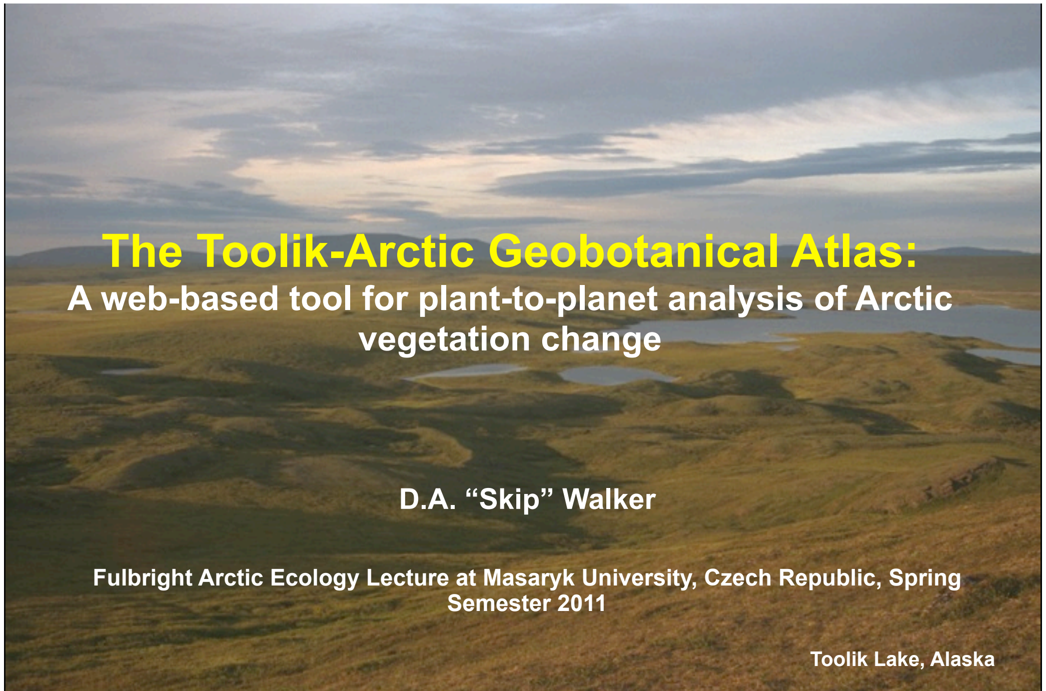


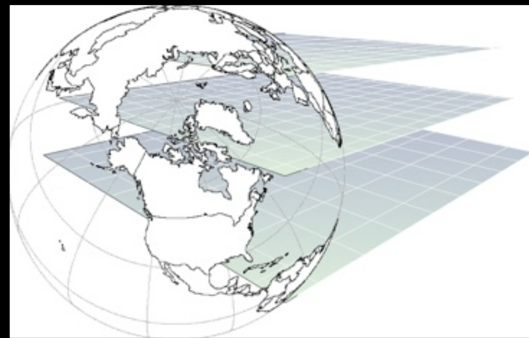
The Toolik-Arctic Geobotanical Atlas:

A web-based tool for plant-to-planet analysis of Arctic vegetation change

D.A. “Skip” Walker

Fulbright Arctic Ecology Lecture at Masaryk University, Czech Republic, Spring Semester 2011

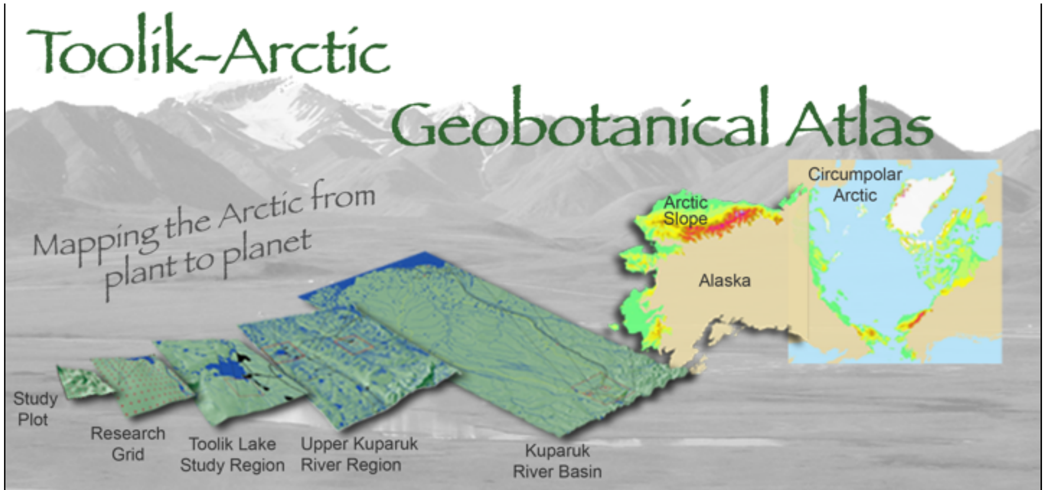
Toolik Lake, Alaska



Themes of Talk

- Provide an overview of the geobotanical atlas and the hierarchy of maps.
- Examples of application of the hierarchy of GIS databases for vegetation change analysis at Toolik and the circumpolar Arctic.
- Integrated landscape-based mapping approach.

AT THE END: Class discussion of the links between vegetation classification, mapping, remote sensing and their future in vegetation science and international vegetation research.

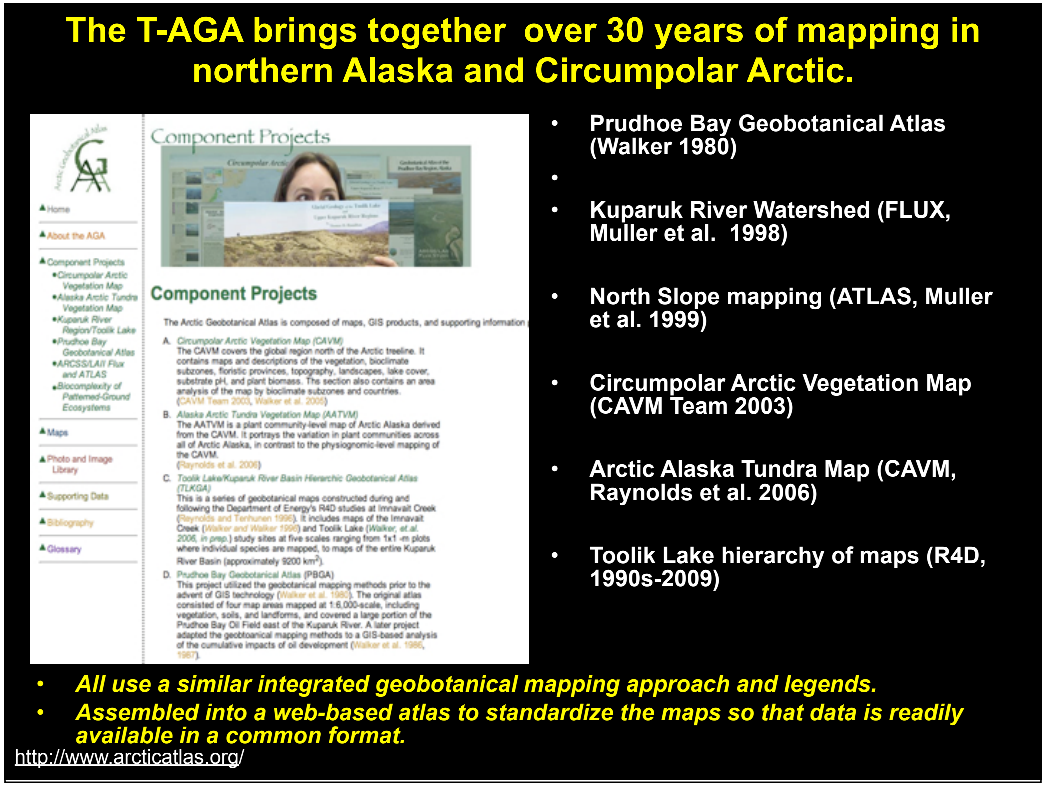


- **Addresses need for vegetation maps at multiple scales for science and science management at the Toolik Arctic Observatory.**
- **Extrapolation of plot-level research to broader regions and the circumpolar Arctic.**

http://www.arcticatlas.org/

Toolik Field Station

- Arctic Observatory for the U.S. Arctic Research Program
- Arctic Long-term Ecological Research Program
- GIS program serves science and management needs.



The Atlas is organized principally by component projects that my lab has been involved with since the 1970s.

These include:

Circumpolar Arctic Vegetation Map (CAVM Team 2003)

Arctic Alaska Tundra Map (CAVM, Raynolds et al. 2006)

North Slope mapping (ATLAS, Muller et al. 1999)

Kuparuk River Watershed (FLUX, Muller et al. 1998)

Toolik Lake hierarchy of maps (R4D, 1990s-2006)

Prudhoe Bay Geobotanical Atlas (Walker 1980)

Key aspects of the hiearchical series of maps

Common geobotanical mapping approach at all scales. Includes vegetation, surface geomorphology, landforms, NDVI, and other landscape variables.

- **Use of the integrated terrain-unit mapping approach for most maps.**
- **Linkage of legends and color schemes between scales.**
- **Use of the Braun-Blanquet approach as the standard for plant community nomenclature where ever possible.**
- **Links to other supporting data. Detailed descriptions of all units, permanent plots data (photographs, vegetation, site and soil information, plant species), and important literature.**

Hiearchical map browser by area and theme

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Circumpolar Arctic Vegetation Map » Map Browser » TAGA Home » Maps » Map Browser

Map Browser

This section lists the maps that can be accessed by area or theme. You can also download the GIS data.

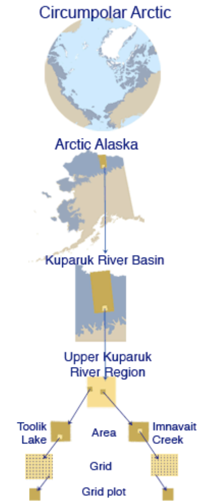
Choose a map area or a theme from the list below, or select a map area from the image to the right. Not sure which map to look at? See all the maps.

Available Map Areas:

- Circumpolar Arctic
- Arctic Alaska
- Kuparuk River Basin
- Upper Kuparuk River Region
- Imnavait Creek Area
- Toolik Lake Area
- Toolik Lake Grid
- Imnavait Creek Grid
- Imnavait Creek Grid Plots
- Toolik Lake Grid Plots

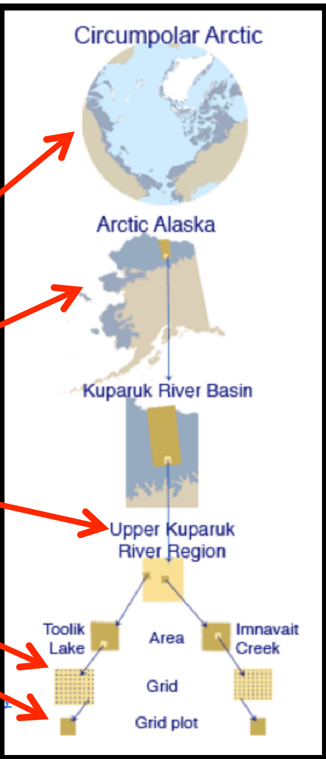
Available Themes:

- Alaska Arctic Tundra Vegetation Map
- AVHRR False-color Infrared Base Map
- Bioclimate Subzones
- Circumpolar Arctic Vegetation Map
- Elevation
- Floristic Provinces
- Hydrology and Watershed Boundary
- Lake Cover
- Landscape
- NDVI/Phytomass
- Spot False-Color Infrared Image
- Substrate Chemistry
- Toolik Lake Area Vegetation
- Toolik Lake Grid Vegetation
- Upper Kuparuk River Region Vegetation
- Vegetation

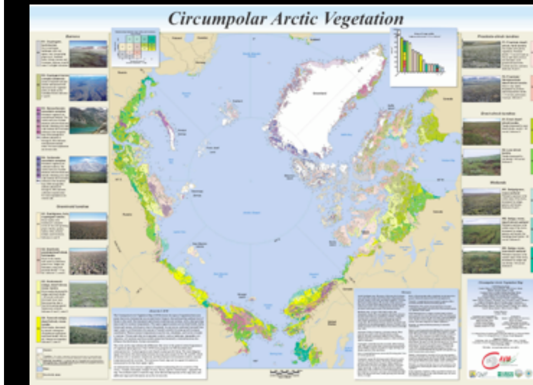


Hierarchy of maps discussed here

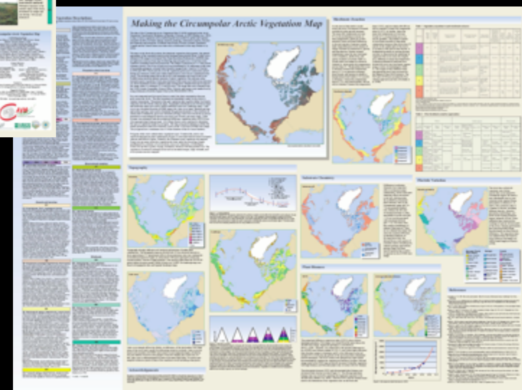
- **Global (circumarctic) scale**: Circumpolar Arctic Vegetation Map
- **Regional (state of Alaska) scale**: Alaska Arctic Tundra Vegetation Map
- **Subregion scale:** Upper Kuparuk River region
- **Landscape scale**: Toolik Lake grid
- **Plot and plant scale**: Toolik grid plots



Circumpolar Arctic Vegetation Map (CAVM)



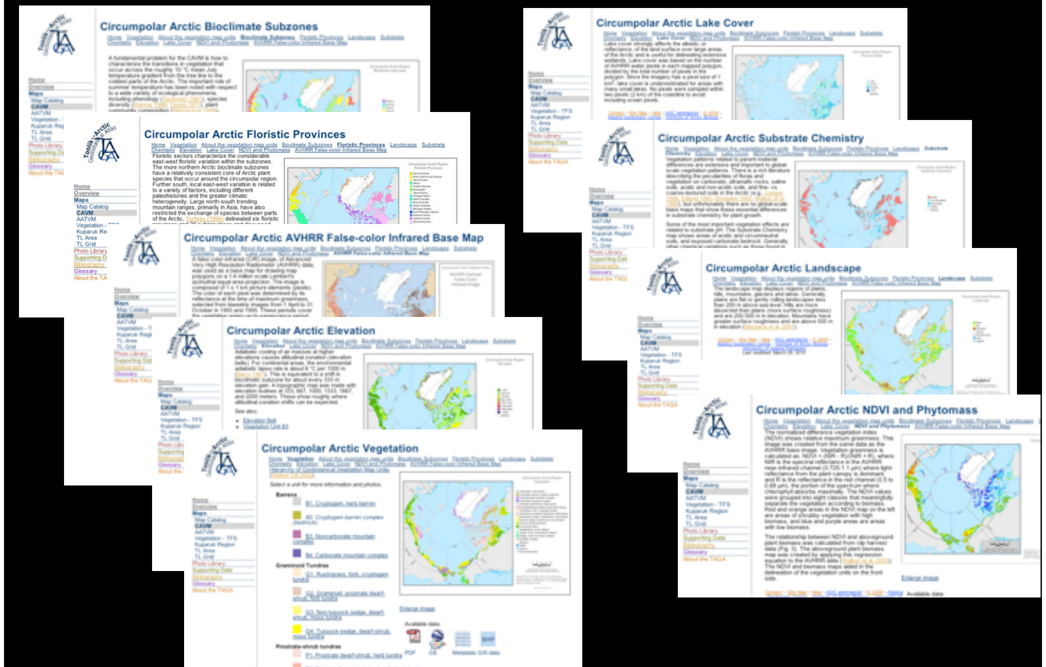
- 13-year international effort to make a vegetation map of the Arctic.
- First detailed map of an entire global biome.
- 1:7.5 M scale.



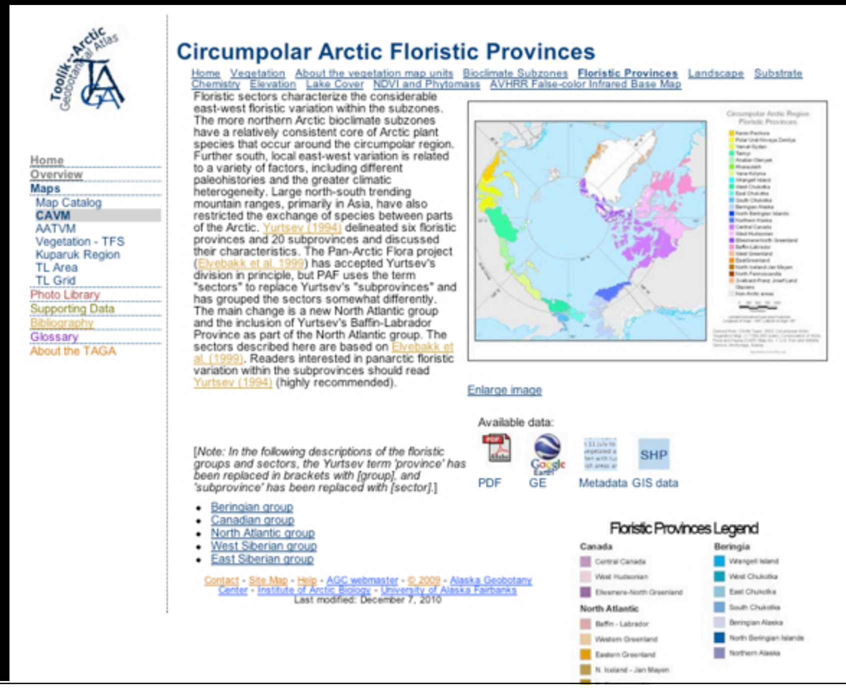
CAVM Team, 2003. *Circumpolar Arctic Vegetation Map*: Anchorage, AK, Conservation of Arctic Flora and Fauna (CAFF) Map No. 1, U.S. Fish and Wildlife Service.

Methods described in Walker et al. 2005. *Jour. Veg. Sci.*, 16-267-282.

Description of map themes



Description of Floristic Provinces theme



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Circumpolar Arctic Floristic Provinces

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Floristic sectors characterize the considerable east-west floristic variation within the subzones. The more northern Arctic bioclimate subzones have a relatively consistent core of Arctic plant species that occur around the circumpolar region. Further south, local east-west variation is related to a variety of factors, including different paleohistories and the greater climatic heterogeneity. Large north-south trending mountain ranges, primarily in Asia, have also restricted the exchange of species between parts of the Arctic. Yurtsev (1994) delineated six floristic provinces and 20 subprovinces and discussed their characteristics. The Pan-Arctic Flora project (Elvebakk et al. 1999) has accepted Yurtsev's division in principle, but PAF uses the term "sectors" to replace Yurtsev's "subprovinces" and has grouped the sectors somewhat differently. The main change is a new North Atlantic group and the inclusion of Yurtsev's Baffin-Labrador Province as part of the North Atlantic group. The sectors described here are based on Elvebakk et al. (1999). Readers interested in panarctic floristic variation within the subprovinces should read Yurtsev (1994) (highly recommended).

Enlarge image

Available data:

PDF GE Metadata GIS data

[Note: In the following descriptions of the floristic groups and sectors, the Yurtsev term 'province' has been replaced in brackets with [group], and 'subprovince' has been replaced with [sector].]

