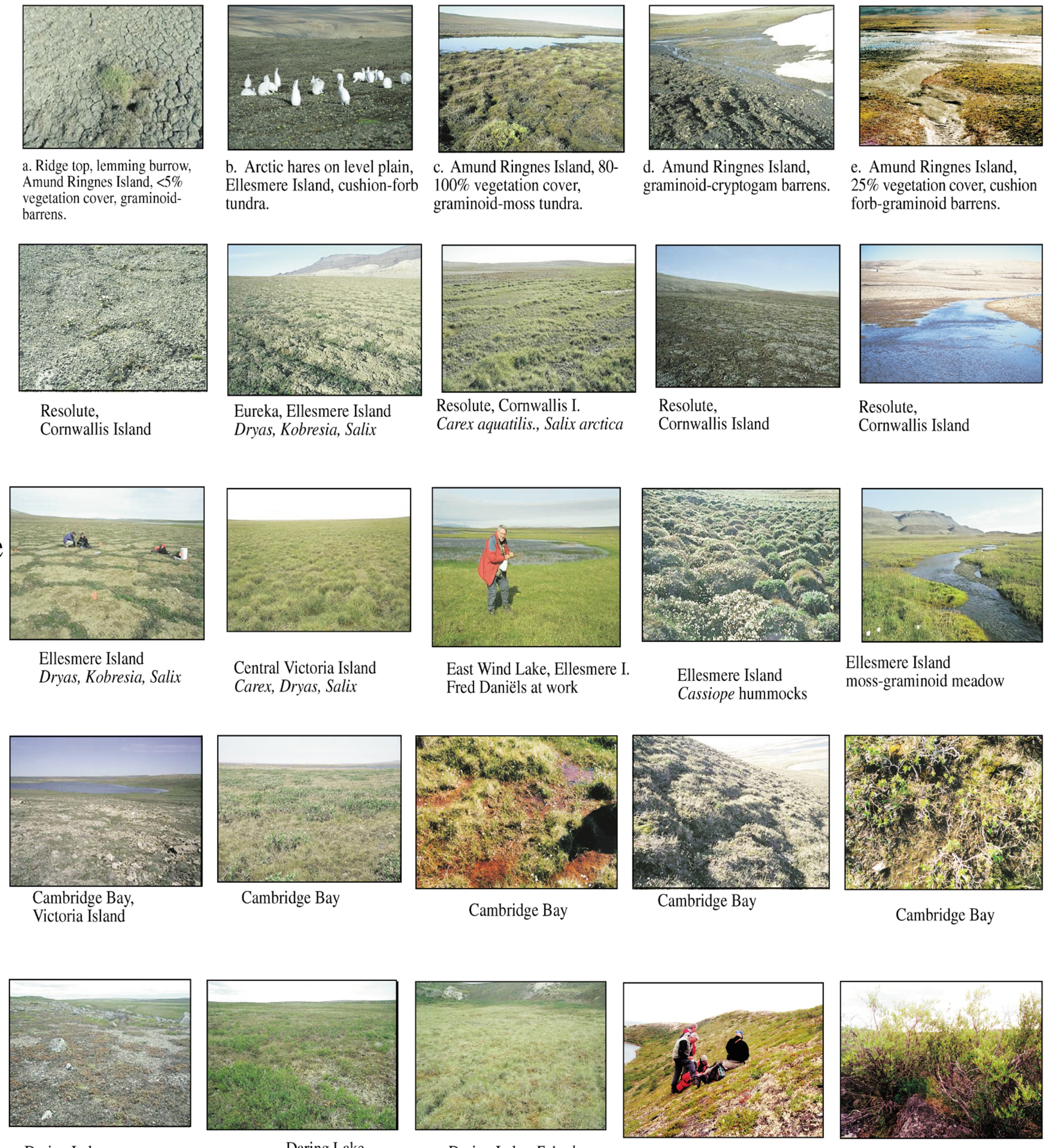
Found on the Arctic islands in eastern and western Canada and on the mainland west of the Foxe Basin. Characterized by the presence of dwarf-shrub heath vegetation with *Cassiope tetragona* on mesic acidic substrates, *Salix arctica* and *Dryas integrifolia* (*Carici-Dryadetum integrifoliae*) on nonacidic zonal sites with *Salicetio-Cassiopetum tetragonae* dominated snowbeds on nonacidic substrates, a higher diversity of sedges in the wetlands, and increased presence of *Epilobium latifolium* communities in the riparian areas. Vegetation cover averages 50-80% and Mean July temperatures range from 5-7°C.