- Beringian group
- Canadian group
- North Atlantic group
- West Siberian group
- East Siberian group

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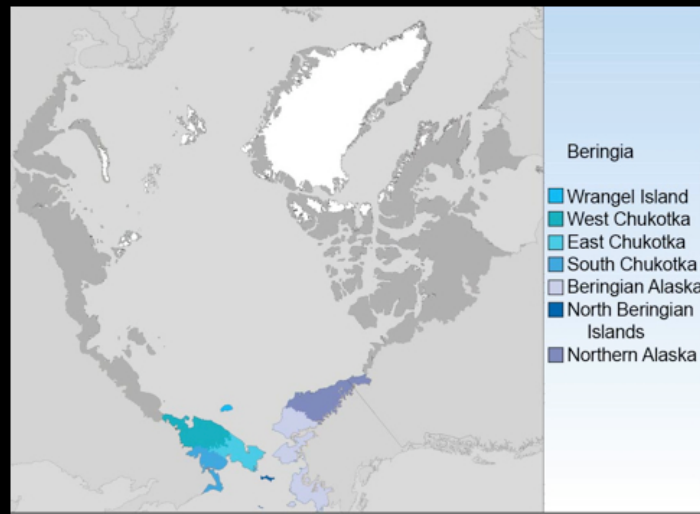
Last modified: December 7, 2010

Floristic Provinces Legend

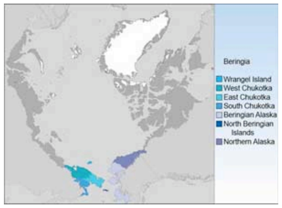
Canada	Beringia
Central Canada	Wrangell Island
West Hudsonian	West Chukotka
Ellesmere-North Greenland	East Chukotka
North Atlantic	South Chukotka
Baffin - Labrador	Beringian Alaska
Western Greenland	North Beringian Islands
Eastern Greenland	Northern Alaska
N. Iceland - Jan Mayen	

Links to map of Beringia Floristic Province and subprovinces



Details of Floristic Provinces and Sectors

Circumpolar Arctic Floristic Provinces - Beringian Group



Floristic Provinces-Beringian Group

All of Arctic Alaska is within the Beringian group of floristic sectors. The term "Beringia" was coined by Eric Hultén to describe the vast region centered on the Bering Strait and extending from the Kolyma River in the west to the Mackenzie River in the Northwest Territories. During the Pleistocene glacial intervals, sea level was as much as 100 m lower than present because of large amounts of water locked up in continental glaciers. This resulted in the large land mass connecting North America with Asia shown in Fig. 1.

Hultén recognized that Beringia was the center of distribution of many plant species that evolved here while most of northern North America was covered with ice. Yurtsev (1994) described the Chukotka and Alaska provinces within in the Beringia region (which he calls the Beringian sector). The PAF project combines Yurtsev's Chukotka and Alaska provinces into a single Beringia floristic group as originally suggested by Hultén (1937).

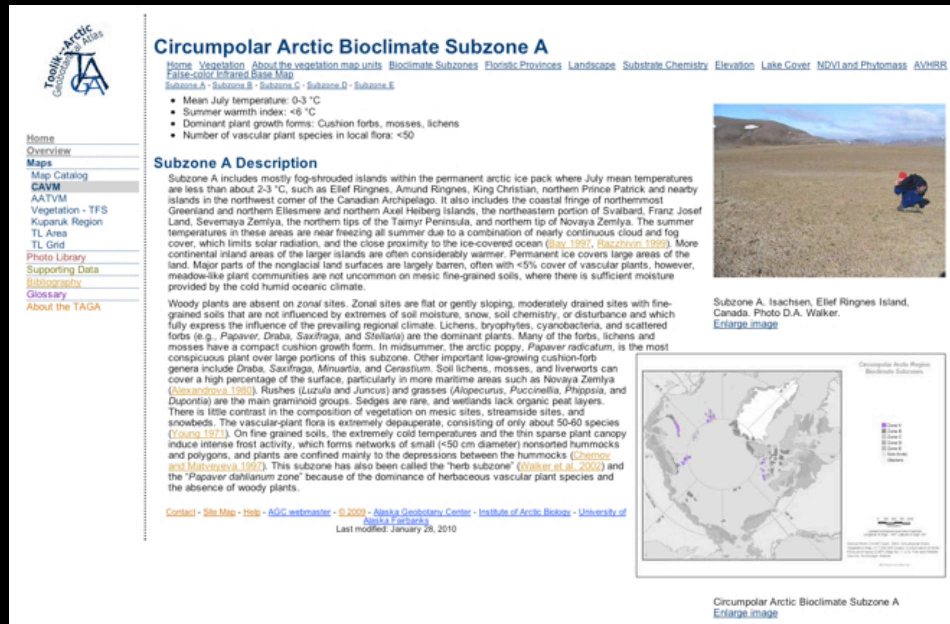
Elvebakk et al. (1999) characterize the Beringia group: "This is a highly diverse and floristically rich group of four to six regions [sectors]…, the number depending on some decisions still to be made. The importance of the group is that it contains all the important areas assumed to have been unglaciated through all or large parts of Quaternary times, including the islands in the shelf areas now submerged. On the Asiatic side are two undisputed regions, *West Chukotka* along the East Siberian Sea, including Wrangel Island, and *East Chukotka* facing the Bering Strait and Sea, the latter region with the strongest Beringian elements on the Asiatic side. Yurtsev also proposes a *South Chukotka* region on both sides of the Anadyr Basin, based on a floristic element connecting it to the more southern mountains and the Koryak Coast. An alternative proposal is to unite this with West Chukotka as it is a small area with insufficient characterization. Another option is to split it into the oceanic and continental parts to be assigned to the West and East Chukotka correspondingly. On the North American side are recognized the *Beringian Alaska* region facing the Bering Strait and Sea, with the strongest Beringian elements on the American side, and the *North Alaska* region of the Brooks Range and the northern coast, also extending into Canada. The eastern delimitation of North Alaska is disputed. Yurtsev proposes to draw the line west of Mackenzie River whereas others argue for including parts of the coast east of Mackenzie and western parts of Banks Isl. and Victoria Isl. in the region. The reason is mainly that parts of these islands and the mainland have been unglaciated and have subendemic plants in common with Beringian regions. The decision will depend on how the remaining of the Canadian Arctic will be subdivided [see Canada group]. Yurtsev proposes a separate *North Beringian Islands* region, which includes Big Diomede Island (Russian), Little Diomede Island, St. Lawrence Island, and St. Matthew Island (all North American). This region is mainly negatively characterized, except for a very few Pacific oceanic species more frequent here than on the mainlands. The islands would have been a natural part of a larger region including Pribyloff Islands, the Aleutian Islands and the Commodore Islands, but we have decided to exclude these from the Arctic. The alternative proposal is to join the islands with the neighboring regions: Big Diomede with East Chukotka, the others with Beringian Alaska." (From Elvebakk et al. 1999).

- Wrangel Island sector

  This small sector includes Wrangel Island and small Herald Island (Petrovsky 1988a, b; Yurtsev 1978). Compared with the other three Chukotkan sectors, this sector shows many characteristic features, including a relatively large number (22) of endemic species and subspecies, some of them being very distinctive, e.g. *Hierochloë wrangelica*, *Oxytropis uniflora* of the *Baicalia-section* (vicarious to *O. putoranica*) and *Potentilla wrangelii*. The most abundant local endemics are found in the

Descriptions of Bioclimate subzones themes

Description of Subzone A



Toolik-Arctic Geobotanical Atlas

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Circumpolar Arctic Bioclimate Subzone A

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Subzone A - Subzone B - Subzone C - Subzone D - Subzone E

- Mean July temperature: 0-3 °C
- Summer warmth index: <6 °C
- Dominant plant growth forms: Cushion forbs, mosses, lichens
- Number of vascular plant species in local flora: <50

Subzone A Description

Subzone A includes mostly fog-shrouded islands within the permanent arctic ice pack where July mean temperatures are less than about 2-3 °C, such as Ellef Ringnes, Amund Ringnes, King Christian, northern Prince Patrick and nearby islands in the northwest corner of the Canadian Archipelago. It also includes the coastal fringe of northernmost Greenland and northern Ellesmere and northern Axel Heiberg Islands, the northeastern portion of Svalbard, Franz Josef Land, Severnaya Zemlya, the northern tips of the Taimyr Peninsula, and northern tip of Novaya Zemlya. The summer temperatures in these areas are near freezing all summer due to a combination of nearly continuous cloud and fog cover, which limits solar radiation, and the close proximity to the ice-covered ocean (Bay 1997, Razzhivin 1999). More continental inland areas of the larger islands are often considerably warmer. Permanent ice covers large areas of the land. Major parts of the nonglacial land surfaces are largely barren, often with <5% cover of vascular plants, however, meadow-like plant communities are not uncommon on mesic fine-grained soils, where there is sufficient moisture provided by the cold humid oceanic climate.

Woody plants are absent on *zonal* sites. Zonal sites are flat or gently sloping, moderately drained sites with fine-grained soils that are not influenced by extremes of soil moisture, snow, soil chemistry, or disturbance and which fully express the influence of the prevailing regional climate. Lichens, bryophytes, cyanobacteria, and scattered forbs (e.g., *Papaver*, *Draba*, *Saxifraga*, and *Stellaria*) are the dominant plants. Many of the forbs, lichens and mosses have a compact cushion growth form. In midsummer, the arctic poppy, *Papaver radicatum*, is the most conspicuous plant over large portions of this subzone. Other important low-growing cushion-forb genera include *Draba*, *Saxifraga*, *Minuartia*, and *Cerastium*. Soil lichens, mosses, and liverworts can cover a high percentage of the surface, particularly in more maritime areas such as Novaya Zemlya (Alexandrova 1980). Rushes (*Luzula* and *Juncus*) and grasses (*Alopecurus*, *Puccinellia*, *Phippsia*, and *Dupontia*) are the main graminoid groups. Sedges are rare, and wetlands lack organic peat layers. There is little contrast in the composition of vegetation on mesic sites, streamside sites, and snowbeds. The vascular-plant flora is extremely depauperate, consisting of only about 50-60 species (Young 1971). On fine grained soils, the extremely cold temperatures and the thin sparse plant canopy induce intense frost activity, which forms networks of small (<50 cm diameter) nonsorted hummocks and polygons, and plants are confined mainly to the depressions between the hummocks (Chernov and Matveyeva 1997). This subzone has also been called the "herb subzone" (Walker et al. 2002) and the "*Papaver dahlianum* zone" because of the dominance of herbaceous vascular plant species and the absence of woody plants.

Subzone A. Isachsen, Ellef Ringnes Island, Canada. Photo D.A. Walker.
Enlarge image

Circumpolar Arctic Bioclimate Subzone A
Enlarge image

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Last modified: January 28, 2010

CAVM Vegetation map Web page

Circumpolar Arctic Vegetation

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Hierarchy of Geobotanical Vegetation Map Units (Walker DA 2002)

Select a unit for more information and photos.

Barrens

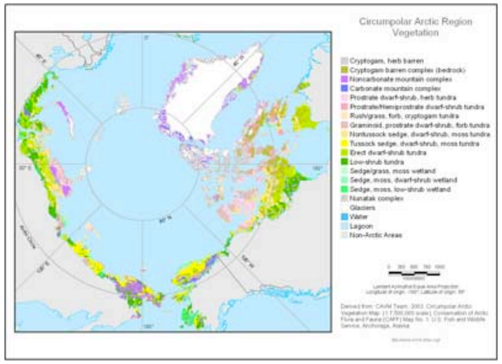
- B1. Cryptogam, herb barren
- B2. Cryptogam barren complex (bedrock)
- B3. Noncarbonate mountain complex
- B4. Carbonate mountain complex

Graminoid Tundras

- G1. Rush/grass, forb, cryptogam tundra
- G2. Graminoid, prostrate dwarf-shrub, forb tundra
- G3. Non-tussock sedge, dwarf-shrub, moss tundra
- G4. Tussock-sedge, dwarf-shrub, moss tundra

Prostrate-shrub tundras

- P1. Prostrate dwarf-shrub, herb tundra
- P2. Prostrate/hemiprostrate dwarf-shrub tundra



Enlarge image

Available data:

PDF GE Metadata GIS data

Coding on the CAVM

Alphanumeric codes refer to 15 physiognomic-level vegetation units

Select a unit for more information and photos.

Barrens

- B1. Cryptogam, herb barren
- B2. Cryptogam barren complex (bedrock)
- B3. Noncarbonate mountain complex
- *B4. Carbonate mountain complex*

Graminoid Tundras

- G1. Rush/grass, forb, cryptogam tundra
- G2. Graminoid, prostrate dwarf-shrub, forb tundra
- G3. Non-tussock sedge, dwarf-shrub, moss tundra
- G4. Tussock-sedge, dwarf-shrub, moss tundra

Prostrate-shrub tundras

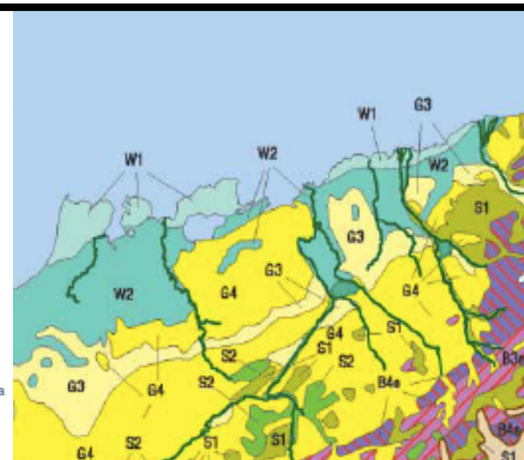
- P1. Prostrate dwarf-shrub, herb tundra
- P2. Prostrate/hemiprostrate dwarf-shrub tundra

Erect-shrub tundras

- S1. Erect dwarf-shrub tundra
- S2. Low-shrub tundra

Wetlands

- W1. Sedge/grass, moss wetland
- W2. Sedge, moss, dwarf-shrub wetland
- W3. Sedge, moss, low-shrub wetland

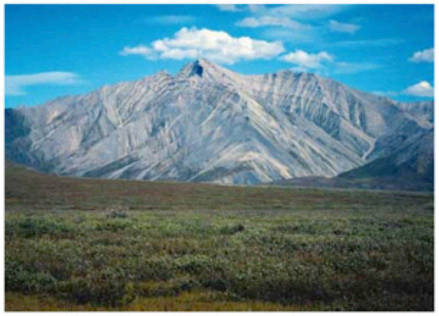


Description of CAVM vegetation map units

Circumpolar Arctic Vegetation Unit B4

B4. Carbonate mountain complex

Mountain vegetation on carbonate bedrock. The variety and size of plants decrease with elevation and latitude. Hatching color and code indicate the bioclimate subzone at the mountain base. B4b through B4e indicate subzones B through E; B4n indicates carbonate nunatak areas.



Brooks Range, Alaska (Photo: D.A. Walker).
Enlarge image

Detailed Description

Dry calcareous tundra complexes on mountains and plateaus with limestone or dolomite bedrock. Vegetation changes with elevation in the mountains, forming elevation belts whose vegetation is physiognomically similar to that of bioclimate subzones with comparable summer climate (see the elevation belt). The color of the polygon hatch pattern denotes the bioclimate subzone at the base of the mountains. For example, B4b occurs in Subzone B, B4c in Subzone C, etc. B4n denotes nunatak areas, with many carbonate mountain peaks surrounded by glaciers. Mesic zonal microsites are relatively uncommon. More common are plant communities growing on wind-swept, rocky ridges, screes, and dry fell-fields, alternating with snowbed plant communities.

Area: 136 x 1000 km^2.

Representative Syntaxa

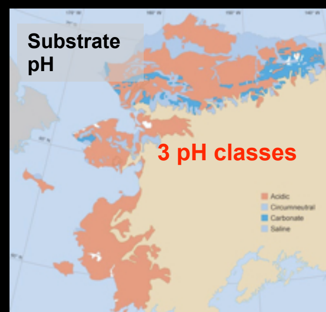
Belt a, *Thlaspietea rotundifolii* vegetation, e.g., *Papaveretum dahliani* Hofm. 1968; Belt b, *Carici-Dryadetum integrifoliae* Dan. 1982; Belt c, *Carici- Dryadetum integrifoliae* Dan. 1982; Belt d, *Dryado integrifoliae-Caricetum bigelowii* Walk. et al. 1994 (all *Carici-Kobresietea*); Belt e, cf. *Anemono-Salicetum richardsonii* Schickh. et al. 2002 (most of Northern America).

The methods used in making the CAVM allows for creation of regional maps that give much detail regarding the plant communities.

1


2


Four-part framework for mapping and identifying plant communities in different regions.

3


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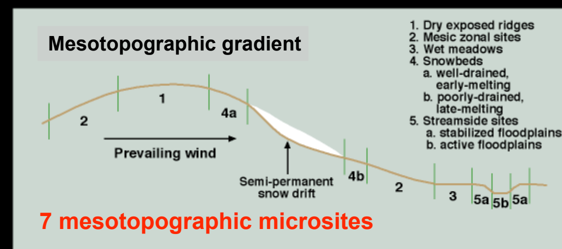
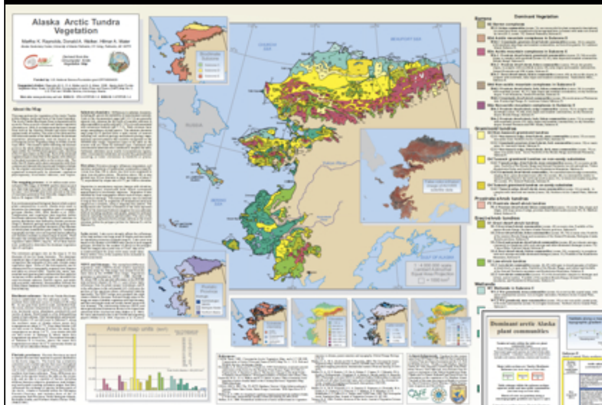
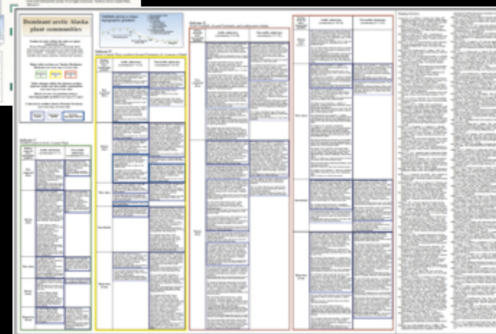


Regional-level mapping: The Alaska Arctic Tundra Vegetation Map



- Derived from the CAVM database.
- Back side of map provides detailed information and literature sources of plant communities along toposequences in each bioclimate subzone, floristic province, and substrate pH class.



Raynolds, M.K., Walker, D.A., and Maier, H.A., 2006. *Alaska Arctic Tundra Vegetation Map*, Conservation of Arctic Flora and Fauna (CAFF) Map No. 2: Anchorage, AK, U.S. Fish and Wildlife Service.

Raynolds et al. 2005. *Phytocoenologia 35: 821-848.*

Framework for plant communities: Example for Subzone C

Dominant arctic Alaska plant communities

Numbered units within the table are plant community types
Braun-Blanquet descriptions, dominant plant functional types and species are listed where data were available. Literature citations (in small font) include unit names, habitat, citation and location.

Major table sections are Tundra Bioclimate Subzones (see inset map on front side)

Subzone C | Subzone D | Subzone E

Table columns within the subzone sections separate acidic and non-acidic communities
(see inset map on front side)

Blocks of rows are positions along a mesotopographic gradient (see figure to right)

Colored text outlines denote Floristic Provinces
(see inset map on front side)

Northern Alaska | Beringian Alaska | Northern Beringian Islands

Subzone C
Northern part of Arctic Coastal Plain

Habitat along the meso-topographic gradient	Acidic substrates (community # 1-7)	Non-acidic substrates (community # 8-12)
Dry exposed sites	1. Prostrate dwarf shrub (*Salix rotundifolia*), lichen (*Alectoria nigricans, Bryocaulon divergens, Dactylina arctica*), rush (*Luzula confusa, L. arctica*), grass (*Arctagrostis latifolia*), forb (*Potentilla hyparctica, Pedicularis lanata*), bryophyte (*Polytrichum strictum, Dicranum elongatum, Gymnomitrion corallioides*). Nodum II (Webber 1978); *Sphaerophorus globosus-Luzula confusa* comm. subtype *Salix rotundifolia*, dry beach and river terraces (Elias et al. 1996) (Barrow).	8. Prostrate dwarf shrub (*Dryas integrifolia*), sedge (*Carex rupestris*), (*Lecanora epibryon, Thamnolia subuliformis*). Type B12, coastal dry nonacidic gravelly sites (Walker 1985) (Prudhoe Bay).
Moist sites	2. Sedge (*Carex aquatilis, Eriophorum angustifolium*), grass (*Poa arctica, Dupontia fisheri*), rush (*Luzula arctica*), prostrate dwarf-shrub (*Salix rotundifolia*), forb (*Saxifraga cernua, S. hieraciifolia, S. hirculus, Cardamine pratensis, Petasites frigidus, Ranunculus nivalis*), moss (*Oncophorus wahlenbergii, Sarmenthypnum sarmentosum, Aulacomnium turgidum*). Nodum IV (Webber 1978); Type 6 and 7, moist, fine-grained soils (Walker et al. 1977); *Saxifraga cernua-Carex aquatilis* comm. (Elias et al. 1996) (Barrow). 3. Rush (*Luzula confusa, L. arctica*), grass (*Poa arctica*), forb (*Potentilla hyparctica, Pedicularis lanata*), lichen (*Alectoria nigricans, Sphaerophorus globosus, Dactylina arctica, Cladonia* spp., *Ochrolechia frigida*), moss (*Polytrichastrum alpinum, Polytrichum strictum, Sarmenthypnum sarmentosum*). Nodum 1 (Webber 1978); Type 5, mesic high-centered polygons, zonal vegetation (Walker et al. 1977); *Sphaerophorus globosus-Luzula confusa* comm. subtype *Saxifraga foliolosa*, Elias et al. 1996) (Barrow).	9. Sedge (*Carex aquatilis*), prostrate dwarf shrub (*Salix pulchra, S. reticulata, Dryas integrifolia*), moss (*Tomentypnum nitens, Oncophorus wahlenbergii, Campylium stellatum, Distichium capillaceum*). Type U12, moist calcareous coastal meadows (Walker 1985) (Prudhoe Bay).
Wet sites	4. Sedge (*Eriophorum angustifolium, Carex aquatilis*), grass (*Dupontia fisheri, Arctophila fulva*), moss (*Sarmenthypnum sarmentosum, Limprichtia revolvens*). Noda V and VI (Webber 1978); Types 9, 10, 12 and 13 (Walker et al. 1977); *Eriophorum angustifolium-Carex aquatilis* comm., wet sites without standing water (Elias et al. 1996) (Barrow).	10. Sedge (*Carex aquatilis, Eriophorum angustifolium*), grass (*Dupontia fisheri*), moss (*Drepanocladus brevifolius*). Type M10, wet calcareous coastal meadows (Walker 1985) (Prudhoe Bay).
Snow-beds	5. Prostrate dwarf shrub (*Salix rotundifolia*), lichen (*Cetrariella delisei*). *Salix rotundifolia-Cetraria delisei* comm. (Elias et al. 1996) (Barrow, early-melting snow beds). 6. Grass (*Phippsia algida, Alopecurus alpinus*), forb (*Cochlearia groenlandica, Ranunculus pygmaeus, Stellaria humifusa, Saxifraga rivularis*). Nodum VIII (Webber 1978); Type 15, late-melting snow beds (Walker et al. 1977) (Barrow).	11. No data. Probably similar to snowbeds in Subzone D.
Riparian areas	7. Grass (*Phippsia algida, Alopecurus alpinus*), forb (*Cochlearia groenlandica, Ranunculus pygmaeus, Stellaria humifusa, Saxifraga rivularis*). Nodum VIII (Webber 1978); Type 15, unstable stream margins (Walker et al. 1977) (Barrow).	12. Forb (*Epilobium latifolium, Artemisia arctica, A. borealis, Papaver 'lapponicum', Polemonium boreale, Astragalus alpinus, Wilhelmsia physodes, Parrya nudicaulis*). Epilobio latifolii-Salicetum alaxensis ass. prov. (Schickhoff et al. 2002) (North Slope, coastal active floodplains).

Raynolds et al. 2005. *Phytocoenologia 35: 821-848.*

Approach for naming communities

1. Prostrate dwarf shrub (*Salix rotundifolia*), lichen (*Alectoria nigricans, Bryocaulon divergens, Dactylina arctica*), rush (*Luzula confusa, L. arctica*), grass (*Arctagrostis latifolia*), forb (*Potentilla hyparctica, Pedicularis lanata*), bryophyte (*Polytrichum strictum, Dicranum elongatum, Gymnomitrion corallioides*).

Nodum II (Webber 1978); *Sphaerophorus globosus-Luzula confusa* comm. subtype *Salix rotundifolia,* dry beach and river terraces (Elias et al. 1996) (Barrow).

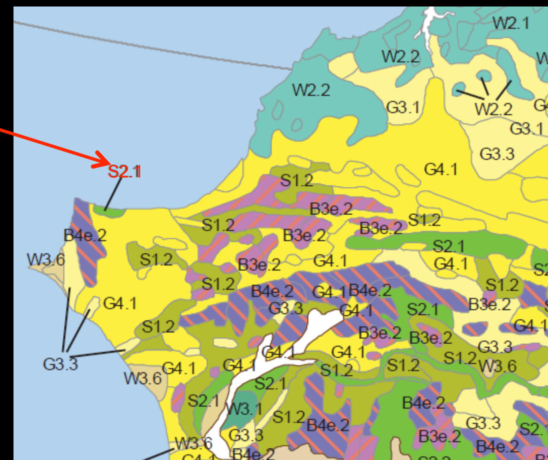
Followed the Russian approach of using dominant plant growth forms followed by dominant species because there are few communities that have formal internationally accepted names according the Br.-Bl. approach.

Synonyms, authors, and habitats described in the literature within the subzone and floristic subprovince are listed below in smaller font.

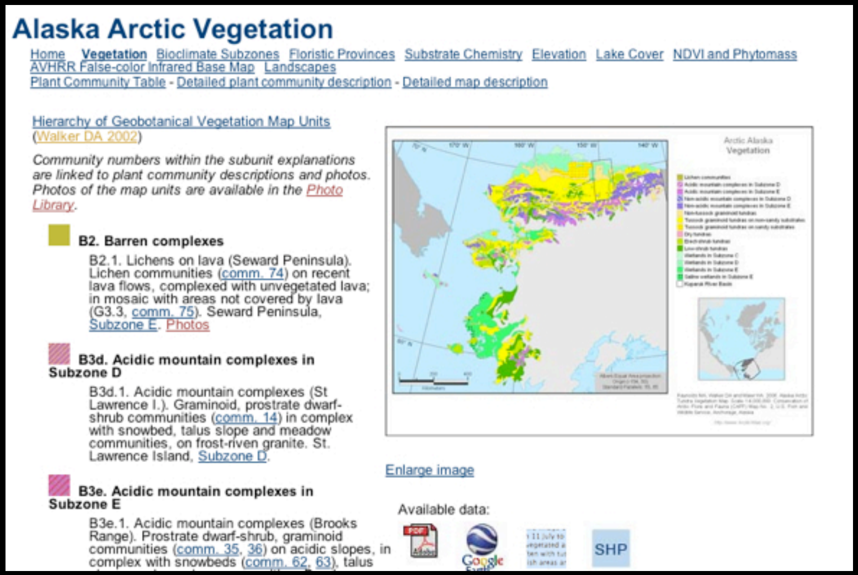
If a Braun-Blanquet community name exists, it is listed first.

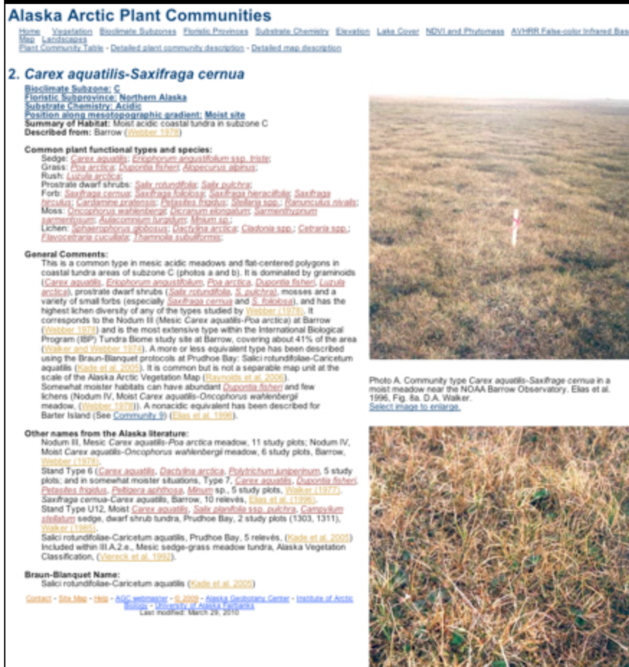
Coding on the Alaska arctic tundra vegetation map

- Additional decimal code refers to vegetation of specific regions on the map.
- The legend provides more details regarding dominant plant communities within large landscapes.



Web page for Alaska Arctic tundra vegetation map legend





Alaska Arctic Plant Communities

Home Vegetation Bioclimate Subzones Floristic Provinces Substrate Chemistry Elevation Lake Cover NDVI and Phytomass AVHRR False-color Infrared Base Map Landscapes
Plant Community Table - Detailed plant community description - Detailed map description

2. *Carex aquatilis-Saxifraga cernua*

Bioclimate Subzone: C
Floristic Subprovince: Northern Alaska
Substrate Chemistry: Acidic
Position along mesotopographic gradient: Moist site
Summary of Habitat: Moist acidic coastal tundra in subzone C
Described from: Barrow (Webber 1978)

Common plant functional types and species:
Sedge: *Carex aquatilis*; *Eriophorum angustifolium* ssp. *triste*;
Grass: *Poa arctica*; *Dupontia fisheri*; *Alopecurus alpinus*;
Rush: *Luzula arctica*;
Prostrate dwarf shrubs: *Salix rotundifolia*; *Salix pulchra*;
Forb: *Saxifraga cernua*; *Saxifraga foliolosa*; *Saxifraga hieracifolia*; *Saxifraga hirculus*; *Cardamine pratensis*; *Petasites frigidus*; *Stellaria* spp.; *Ranunculus nivalis*;
Moss: *Oncophorus wahlenbergii*; *Dicranum elongatum*; *Sarmentypnum sarmentosum*; *Aulacomnium turgidum*; *Mnium* sp.;
Lichen: *Sphaerophorus globosus*; *Dactylina arctica*; *Cladonia* spp.; *Cetraria* spp.; *Flavocetraria cucullata*; *Thamnolia subuliformis*;

General Comments:
This is a common type in mesic acidic meadows and flat-centered polygons in coastal tundra areas of subzone C (photos a and b). It is dominated by graminoids (*Carex aquatilis*, *Eriophorum angustifolium*, *Poa arctica*, *Dupontia fisheri*, *Luzula arctica*), prostrate dwarf shrubs (*Salix rotundifolia*, *S. pulchra*), mosses and a variety of small forbs (especially *Saxifraga cernua* and *S. foliolosa*), and has the highest lichen diversity of any of the types studied by Webber (1978). It corresponds to the Nodum III (Mesic *Carex aquatilis-Poa arctica*) at Barrow (Webber 1978) and is the most extensive type within the International Biological Program (IBP) Tundra Biome study site at Barrow, covering about 41% of the area (Walker and Webber 1974). A more or less equivalent type has been described using the Braun-Blanquet protocols at Prudhoe Bay: Salici rotundifoliae-Caricetum aquatilis (Kade et al. 2005). It is common but is not a separable map unit at the scale of the Alaska Arctic Vegetation Map (Raynolds et al. 2006). Somewhat moister habitats can have abundant *Dupontia fisheri* and few lichens (Nodum IV, Moist *Carex aquatilis-Oncophorus wahlenbergii* meadow, (Webber 1978)). A nonacidic equivalent has been described for Barter Island (See Community 9) (Elias et al. 1996).

Other names from the Alaska literature:
Nodum III, Mesic *Carex aquatilis-Poa arctica* meadow, 11 study plots; Nodum IV, Moist *Carex aquatilis-Oncophorus wahlenbergii* meadow, 6 study plots, Barrow, Webber (1978).
Stand Type 6 (*Carex aquatilis*, *Dactylina arctica*, *Polytrichum juniperinum*, 5 study plots; and in somewhat moister situations, Type 7, *Carex aquatilis*, *Dupontia fisheri*, *Petasites frigidus*, *Peltigera aphthosa*, *Mnium* sp., 5 study plots, Walker (1977).
Saxifraga cernua-Carex aquatilis, Barrow, 10 relevés, Elias et al. (1996).
Stand Type U12, Moist *Carex aquatilis*, *Salix planifolia* ssp. *pulchra*, *Campylium stellatum* sedge, dwarf shrub tundra, Prudhoe Bay, 2 study plots (1303, 1311), Walker (1985).
Salici rotundifoliae-Caricetum aquatilis, Prudhoe Bay, 5 relevés, (Kade et al. 2005)
Included within III.A.2.e., Mesic sedge-grass meadow tundra, Alaska Vegetation Classification, (Viereck et al. 1992).

Braun-Blanquet Name:
Salici rotundifoliae-Caricetum aquatilis (Kade et al. 2005)

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Last modified: March 29, 2010

Photo A. Community type *Carex aquatilis-Saxifrage cernua* in a moist meadow near the NOAA Barrow Observatory. Elias et al. 1996, Fig. 8a. D.A. Walker.
Select image to enlarge.

Descriptions of plant communities

- 2-species plant-community names, that include the dominant species and a differential or characteristic species.
- Photos.
- Habitat information.
- Common plant functional types and species.
- Links to species photos.
- General description.
- Other names and citations in the Alaska literature.

Species photos in photo library

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Photo Library

The Photo and Image Library includes graphics used on the website; images of the map units; photographs of vegetation units, bioclimate subzones, plant communities, and the Toolik Lake and Imnavait Creek permanent vegetation plot photos; and up to five photos of each plant species.

Map Unit Photos and Images

- Graphics
- Map Unit Images
- Vegetation Unit Photos
- Plant Community Photos
- Circumpolar Arctic Bioclimate Subzone Photos
- Toolik Lake Permanent Vegetation Plot Photos
- Imnavait Creek Permanent Vegetation Plot Photos

Plant Species Photos

- Alphabetical List of Plant Species

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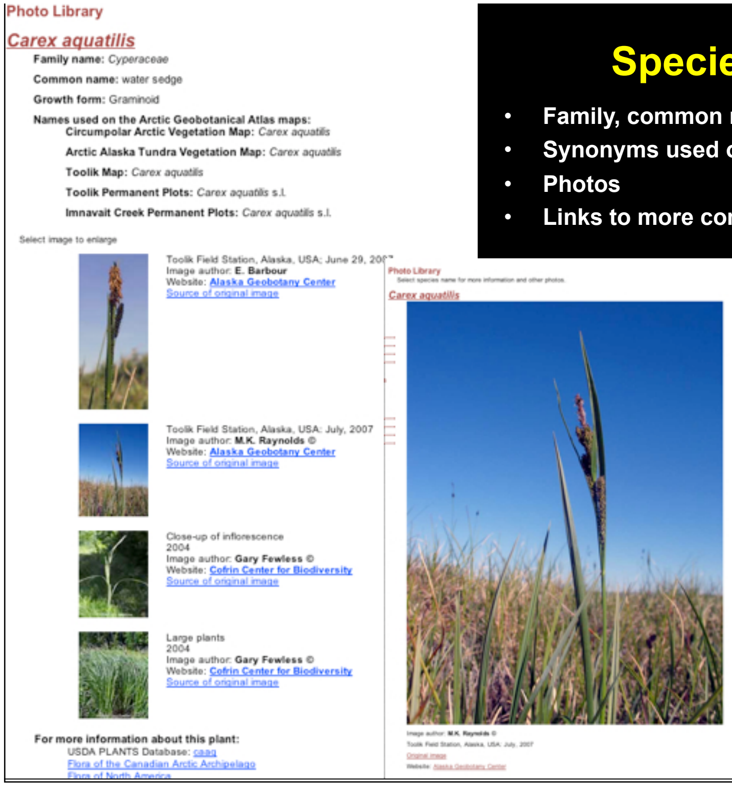
Last modified: November 19, 2010

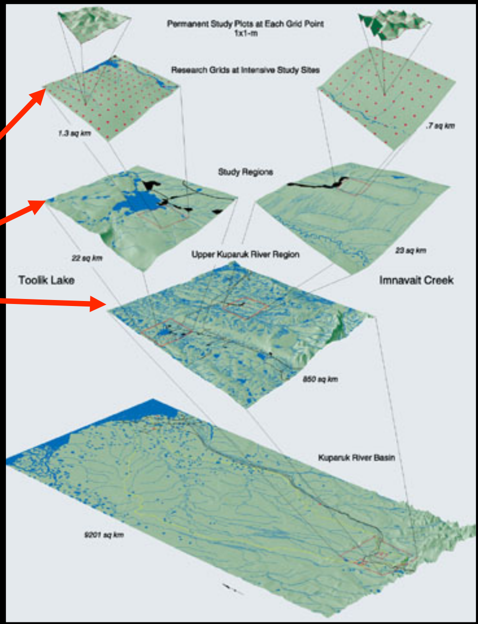
Species photos

- Family, common name, growth form.
- Synonyms used on other T-AGA maps.
- Photos
- Links to more complete descriptions.

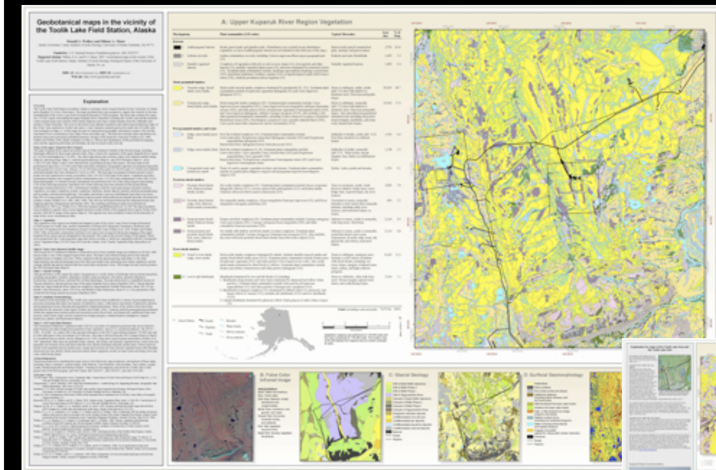


Landscape level mapping: Hierarchy of GIS databases for the Kuparuk River/Toolik Lake region

- Mapping was done for the Toolik Lake LTER, ARCSS FLUX and ATLAS projects.
- 5 scales. Middle 3 scales published on the Walker and Maier (2008) map.