Subzone 4: Erect dwarf-shrub

Found on the Arctic Islands in the west and on the mainland of eastern Canada. Dry sites on nonacidic coarse textured soils are dominated by *Salix arctica* and *Dryas integrifolia*. Mesic (zonal) sites are characterized by the presence of *Salix lanata ssp. richardsonii*. Zonal vegetation on the more acidic mainland is dominated by *Ledum decumbens* and *Betula glandulosa*. Low shrub vegetation can be found along sheltered streambanks. Vegetation cover is continuous on mesic and wet sites and discontinuous on knolls and ridges. Mean July temperatures range from 7-9°C.

Subzone 5: Low-shrub

Found entirely on the mainland in Canada and characterized by low-shrub vegetation on the zonal sites, primarily *Betula glandulosa* on acidic sites and *Salix glauca* on nonacidic sites. *Eriophorum vaginatum* tussock tundra can be dominant on acidic substrates in the western portion of this subzone in Canada. Boreal floristic elements are common (Yurtsev 1994). A variety of tall shrubs are found in riparian and sheltered areas. Wetlands show considerable peat development. Vegetation cover is continuous except on exposed ridges and areas of the Canadian shield with minimal surficial deposits. Mean July temperatures range from 9-12°C.



Dry | Mesic | Wet | Snowbed | Riparian

Subzone 1 Cushion-forb
a. Ridge top, lemming burrow, Amund Ringnes Island, <5% vegetation cover, graminoid-barrens.
b. Arctic hares on level plain, Ellesmere Island, cushion-forb tundra.
c. Amund Ringnes Island, 80-100% vegetation cover, graminoid-moss tundra.
d. Amund Ringnes Island, graminoid-cryptogam barrens.
e. Amund Ringnes Island, 25% vegetation cover, cushion forb-graminoid barrens.

Subzone 2 Prostrate dwarf-shrub
Resolute, Cornwallis Island | Eureka, Ellesmere Island *Dryas, Kobresia, Salix* | Resolute, Cornwallis I. *Carex aquatilis., Salix arctica* | Resolute, Cornwallis Island | Resolute, Cornwallis Island

Subzone 3 Hemiprostrate dwarf-shrub
Ellesmere Island *Dryas, Kobresia, Salix* | Central Victoria Island *Carex, Dryas, Salix* | East Wind Lake, Ellesmere I. Fred Daniëls at work | Ellesmere Island *Cassiope* hummocks | Ellesmere Island moss-graminoid meadow

Subzone 4 Erect dwarf-shrub
Cambridge Bay, Victoria Island | Cambridge Bay | Cambridge Bay | Cambridge Bay | Cambridge Bay

Subzone 5 Low-shrub
Daring Lake | Daring Lake erect shrubs | Daring Lake, *Eriophorum Sphagnum* tussock tundra | Daring Lake | Daring Lake

Figure 4a-y. Characteristic vegetation communities along a mesotopographic sequence in each of the five subzones of the Canadian Arctic.

Polar Desert

Vegetation zonation in the North American Arctic has been characterized in a variety of ways, often inconsistently with European and Russian zonation schemes and within the North American literature (Walker 2000). The greatest source of confusion lies in the use of the term "Polar Desert". In the Russian and European traditions this refers to the climatic zone north of the limit of woody plants – Subzone 1 in the CAVM zonation. In much of the North American literature "Polar Desert" refers to barren areas in a range of climatic zones that have scant vegetation cover (Bliss 1997). These barrens are due to a variety of interacting conditions including climate, moisture, soil texture, and substrate chemistry. The CAVM zonation is based on distributions of plant species and functional types controlled solely by climate. It will be useful in global modelling efforts investigating vegetation change related to climate and can be applied unambiguously on a circumpolar scale.

References

Bliss, L.C. 1997. Arctic Ecosystems of North America. In: *Polar and Alpine Tundra*. F.E. Wielgolaski, ed. pp.551-684. Elsevier, Amsterdam.
Walker, D.A. 2000. Hierarchical subdivision of Arctic tundra based on vegetation response to climate, parent material, and topography. Global Change Biology. In press.
Walker D.A. and A. Lillie. 1997. *Proceedings of the second CAVM workshop, Arendal, Norway, 1996, and The CAVM-North American Workshop*, Anchorage, Alaska, USA, 1997. INSTAAR Occasional Paper, 52:61.
Yurtsev, B.A. 1994. Floristic division of the Arctic. Journal of Vegetation Science. 5:765-776.