Landscape-level mapping: Hierarchy of Toolik Lake vegetation maps



- 3 scales of maps for the Upper Kuparuk River and Toolik Lake region, AK.
- Legends provide information on vegetation physiognomy and dominant plant communities.

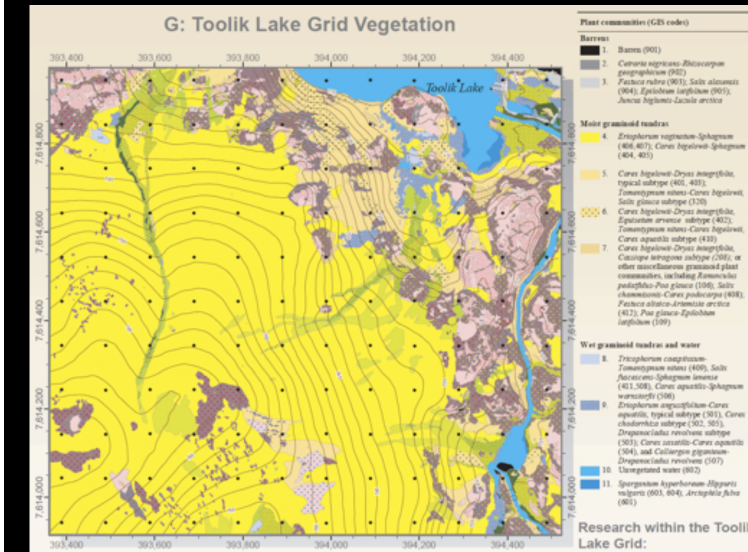
Walker, D. A., and H. A. Maier. 2008. *Geobotanical Maps in the Vicinity of the Toolik Lake Field Station*. Biological Papers of the University of Alaska, No. 28.

Map unit descriptions for the Toolik Lake map

Physiognomy	Plant Communities (GIS codes)	Typical Microsites	Area (ha)	% of Map
Barren				
1. Barren	Unvegetated (91, 101).	Unvegetated natural and anthropogenic barrens.	23.8	1.2
2. Lichens on rocks	Lichen communities on rocks, including *Cetraria nigricans-Rhizocarpon geographicum* (92).	Xeric blockfields, glacial erratics.	3.9	0.2
3. Partially vegetated barrens and revegetated disturbed areas	Revegetated gravel pads (e.g., *Festuca rubra* or *Salix alaxensis* 102).	Partially vegetated disturbed barrens on gravel pads, abandoned roads, bulldozed areas.	24.9	1.2
Moist graminoid tundra				
4. Tussock sedge, dwarf-shrub, moss tundra	Moist acidic tussock tundra complexes dominated by graminoids. Dominant plant communities include: *Eriophorum vaginatum-Sphagnum* (41) and *Carex bigelowii-Sphagnum* (no code).	Mesic to subhygric, acidic, shallow to moderate snow. Stable slopes. Some areas on steeper slopes with solifluction are dominated by Bigelow sedge (*Carex bigelowii*) (no code).	605.1	29.8
5. Nontussock sedge, dwarf-shrub, moss tundra	Moist nonacidic tundra complexes. Dominant plant communities include: *Carex bigelowii-Dryas integrifolia* (42) and other subtypes of this unit (e.g., *Salix glauca* (33), *Equisetum arvense* and *Cassiope tetragona* (no codes)). Includes some miscellaneous graminoid communities mostly on disturbed areas, such as *Deschampsia caespitosa* (45); *Rumex arcticus-Carex saxatilis* (75) *Salix chamissonis-Carex aquatilis* (65); *Ranunculus pedatifidus-Poa glauca* (104).	Mesic to subhygric, circumneutral, shallow to moderate snow. Solifluction areas and somewhat unstable slopes (42), mainly on Itkillik II glacial surfaces. Some south-facing slopes have scattered glaucous willow (*Salix glauca*) (33). Also includes some miscellaneous graminoid-dominated sites: deep-snow stream margins (65), landslides, some rocky drained lake basins (45, 75) and animal dens (104).	306.8	15.1

- General physiognomy of map unit.
- Typical plant communities with GIS code used in the database.
- Links to full community descriptions, and photos.
- Description of typical habitats for plants communities.
- Area and percent of map.

Toolik Grid Map



- 1 x 1-km CALM grid for long-term monitoring of landscape change at grid points
- Grids surveyed in 1989-90 at Imnavait Crk. and Toolik Lake.
- Grid points at 100-m interval
- Active layer, snow depth, plant species change measured regularly.

Walker and Maier, 2008. Biol. Papers Univ. of AK No. 28.

Supporting data: Information behind the maps

Plant Species Photo Enlargement » Plant Species Photos - Alphabetical List » Detailed Plant Species Page » TAGA Home » Supporting Data

Toolik-Arctic Geobotanical Atlas
TAGA

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Supporting Data

Data Reports

Supporting information includes the baseline plot information for vegetation, soils, and site factors for the study plots at Toolik Lake, Imnavait creek, Happy Valley, Prudhoe Bay, and elsewhere.

- Toolik Lake Permanent Vegetation Plots
- Imnavait Creek Permanent Vegetation Plots
- Happy Valley data report
- Prudhoe Bay data

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Last modified: December 29, 2010

Illustration by John Adams, 1991 ©

Toolik Lake data

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Toolik Lake Permanent Vegetation Plots

Walker D.A. and Barry N. 1991. Toolik Lake permanent vegetation plots: site factors, soil physical and chemical properties, plant species cover, photographs, and soil descriptions. Data Report 48, Department of Energy R4D Program, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO.

Table of Contents

(see Tables 1, 2, 4, 5, and 6 for links to individual plots; each plant species name links to a descriptive webpage with photos)

Toolik Lake Permanent Vegetation Plots
Illustration by John Adams 1991 ©

August 25, 2010 - I've posted the PDF and data files; still have a few edits, but most corrections have been made.

Introduction

This data report is a summary of environmental, soil, and vegetation information collected from 81 study plots at the Toolik Lake research site, located in the southern Arctic Foothills of the Brooks Range, Alaska (68°37'N, 149°32'W). It brings together for easy reference all the available information collected from the plots. This information is being used for the classification, mapping and analysis of the geobotanical factors in the Toolik Lake and Imnavait Creek region. A separate equivalent data report is available for 73 permanent plots at Imnavait Creek (Walker et al., 1987).

Methods and data summaries

Reconnaissance survey, sampling dates, and plot locations

A reconnaissance survey was conducted in August 1988 to define the primary vegetation types in the Toolik Lake area. Unknown plants were collected and many informal partial relevés were sampled with reference to spectral signatures on a 1:50,000-scale color-infrared photograph. A total of 22 preliminary vegetation types were defined based on habitat and dominant species (Table 1).

Formal relevé sampling for the plots in this data report was done during the period 1-26 August 1989. An attempt was made to sample at least three relevés for each of the types defined in 1988, but this was not possible in all cases (Table 1 and Table 2).

The plots were located in homogeneous areas of vegetation using the centralized replicate method of the Braun-Blanquet approach to vegetation classification (Mueller-Dombois and Ellenberg, 1974; Westhoff and van der Maarel, 1978).

Nearly all of the plots are permanently marked. The exception is plot SWT-55. The plots are marked with 48-inch (122-cm) wooden stakes, and aluminum tags at the base of the stakes with the plot numbers. Some of the stakes have broken off since sampling. We intend to replace all of the wooden stakes with tall plastic stakes.

Forty of the plots are located along transects as follows:

West-facing toposequence of Itkillik II glacial outwash and retransported hillslope deposits on the south side of Toolik Lake: (from top of hill) SWT-7, 8, 9, 10, and 11.
East-facing toposequence of slope that includes Itkillik I and Itkillik glacial till and retransported hillslope deposits on the south side of Toolik Lake: SWT-18, 19, 20, 21, 22, 23, 24, and 77.
South-facing toposequence on Itkillik II till and retransported hillslope deposits on the west side of Toolik Lake: SWT-46, 45, 44, 41, 40, 43, 39, 42, 38, and 37. These are in mixed positions on stone-stripes and inter-stripe sites. Plots 38 and 37 are in a colluvial basin at the base of the hill.
North-facing toposequence on Itkillik II till and retransported hillslope deposits: SWT-48, 47, 49, 50, 51, 52, 53, 54, and 81. Plot SWT-48 is on a ground-squirrel mound, and most of the sequence is through a deep snowbed.
Water-track transect on the south side of Toolik Lake: SWT-80, 32, 35, 75, 78, 27, 79, 36, 73, 74, 64. Plots SWT-80, 35, 74, and 64 are on frost scars.
The remaining plots were located around Toolik Lake to sample the diversity of vegetation types of the region (Figure 1, Table 2).

Sampling methods

Plot size, species cover estimation, and photographs

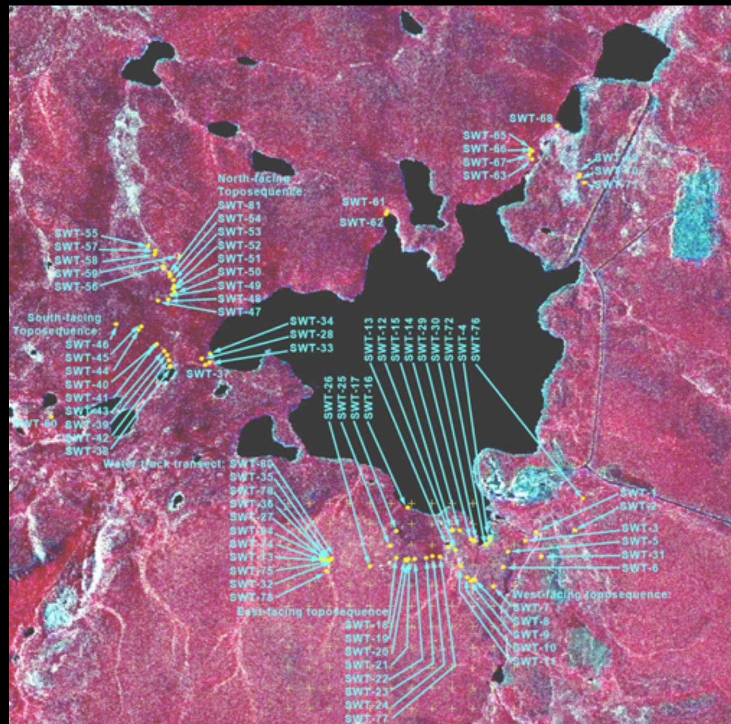
The plots have no fixed size because our main objective was to obtain a complete species list for each relevé.

Photographs were taken of each plot (see Appendix). Usually photos were taken of (1) the general site, (2) closeup of the vegetation, and (3) closeup of the soil.

Site factors

The site of each plot was described according to the variables listed in Table 3 plus measurements of thaw depth, estimates of cover of bare soil, rocks,

Plot location map



Toolik Lake Permanent Vegetation Plots

Walker D.A. and Barry N. 1991. Toolik Lake permanent vegetation plots: site factors, soil physical and chemical properties, plant species cover, photographs, and soil descriptions. Data Report 48, Department of Energy R4D Program, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO.

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Environmental information: Abiotic data, Biotic data // Soils Characteristics // Species Composition // Selected Soil Descriptions // Plot Photos

Table 2. List of vegetation communities and microsites sampled in 1989

PDF - MS Word

Plot No.	Plant Community	Microsite
SWT-1	Moist *Carex membranacea*, *Carex scirpoidea*, *Salix chamissonis*, *Salix reticulata*, *Potentilla fruticosa*, sedge, dwarf-shrub, forb tundra	Featureless active floodplain
SWT-2*	Moist *Salix alaxensis*, *Aster sibiricus*, *Calamagrostis canadensis s.l.*, *Potentilla fruticosa*, tall shrubland	Featureless active floodplain
SWT-3	Dry *Betula nana s.l.*, *Ledum palustre ssp. decumbens*, *Hierochloe alpina*, *Cladonia arbuscula*, dwarf-shrub, lichen tundra	Small turf hummocks on footslope
SWT-4	Aquatic *Arctophila fulva*, marsh	Lake, in 20-30 cm of water
SWT-5*	Dry *Arctous alpina*, *Hierochloe alpina*, dwarf-shrub, fruticose-lichen tundra	High centered polygons on top of glacial outwash terrace
SWT-6	Dry *Betula nana s.l.*, *Hierochloe alpina*, *Cetraria cucullata*, low-shrub, fruticose-lichen tundra	High centered polygons on glacial outwash terrace
SWT-7	Dry *Dryas octopetala*, *Selaginella sibirica*, *Thamnolia subuliformis*, dwarf-shrub, fruticose-lichen tundra	Featureless hill crest of outwash terrace
SWT-8^	Dry *Empetrum nigrum hermaphroditum*, *Betula nana s.l.*, *Vaccinium uliginosum*, *Loiseleuria procumbens*, *Cladonia arbuscula*, *Stereocaulon alpinum*, dwarf-shrub, fruticose-lichen tundra	Small hummocks and solifluction features on midslope
SWT-9	Dry *Cassiope tetragona*, *Dryas integrifolia*, *Hylocomium splendens*, *Carex microchaeta*, *Salix glauca*, *Cetraria cucullata*, dwarf-shrub, fruticose-lichen tundra	Snowbed, hummocky terrain, including turf hummocks and some solifluction features on footslope
SWT-10	Moist *Carex bigelowii*, *Cassiope tetragona*, *Equisetum arvense*, *Dryas integrifolia*, *Hylocomium splendens*, *Tomentypnum nitens*, sedge, horsetail, dwarf-shrub tundra	Stone stripes on footslope
SWT-11*	Wet *Carex chordorrhiza*, *Carex rotundata*, *Scorpidium scorpioides*, sedge tundra	Wet element of strangmoor in fen of colluvial basin
SWT-12	Wet *Carex aquatilis s.l.*, *Eriophorum angustifolium s.l.*, *Carex rotundata*,	Strangmoor and aligned hummocks in fen of colluvial basin

Plot Index

- Plant communites.
- Microsites.
- Link to photos, species, and environmental data.

Complete plot information

- Photos
- Site information
- Species information
- Soils information (description, chemical and physical properties).

Toolik Lake Permanent Vegetation Plots

Walker D.A. and Barry N. 1991. Toolik Lake permanent vegetation plots: site factors, soil physical and chemical properties, plant species cover, photographs, and soil descriptions. Data Report 48, Department of Energy R4D Program, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO.

Home // Plot location map // Preliminary vegetation classification // Communities and microsites // Environmental variables // Environmental information: Abiotic data, Biotic data // Soils Characteristics // Species Composition // Selected Soil Descriptions // Plot Photos

Table 6. Toolik Lake permanent plot species data

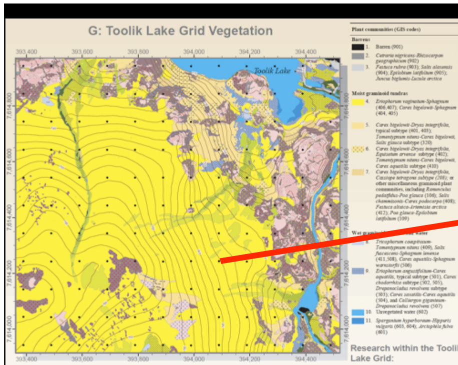
PDF - MS Excel

	SWT-1	SWT-2*	SWT-3	SWT-4	SWT-5*	SWT-6	SWT-7	SWT-8^	SWT-9	SWT-10	SWT-11*	SWT-12	SWT-13*	SWT-14*	SWT-15	SWT-16	SWT-17	SWT-18	SWT-19	SWT-20	SWT-21	SWT-22	SWT-23	SWT-24	SWT-25	SWT-26*	SWT-27*	SWT-28	SWT-29
Algae																													
Nostoc commune				+																									
Shrub																													
Andromeda polifolia	+							+		+				+								+	+	+	+				
Arctous alpina					4			+		+									1										
Arctous rubra														+								+	+	+					
Betula nana s.l.	r		4		r	4		1	1					r					1	+	r				3	3	+	+	
Cassiope tetragona	r		1					r	3	2									1	3	+	1	1	1	1	1			
Diapensia lapponica ssp. obovata					+			+											+										
Dryas integrifolia							+		2	2									+	2	3	3	3	3					
Dryas octopetala							3										+	3	+										
Empetrum nigrum hermaphroditum						+		1	+										1			r			+	+			
Ledum palustre ssp. decumbens			4		+	+		1	1										2		+	r			2	3			
Loiseleuria procumbens	r				+			2											+	1									
Potentilla fruticosa	1	1																										r	
Potentilla palustris																													
Pyrola asarifolia	+								+															+					
Rhododendron lapponicum																					+	+	+						
Rubus chamaemorus										r												r			+	1	1	+	
Salix sp.		1																											
Salix alaxensis		4																											
Salix arctica																					+								
Salix chamissonis	2	1																	r										
Salix fuscescens														r															
Salix glauca									2										+			r							
Salix lanata richardsonii		2																										5	
Salix phlebophylla			r		+		r	+									+	+	+			r							
Salix planifolia ssp. pulchra		1																			+				2	1	2		
Salix reticulata	1								1	1				+		3			+	2	2	2		1	r				
Salix rotundifolia																1													
Spirea beauverdiana																													
Vaccinium uliginosum	1		1		+	1	r	1	2	+									2	1	r	+	+	+	+	+			
Vaccinium vitis-idaea minus			3		3	4	r	+	+	+								+	+		r	r			3	2			
Graminoid																													
Arctagrostis latifolia		r																			r	+						r	
Arctophila fulva				3																									
Bromus pumpellianus s.l.																													
Calamagrostis canadensis s.l.	+	2	+			+																							

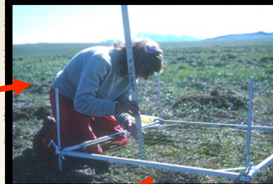
Summary tables:

- Plot species cover-abundance data.
- Plant growth form summaries
- Plot environmental data.
- Soils data.

Plot-level mapping: Toolik Grid plots



1 x 1-m permanent plot at each grid point



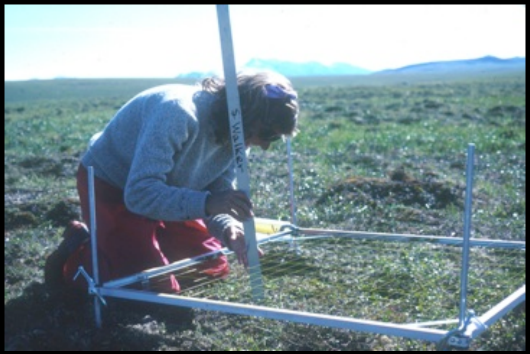
Canopy height,and microtopography

Species Top of Canopy

Species Bottom of Canopy

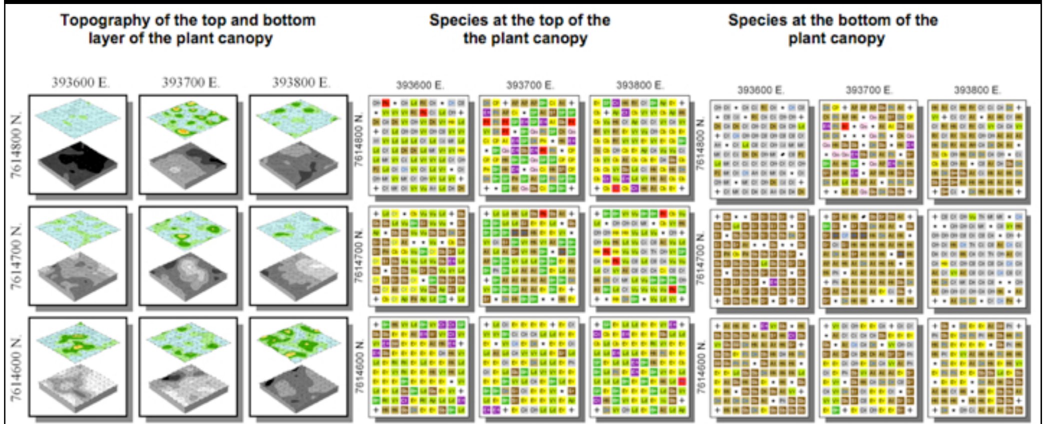
Walker, Walker, Auerbach, et al. In prep. Biol. Papers Univ. of AK.

1 x 1-m plots



- Frame is relocated on permanent 1 x 1-m plots with fixed holes for the vertical legs and three registration points that are nailed into the tundra and aligned with grid points defined by the grid of monofilament fishing line.
- The frame is leveled and the distances from the bottom of the frame to the top of the leg holes are measured.
- At each point the species at the top of the canopy and at the moss layer or ground surface are recorded.
- The distances from the bottom string to the top and bottom hits are measured.

Maps of Grid Plots



Grid plot spacing: 100 m

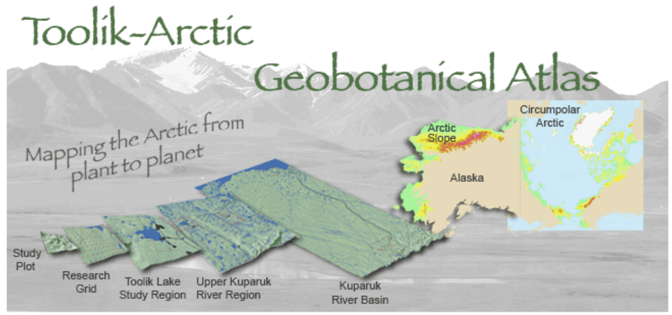
Point sampling spacing within plots: 10 cm

Sampled four times at 6-yr intervals: 1990, -96, 2002, -08

Links to species photos.

Other features of the Toolik-Arctic Geobotanical Atlas

- Home
- Overview
- Maps
- Supporting Data
- Photo Library
- Bibliography
- Glossary
- About the TAGA
  - Contact
  - Help - Using the TAGA
  - Site Map

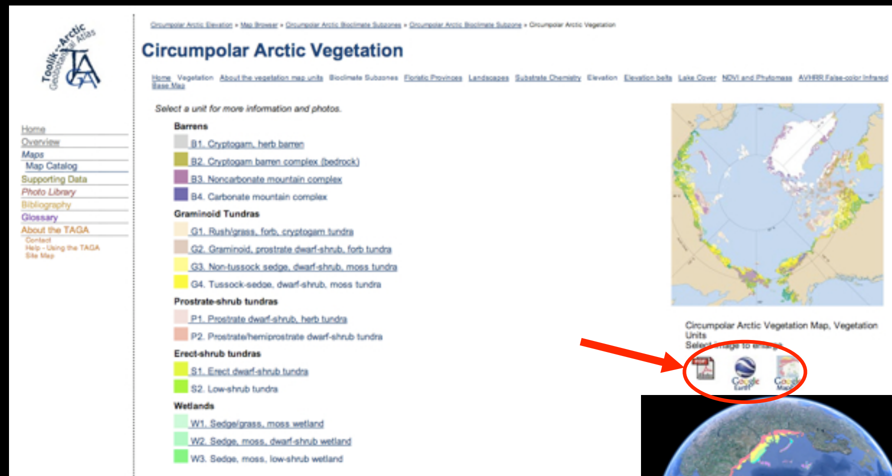


The Toolik-Arctic Geobotanical Atlas (TAGA) is a web-based multi-scale collection of geobotanical maps and related material. It includes maps at seven different scales, from 1-m² plots to the entire Arctic. The TAGA focuses on research sites at the Toolik Field Station and Imnavait Creek, Alaska, but also covers the Kuparuk River Basin, northern Alaska, Arctic Alaska, and the Circumpolar Arctic. Diverse geobotanical themes include geology, topography landforms, surficial geomorphology, soils, and vegetation. The maps and web site were developed at the Alaska Geobotany Center in collaboration with several other groups at the University of Alaska Fairbanks (see About the TAGA).

The Toolik-Arctic Geobotanical Atlas is the outreach and education component of the Greening of the Arctic initiative of the International Polar Year. Educational application of the TAGA in the classroom is a major goal of the initiative through linkage of the project to the University of the Arctic and the UNEP Environment Programme / Grid-Arendal and the Arctic Environmental Atlas.

Contact - Site Map - Help - AGC webmaster - © 2009 - Alaska Geobotany Center - Institute of Arctic Biology - University of Alaska Fairbanks
Last updated: September 1, 2009

Several options to view and download data

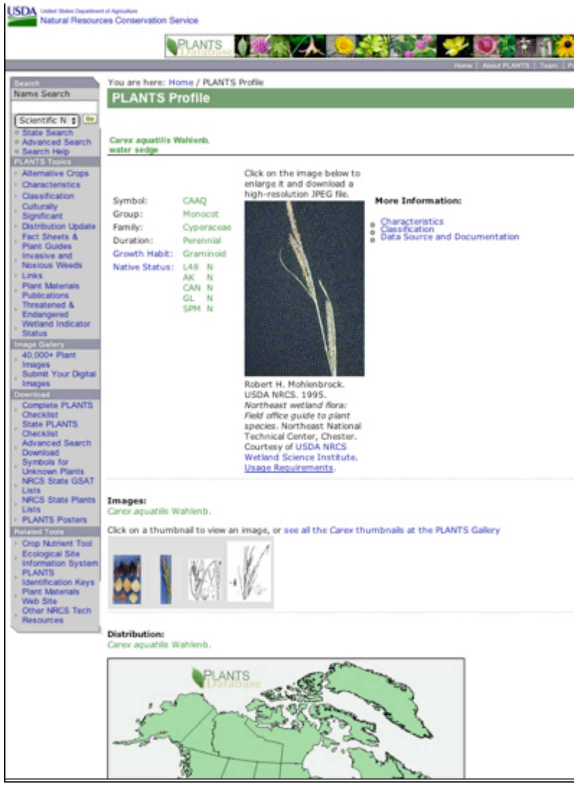


The Google Earth option

Further links to plant species photos and descriptions….

Tephroseris frigida

Androsace chamaejasme



Links to more species information:

e.g. U.S. PLANTS Database

Or other sources:

www.eFloras.org

Flora of North America

Search | All Floras | Advanced Search

FNA Vol. 23 Page 380, 382, 383, 384, 385, 388, 389, 390, 394, 395, **397**

Login | eFloras Home | Help

FNA | Family List | FNA Vol. 23 | Cyperaceae | Carex

197. **Carex aquatilis** Wahlenberg, Kongl. Vetensk. Acad. Nya Handl. 24: 165. 1803.

Plants not cespitose. Culms 20–150 cm. Leaves: basal sheaths red-brown or brown; sheaths of proximal leaves glabrous, fronts with indistinct spots, veinless, apex U-shaped; blades usually amphi-stomic, papillose on both surfaces. Inflorescences: proximal bract longer than inflorescence. Spikes: erect; proximal 2–6 spikes pistillate; terminal (1–)2–4 spikes staminate. Pistillate scales red-brown to purple-brown, apex obtuse or acute, awnless. Perigynia ascending, veinless, somewhat flattened, loosely enclosing achenes, ellipsoid or obovoid, dull, apex obtuse or acute, papillose. Achenes not constricted, glossy. 2n = 72–80.

Varieties 4 (4 in the flora): North America, Europe.

Carex aquatilis is circumboreal and variable; four extensively intergrading varieties are recognized in North America. The species is distinguished by amphistomic (epistomic in var. dives) papillose leaves, glabrous sheaths with a concave apex, perigynia that lack veins and are usually brown-spotted on the proximal half, and have glossy achenes.

1	Spikes pendent or the terminal erect; proximal peduncle to 11 cm; perigynia ellipsoid; beak purple-brown, 0.3–0.4 mm; culms scabrous on angles.	197b var. dives
+	Spikes erect; proximal peduncle not more than 4 cm; perigynia usually obovoid; beak pale or purple-brown, not more than 0.2 mm; culms glabrous or scabrous on angles.	(2)
2 (1)	Pistillate scales pale brown with narrow red-brown margins and broad pale midvein.	197c var. substricta
+	Pistillate scales red- or purple-brown and narrow pale midvein.	(3)
3 (2)	Perigynia pale brown; staminate spikes usually 2–4.	197a var. aquatilis
+	Perigynia purple-brown on apical 1/2; staminate spikes usually 1–2.	197d var. minor

Lower Taxa

- **Carex aquatilis** var. **aquatilis**
- **Carex aquatilis** var. **dives** (T. Holm) Kükenthal
- **Carex aquatilis** var. **minor** Boott
- **Carex aquatilis** var. **substricta** Kükenthal

Related Objects

- Distribution Map — Map

Related Links (opens in a new window)

Treatments in Other Floras @ www.efloras.org

- Flora of Missouri

Other Databases

- W3TROPICOS
- IPNI

| eFlora Home | People Search | Help | ActKey | Hu Cards | Glossary |

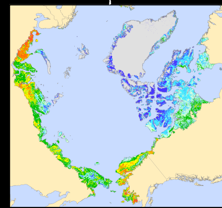
Flora of the Canadian Arctic Archipelago

S.G. Aiken, M.J. Dallwitz, L.L. Consaul, C.L. McJannet, L.J. Gillespie, R.L. Boles, G.W. Argus, J.M. Gillett, P.J. Scott, R. Elven, M.C. LeBlanc, A.K. Brysting and H. Solstad

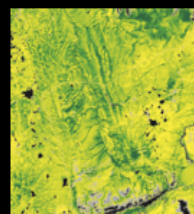
Carex aquatilis Wahlenb. subsp. stans (Drejer) Hultén

Bibliography and Glossary

Circumpolar NDVI



Toolik NDVI



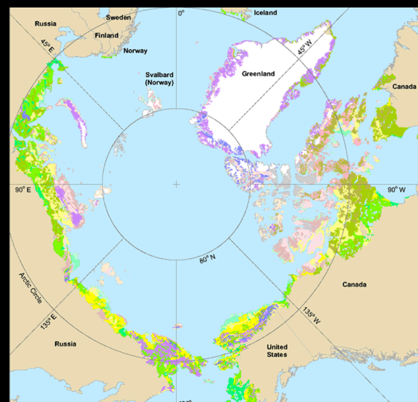
Toolik plant communities

Applications of the hierarchy of maps

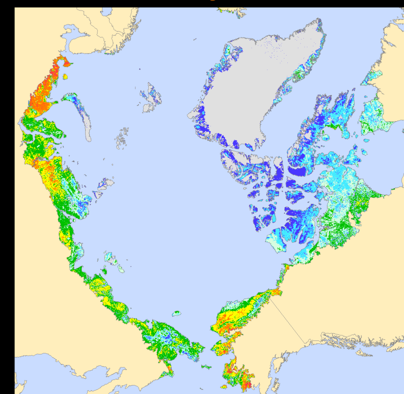
- **Circumpolar —** How are the spatial and temporal patterns of vegetation photosynthetic activity affected by changes to summer sea-ice and summer land temperatures?
  - Circumpolar spatial analysis: M.K Raynolds, Ph.D. thesis
  - Temporal analysis: U.S. Bhatt et al. submitted.
- **Landscapes —** Where in arctic landscapes are the changes occurring the fastest?
  - Toolik Lake Region: C. Munger et al. 2008
- **Plants —** Are the structure and composition of plant communities being affected by the on-going changes?
  - Toolik Lake and Imnavait Creek Grids: Gould et al. in prep.

Spatial and temporal analysis of circumpolar vegetation and productivity Patterns

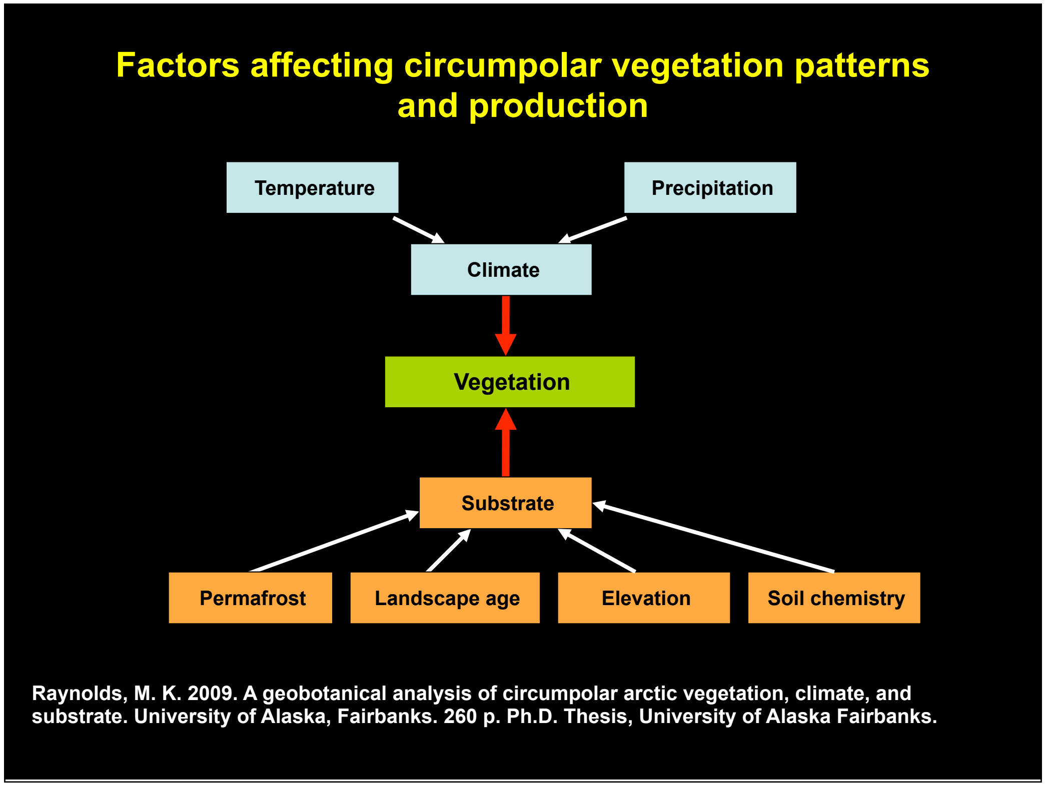
Vegetation



Productivity: Max NDVI

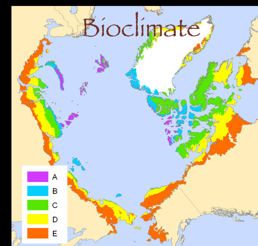


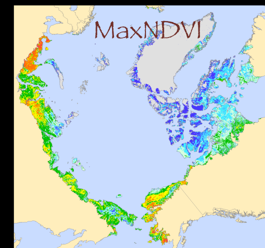
Raynolds, M. K. 2009. Circumpolar analysis of vegetation and greenness. University of Alaska Fairbanks, Ph.D thesis.

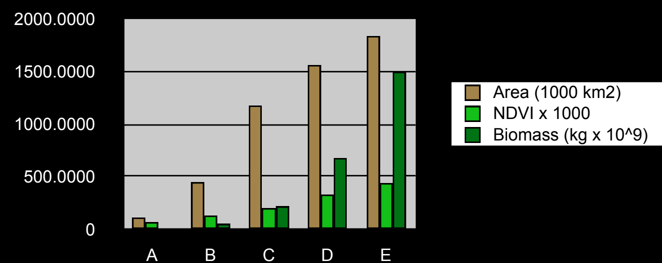


Theory of CAVM mapping, and goal of my research

Area of subzones, average NDVI and total biomass



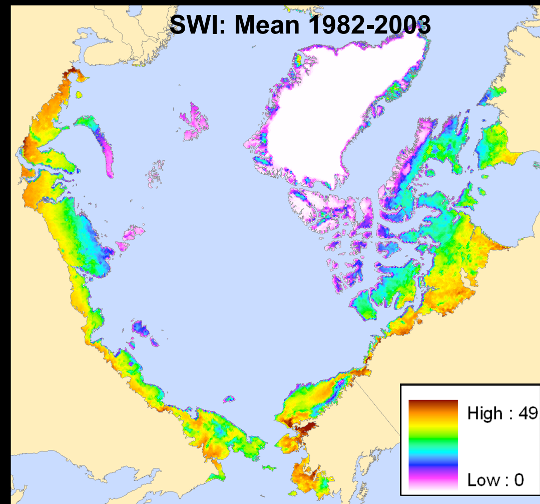


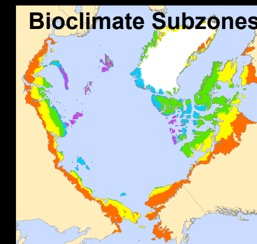


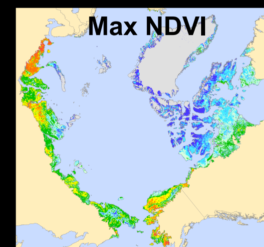
Total area = 7.1 x 10^6 km^2, average NDVI = 0.32, Total biomass = 2.5 x 10^{12} kg

Published in Raynolds et al. 2006, Remote Sensing of Environment, 102:271-281

Land surface temperatures:
Summer Warmth Index (SWI)





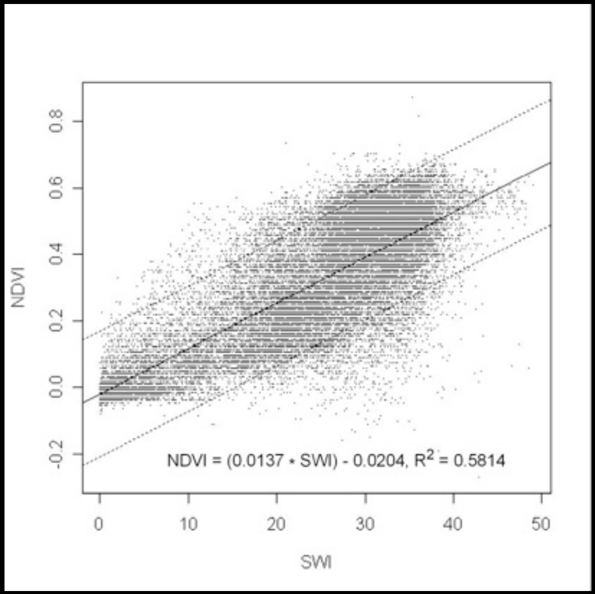


SWI = Sum of monthly mean temperatures > 0 ˚C

Raynolds et al. 2008, Remote Sensing of the Environment, 112:1884-1894.

NDVI vs. SWI

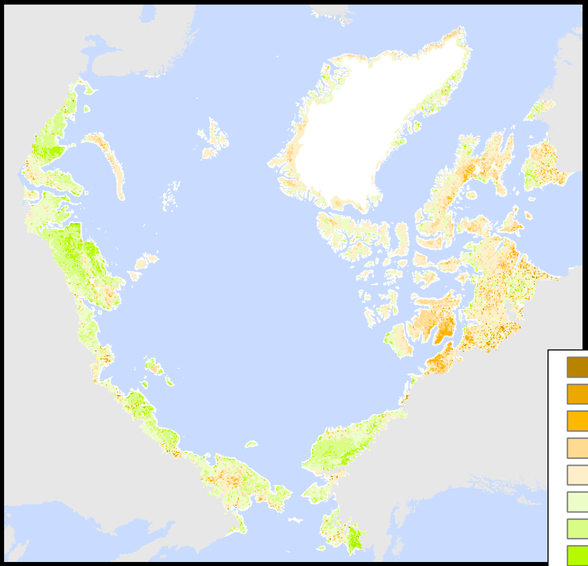
High NDVI
Subzone E

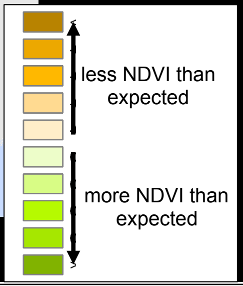


Low NDVI
Subzone A

Raynolds et al. 2008, Remote Sensing of Environment, 112: 1884-1894.

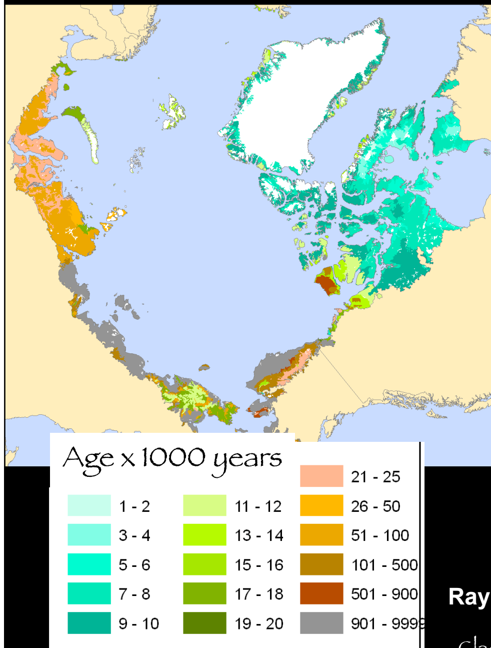
Where is NDVI greater or less than expected based on the the NDVI-SWI relationship?

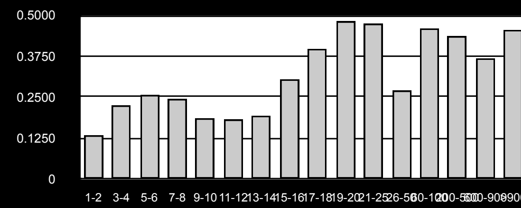




Raynolds et al. 2008, Remote Sensing of Environment, 112: 1884-1894.

Landscape age vs. NDVI



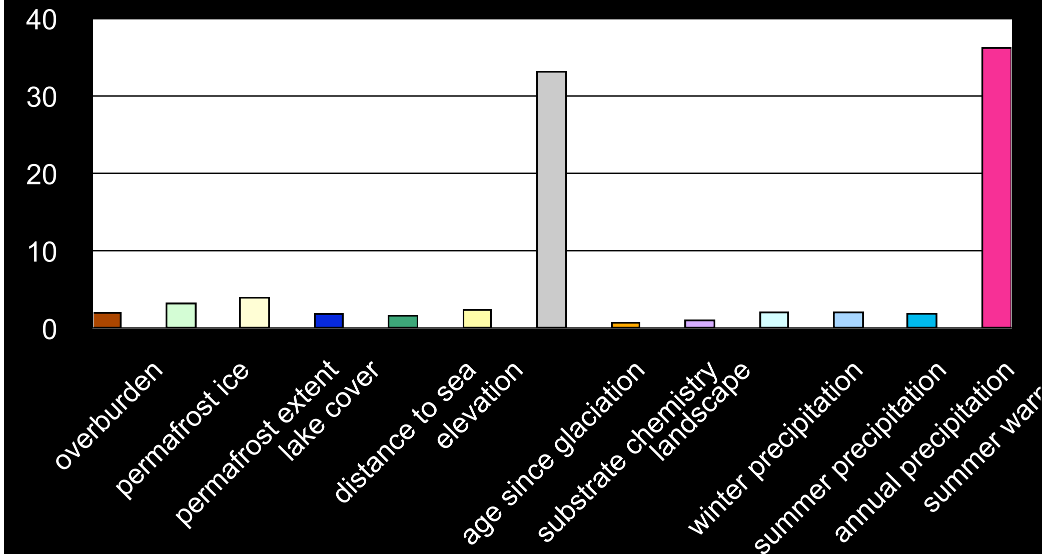


Mean NDVI of landscapes older than last glacial are much greener.

Raynolds and Walker. 2009, Can. *J. Remote Sensing*

Glacial geology map based mostly on Ehlers & Gibbard, 2004.

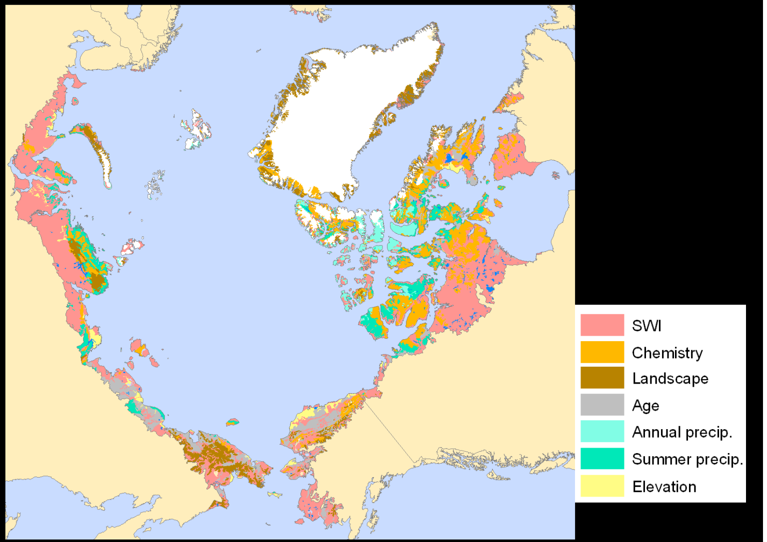
Importance of environmental variables in boosted regression tree analysis of NDVI



Raynolds, M. K. 2009. A geobotanical analysis of circumpolar arctic vegetation, climate, and substrate. University of Alaska, Fairbanks. 260 p. Ph.D. Thesis, University of Alaska Fairbanks.

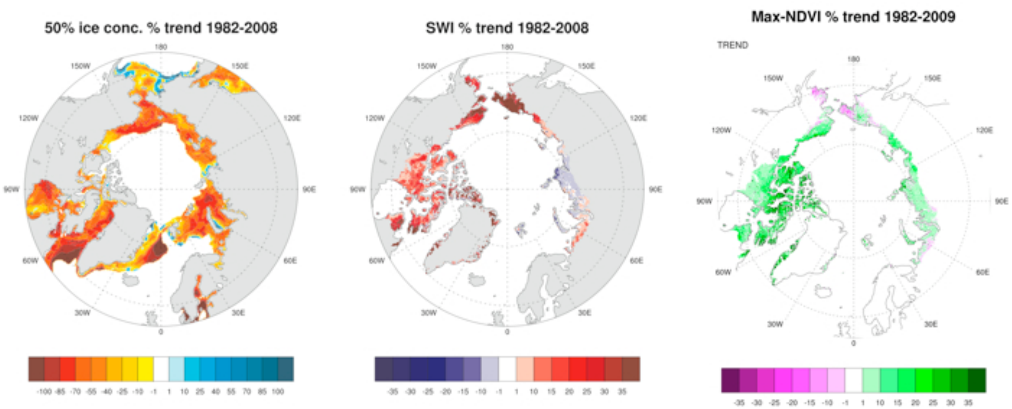
Importance of environmental variables in controlling vegetation

- BRT was used to calculate the most important factor controlling each vegetation type.
- The vegetation map was then colored according to environmental variables having the strongest control over each type.
- Gives indication of where changes in climate are more likely to result in major vegetation change.



Raynolds, M. K. 2009. A geobotanical analysis of circumpolar arctic vegetation, climate, and substrate. University of Alaska, Fairbanks. 260 p. Ph.D. Thesis, University of Alaska Fairbanks.

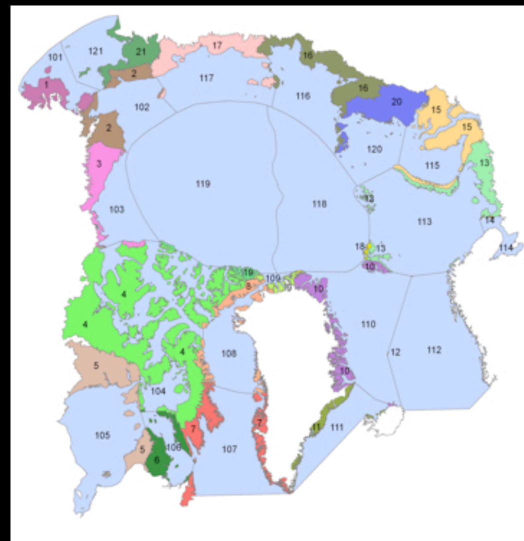
Temporal analysis of circumpolar linkages between Arctic sea ice, summer land temperatures and photosynthetic activity (NDVI), 1982-2008



Bhatt, U.S. et al. 2009 in prep.

Division of Arctic Ocean and associated land masses according to Russian Arctic Atlas and CAVM floristic provinces

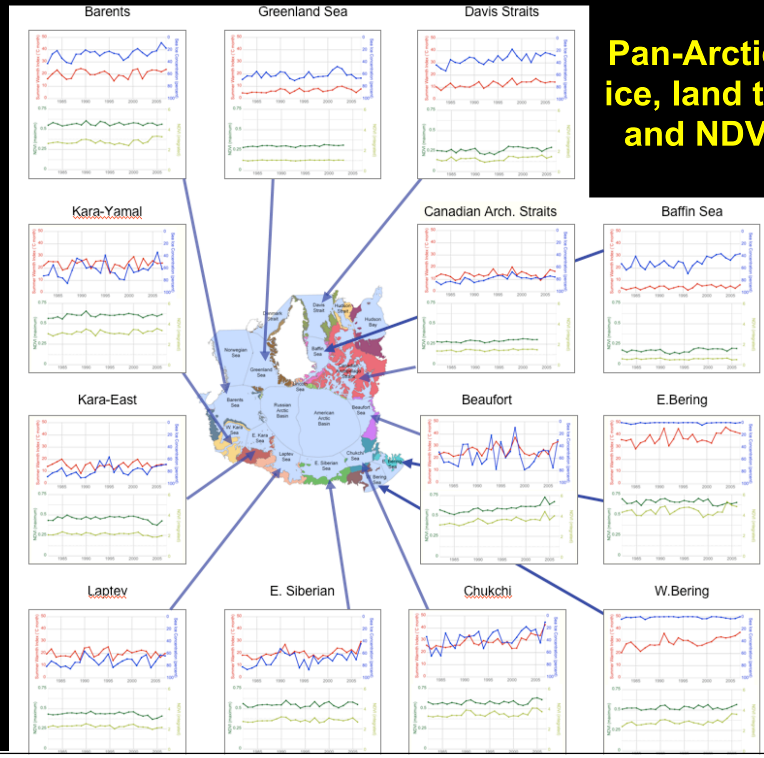
101 & 1* East Bering Sea
102 & 2 Chukchi Sea
103 & 3 Beaufort Sea
104 & 4 Canadian Arch. Straits
105 & 5 Hudson Bay
106 & 6 Hudson Strait
107 & 7 Davis Strait
108 & 8 Baffin Sea
109 & 9 Lincoln Sea
110 & 10 Greenland Sea
111 & 11 Denmark Strait
112 & 12 Norwegian Sea
113 & 13 Barents Sea
114 & 14 White Sea
115 & 15* West Kara Sea
116 & 16 Laptev Sea
117 & 17 East Siberian Sea
118 & 18 Russian Arctic Basin
119 & 19 American Arctic Basin
120 & 20* East Kara Sea
121 & 21* West Bering Sea



- Analysis of 50-km buffers seaward and landward along each sea coast and also for entire non-alpine tundra area.
- 1982-20008 AVHRR data to analyze trends in sea ice concentration, LST, and NDVI.

Uma Bhatt, D.A. Walker, M.K. Raynolds, J. Comiso, H.E. Epstein, G.J. Jia. 2009 in prep.

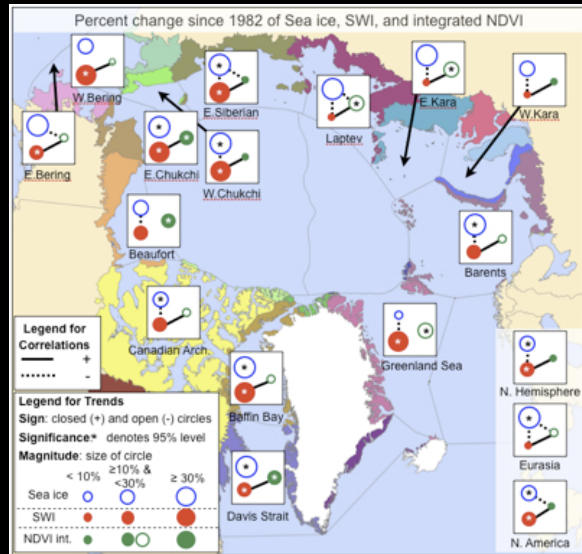
Pan-Arctic trends: Sea ice, land temperatures, and NDVI, 1980-2008



- Mid July Sea-Ice percentage cover
- Summer warmth index (SWI)
- Max NDVI
- Integrated NDVI

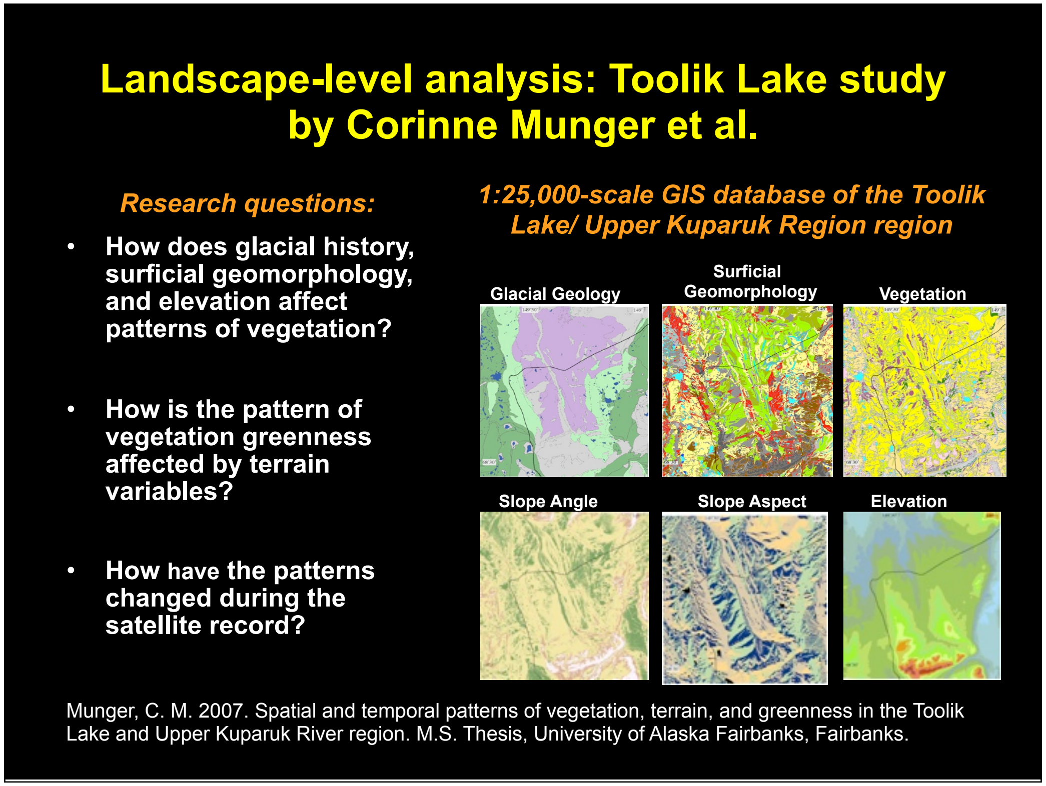
Bhatt et al: Yamal LCLUC Workshop, Moscow, 28-30 Jan 2008, and EGU 2008.

Summary of trends



Bhatt et al., 2010. *Earth Interactions*.

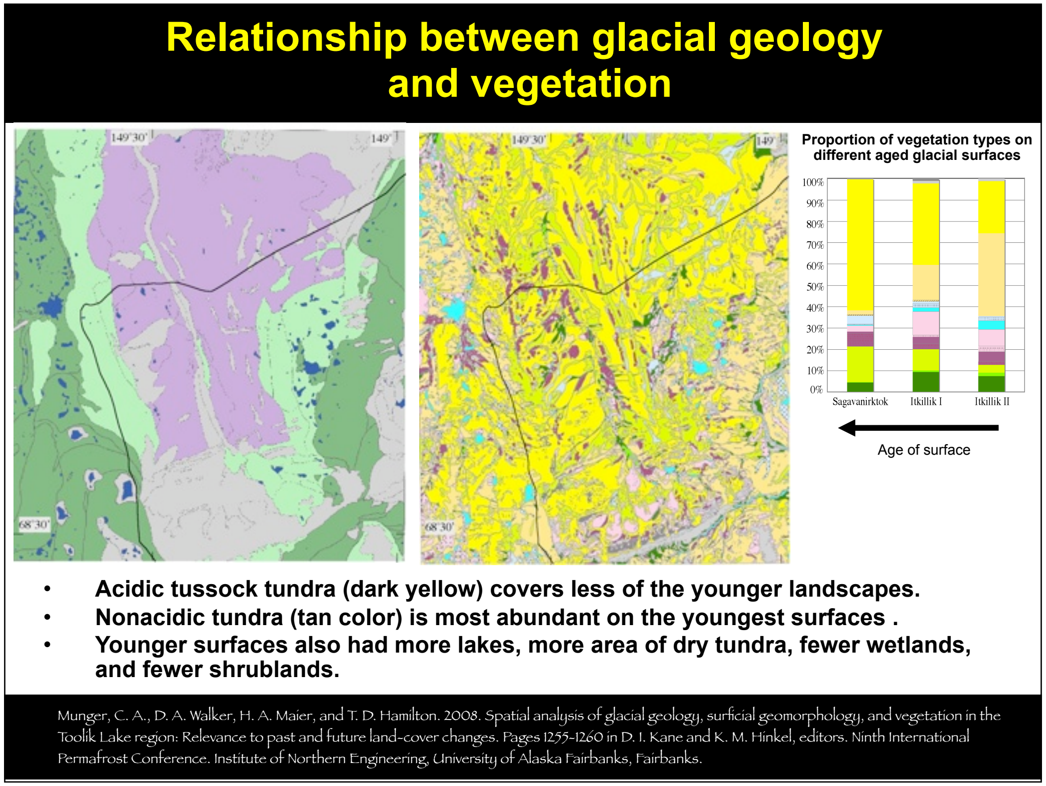
- **Sea ice** is strongly decreasing throughout the Arctic except the Greenland Sea. The strongest most significant trends are in the E. Siberian to E. Chukchi region.
- **Summer warmth** is increasing most strongly in the Beringian region between the E. Siberian Sea and the E. Chukchi and also in the Canadian High Arctic and Greenland. Relatively small increases are seen between the W. Kara and Laptev seas.
- **NDVI** is increasing most strongly in North America, particularly the Canadian High Arctic and Greenland. Negative trends in Chukotka and Bering Sea region.



SLIDE 6:

Our primary research questions, used the regional GIS to address three questions related to the spatial and temporal patterns of vegetation:

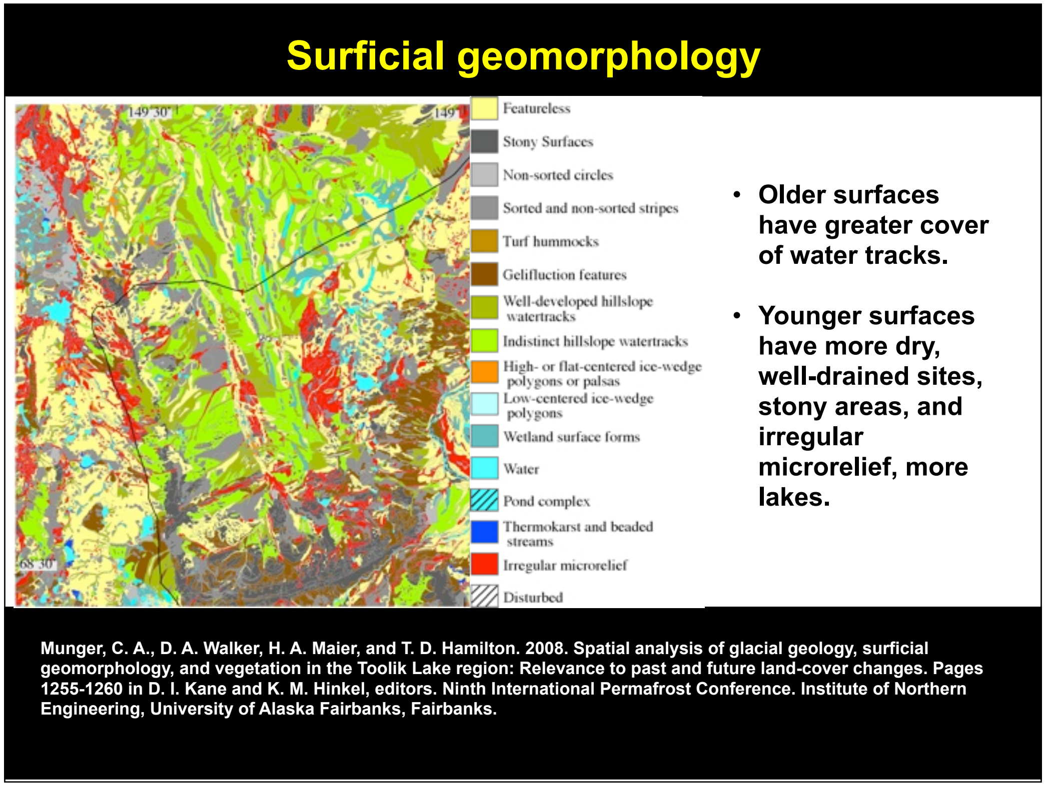
1. How does glacial history, surficial geomorphology, and elevation affect patterns of vegetation?
2. How is the pattern of vegetation greenness affected by terrain variables?
3. How have the patterns changed during the satellite record?



SLIDE 12:

The GIS analysis showed that there were distinctive trends of vegetation with surface age:

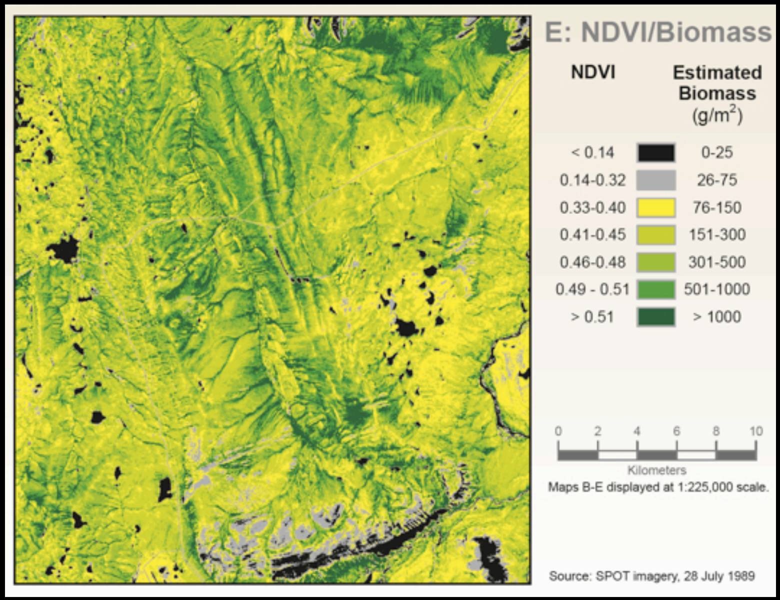
1. Acidic tussock tundra (dark yellow) covers less of the younger landscapes. There was 61% cover of tussock tundra on the oldest surfaces, 38% on the intermediate -age surfaces, and 24% on the youngest surfaces.
2. There was a corresponding increase in moist nonacidic tundra (tan areas) on the younger surfaces, with 39% cover on the youngest surfaces, 17% on the intermediate-age surfaces, and 2% on the oldest surfaces
3. Younger surfaces also had more lakes, more area of dry tundra, fewer wetlands, and fewer shrublands.



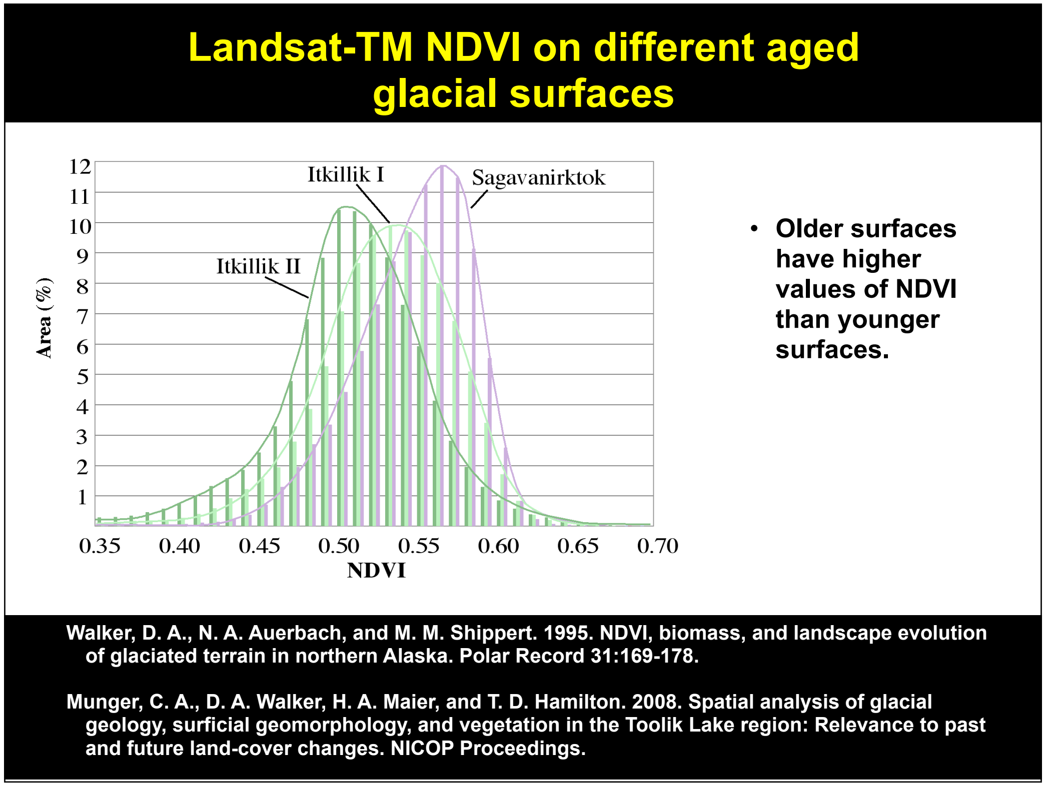
SLIDE 10:

Similar analyses were done relating the vegetation to the surficial geomorphology map, which shows the characteristics periglacial features such as non-sorted circles, stripes, ice-wedge polygons, and water tracks that could be interepreted at the 1:25,000 scale of the base images used in mapping.

NDVI of the Upper Kuparuk-Toolik Lake region



Shippert, M. M., D. A. Walker, N. A. Auerbach, and B. E. Lewis. 1995. Biomass and leaf-area index maps derived from SPOT images for Toolik Lake and Imnavait Creek areas, Alaska. Polar Record 31:147-154.

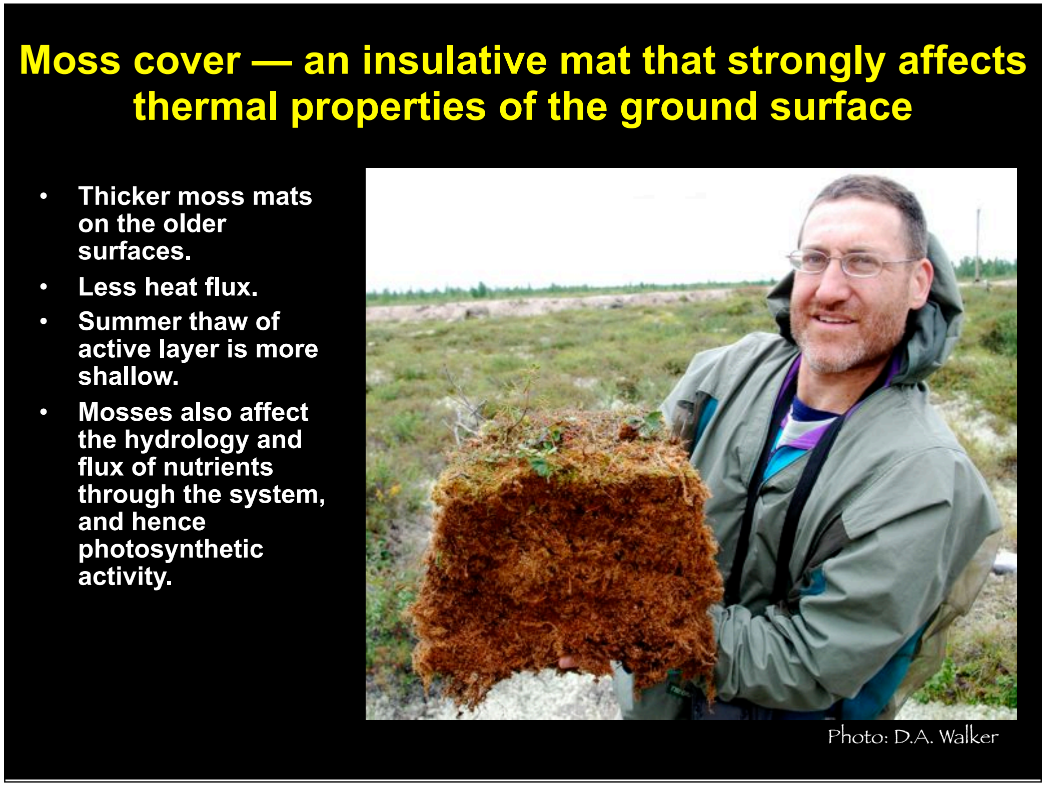


This graph shows the distribution of 35 equally spaces NDVI classes for each of the 3 different-aged glacial surfaces. Remember that the Sagavanirktok is the oldest surface and the Itkillik II is the youngest.

There is a clear trend of higher NDVI values with age of the surfaces.

This is in keeping with the GIS analysis that showed that the older surfaces have greater cover of shrub-rich tussock tundra and shrub-filled water tracks, whereas younger surfaces have more dry, well-drained sites, stony areas, and irregular microrelief.

Shrub cover is likely the most important factor that affects canopy greenness. The highest NDVI values occur in portions of the landscape with abundant shrubs, such as water tracks, on moderate slopes, and on older glacial surfaces.

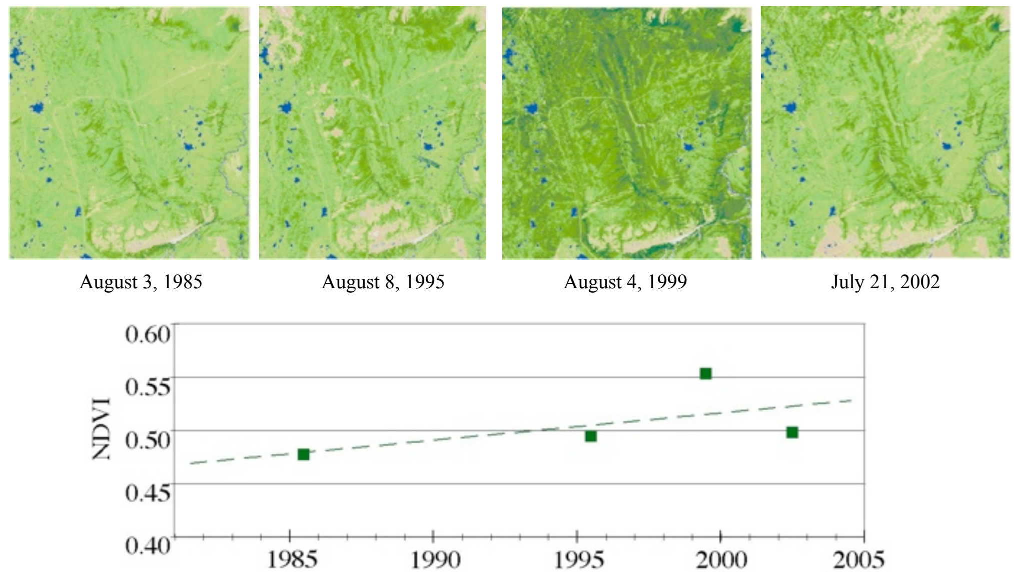


SLIDE 2:

Changes in plant biomass are expected due to climate warming and will have an important influence on surface heat flux.

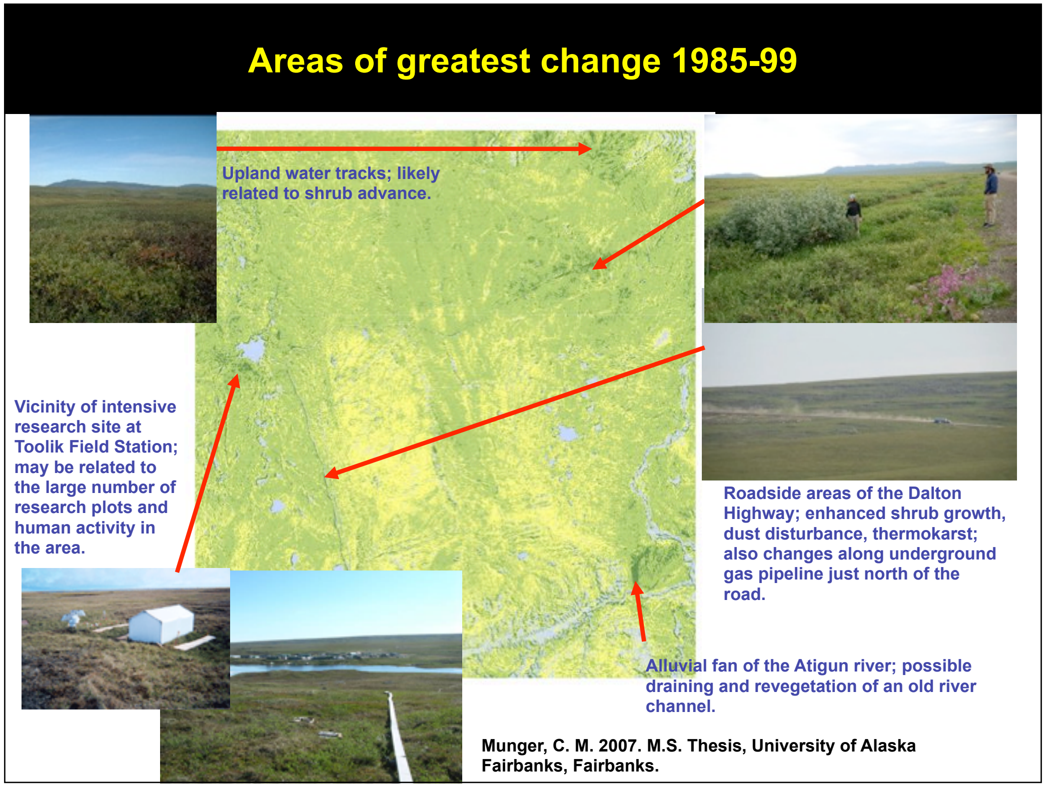
In tundra regions the plant cover acts as an insulative layer that affects the flux of heat into and out of the surface. The amount of vegetation on the surface is thus important for a wide variety of properties related to permafrost, including the n-factor, which is an index of the insulative properties of the tundra surface, the active layer depths, and permafrost temperatures.

Temporal changes in Landsat-derived NDVI



Munger, C. M. 2007. Spatial and temporal patterns of vegetation, terrain, and greenness in the Toolik Lake and Upper Kuparuk River region. M.S. Thesis, University of Alaska Fairbanks, Fairbanks.

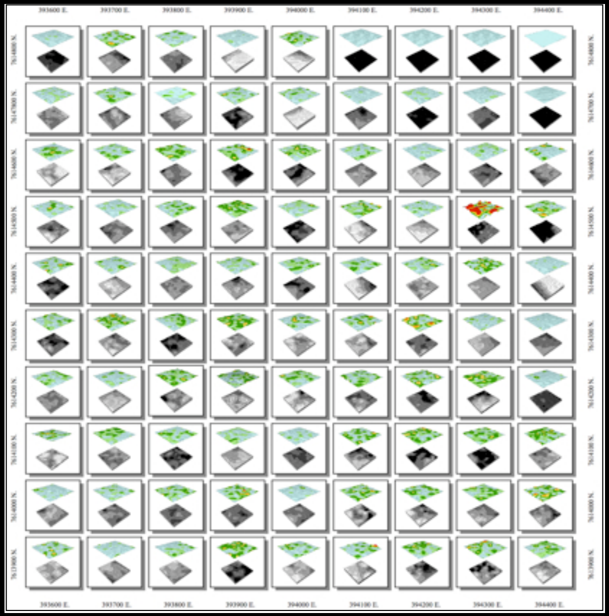
2003 image is pretty much left out in the rest of my analysis because of its earlier acquisition date



I analyzed the surface types of four distinct areas that appeared to show especially large amounts of change between 85 and 99.

There appears to be a variety of surface types that showed especially high change. The large amount of change in area 1 appears to correspond with upland watertracks, area 2 appears to be related to the effect of dust from the Dalton highway, area 3 is possibly due to human activity near Toolik Lake, and change in area 4 exists upon an alluvial fan of the Atigun River.

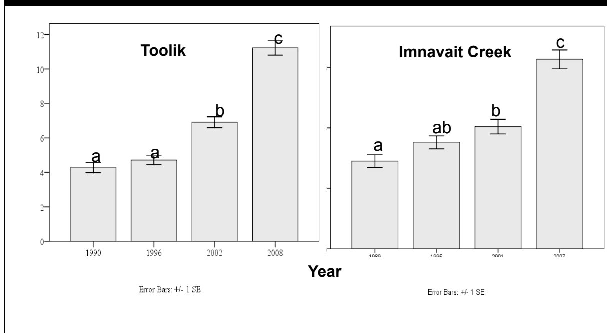
Plot-level analysis: 20 years of change to the Toolik and Imnavait Crk. grid plots



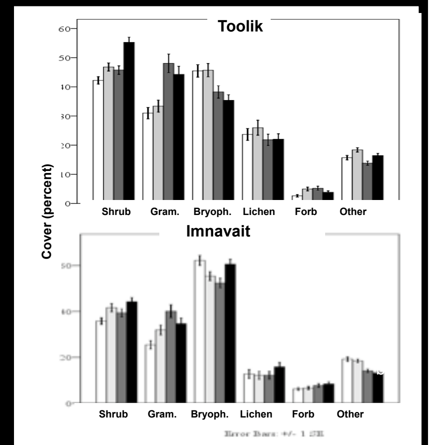
- Grids are sampled every 6 years as part of the International Tundra Experiment (ITEX) project.

Changes in plant canopy height and cover of plant growth forms (1989-2008), Toolik and Imnavait Creek Grids

Plant Canopy Height



Cover of Plant Growth Forms



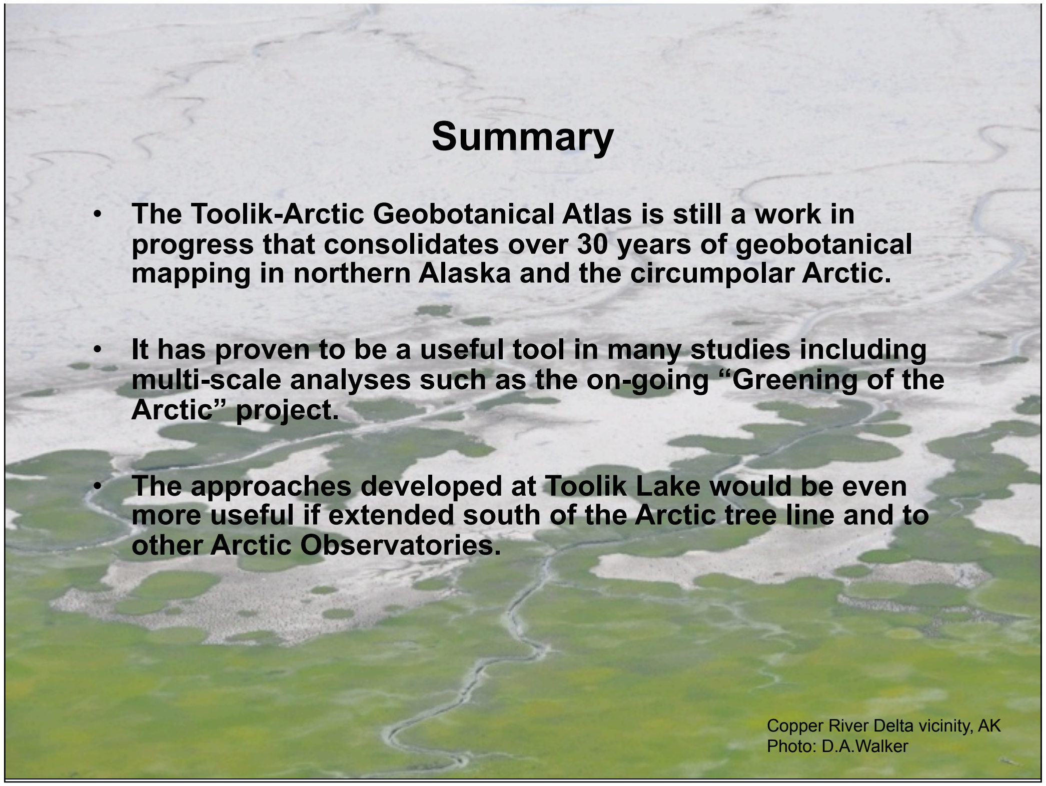
Results from Gould, Mercado et al. 2010, ITEX project.

Summary

- The Toolik-Arctic Geobotanical Atlas is still a work in progress that consolidates over 30 years of geobotanical mapping in northern Alaska and the circumpolar Arctic.

- It has proven to be a useful tool in many studies including multi-scale analyses such as the on-going “Greening of the Arctic” project.

- The approaches developed at Toolik Lake would be even more useful if extended south of the Arctic tree line and to other Arctic Observatories.



Copper River Delta vicinity, AK
Photo: D.A.Walker

The CAVM integrated terrain unit mapping approach as developed for northern Alaska

D.A. Walker
Alaska Geobotany Center
Institute of Arctic Biology,
University of Alaska Fairbanks

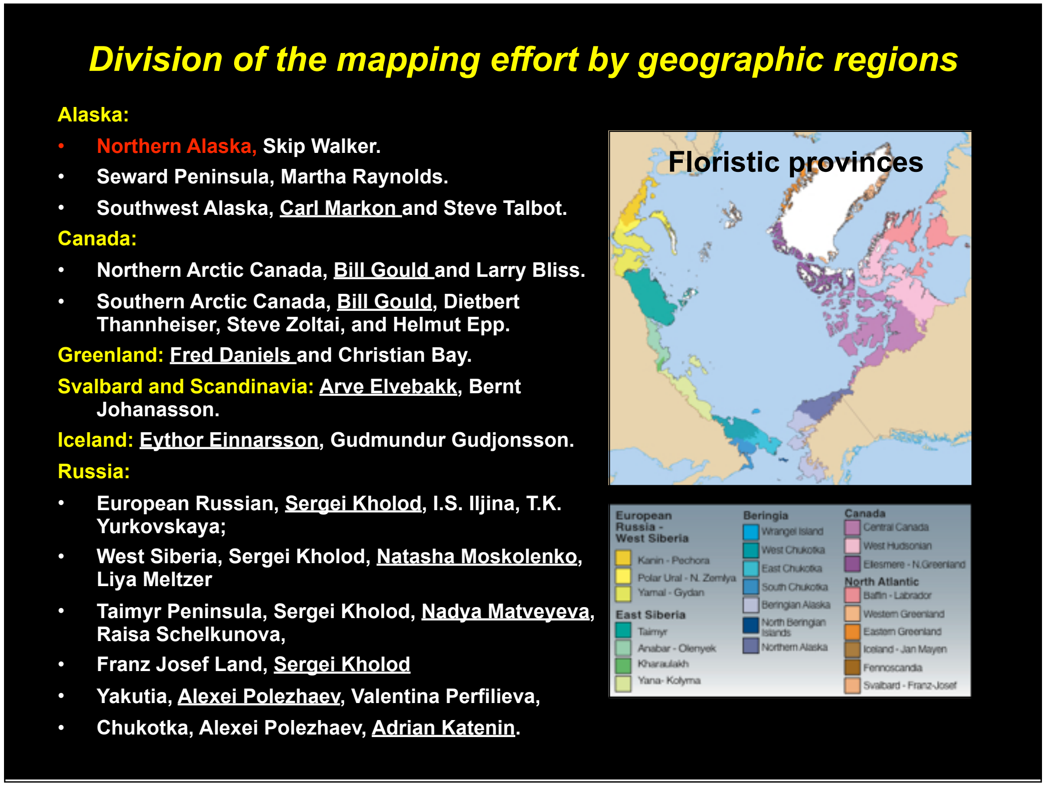
Presented at the 2nd International CBVM Workshop, Helsinki, Finland, 12-14 Mar 2010

Introduction

- ***The mapping methodology is distinct from development of the mapping legend. It refers to the process of delineation of the map polygons.***

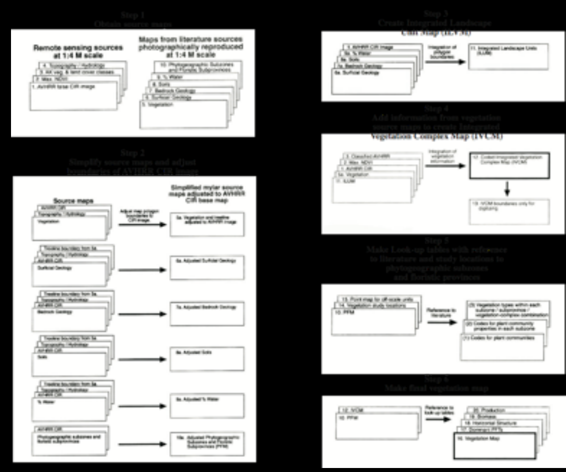
- ***Existing maps of the arctic and boreal region have a multitude of scales, legends, projections, languages and mapping approaches. Most areas have no good existing detailed vegetation maps.***

- ***A 6-step integrated mapping method was used for making the Circumpolar Arctic Vegetation Map with specific reference to the Alaska North Slope, where the method was first applied.***



The labor of making the map was divided up according to individuals with the best regional knowledge of the respective parts. The boundaries in Russia somewhat followed those of Yurtsev's Arctic Floristic regions.

The 6-Step Integrated Vegetation Mapping Method



- *Consolidation of information from many source maps onto a single map.*
- *Map polygons are coded with many attributes in a GIS database.*
- *In areas where the vegetation is poorly known, terrain attributes help determine the dominant vegetation.*

Similar approaches

- Landscape units of the "Landschaft" approach in Russia (Minkin et al. 2002).
- The landscape-guided approach used in Europe (Zonneveld 1980, 1989).
- The geobotanical mapping method developed for northern Alaska (Walker et al. 1980).
- Integrated terrain unit mapping approach (ITUM) used by ESRI in the U.S. (Dangermond and Harnden 1990).

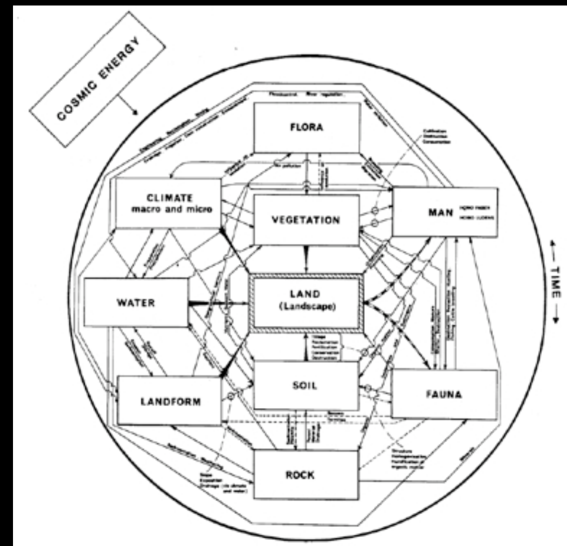
From Walker et al. 1999. Int. J. Remote Sens. 21: 4551-4570.

In Arendal, in 1996, we agreed to an approach, whereby we would integrate information from many map sources to make the map. This method has had various names, but it conforms probably most closely to the integrated mapping approach defined by Dangermond and Harding, who developed a method that was particularly well suited for mapping large regions using geographic information technology.

The ecological and practical reasons for a landscape-guided mapping approach are most clearly described by Isaac Zonneveld:

Zonneveld, I.S., 1988, The ITC method of mapping natural and semi-natural vegetation, in Küchler, A.W., and Zonneveld, I.S., eds., *Vegetation mapping: Handbook of vegetation science*: Boston, Kluwer Academic Publishers, p. 401-426.

Zonneveld, I.S., 1989, The land unit - A fundamental concept in landscape ecology, and its applications: *Landscape Ecology*, v. 3, p. 67-86.



The cartographic and GIS data-management advantages of the integrated mapping approach are most clearly explained in an obscure but excellent publication.

Dangermond, J., and Harnden, E., 1990, Map data standardization: a methodology for integrating thematic cartographic data before automation: ARC News, v. 12, p. 16-19.


ARC News Spring 1990 Page 16

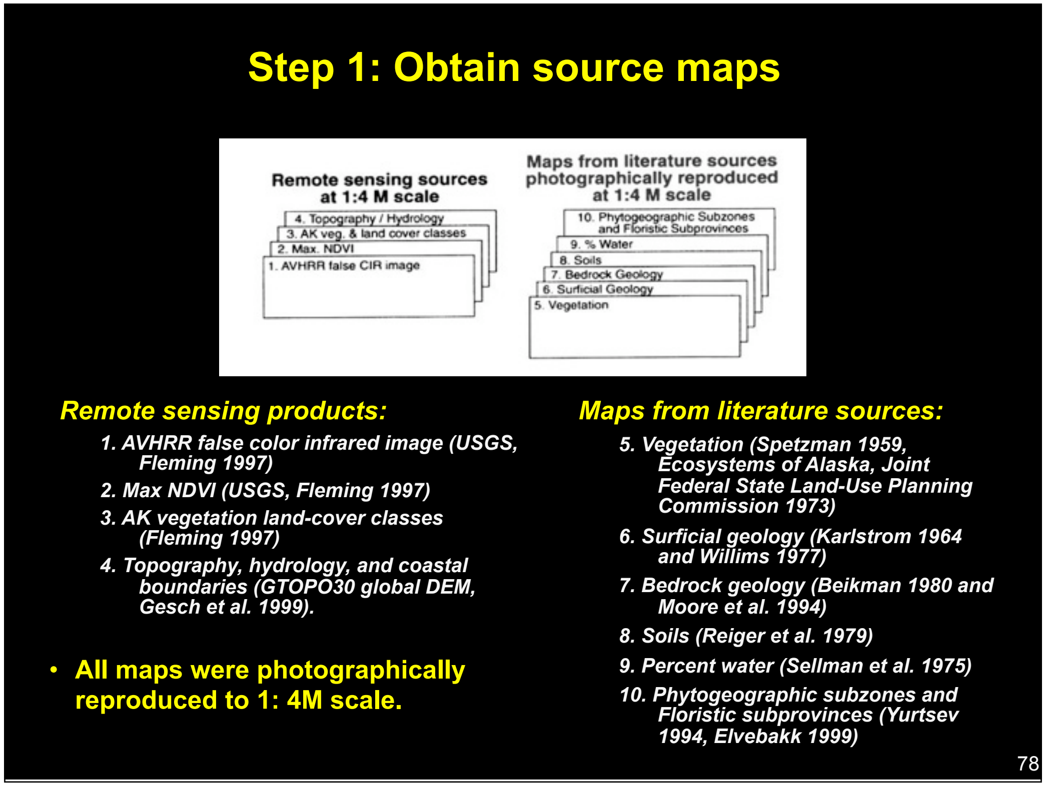
Environmental Systems Research Institute

GIS Trends

Map Data Standardization *A Methodology for Integrating Thematic Cartographic Data Before Automation*

by Jack Dangermond, ESRI President and Eric Harnden, Director of Aerial Information Systems

Users of GISs commonly analyze and compare map overlays of geographic features such as vegetation, soils, landforms, geology, and slope.



Step 1: Obtain source maps

Remote sensing products:

- *AVHRR false color infrared image (USGS, Fleming 1997)*
- *Max NDVI (USGS, Fleming 1997)*
- *AK vegetation land-cover classes (Fleming 1997)*
- *Topography, hydrology, and coastal boundaries (Digital Chart of the World, ESRI 1997)*

Maps from literature sources:

- *Vegetation (Spetzman 1959, Ecosystems of Alaska, Joint Federal State Land-Use Planning Commission 1973)*
- *Surficial geology (Karlstrom 1964 and Willims 1977)*
- *Bedrock geology (Beikman 1980 and Moore et al. 1994)*
- *Soils (Reiger et al. 1979)*
- *Percent water (Sellman et al. 1975)*
- *Phytogeographic subzones and Floristic subprovinces (Yurtsev 1994, Elvebakk 1999)*

All maps were photographically reproduced to 1: 4M scale.

Selection of base image or images

- *The base image is the key first step because it provided a common base and scale on which all map boundaries are adjusted.*
- *For the map of northern Alaska, the base image was the same as for all areas mapped for the CAVM: the mosaic of false colored near-infrared AVHRR images with 1-km pixel resolution developed by the U.S. Geological Survey.*
- *On this image, the first boundaries are those that define the map extent.*

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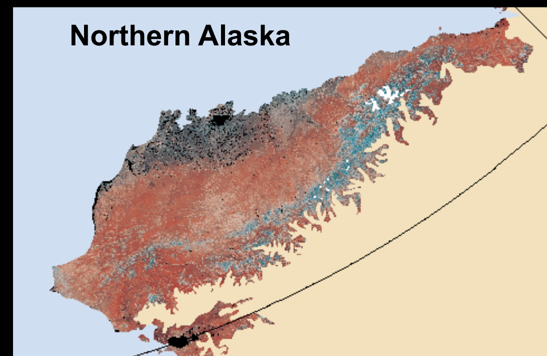
From the outset, it was important that we define the spatial domain of the map. There were a lot of ways we could have done this based on various definitions of the Arctic. There was some pressure to conform to political boundaries and include areas outside of the tundra. However, the general consensus was that for the purposes of this map, we should confine ourselves to the true biological Arctic, which is the region north of the Arctic treeline, with an Arctic climate, and an Arctic flora. This meant that some areas that might be perceived as part of the Arctic such as the Aleutian Islands or the majority of Iceland, were outside the boundary of the map.

Should also point out that this image was base map used for making the CAVM. It in itself was a very important step. It was produced by Mike Fleming at the USGS office in Anchorage. It is a mosaic of AVHRR data from two years that show the Arctic at maximum greenup in the summer and with minimum coverage of snow, clouds or ice. This was truly a critical step in making the map because it provided a standard base on which we could draw the map polygon boundaries ADJUSTED TO THE TERRAIN FEATURES.

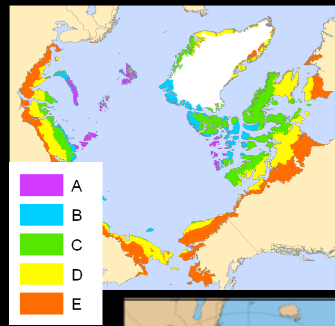
Map extent

- Most map polygon boundaries were adjusted to the boundaries of visible landscape features on this image.
- The first boundaries define the extent of the map. In this case the southern boundary was defined by tree line, which was determined by a combination of features visible on the image, and as mapped in the *Alaska Regional Profiles* (Selkregg 1975).

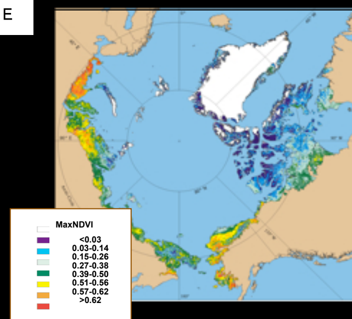


The six-step mapping proceudure that we followed was outlined in a paper published in the International Journal of Remote Sensing in 1999. Not all of the Arctic was mapped using this method. It was used primarily in areas where there were not already fairly good vegetation maps. Areas of Russia, Iceland, and Svalbard had good maps, so in these areas, the most critical factor was to adjust the map boundaries to conform to a uniform legend system and to a standard base map, which was a mosaic of AVHRR satellite images

Other global products that were used

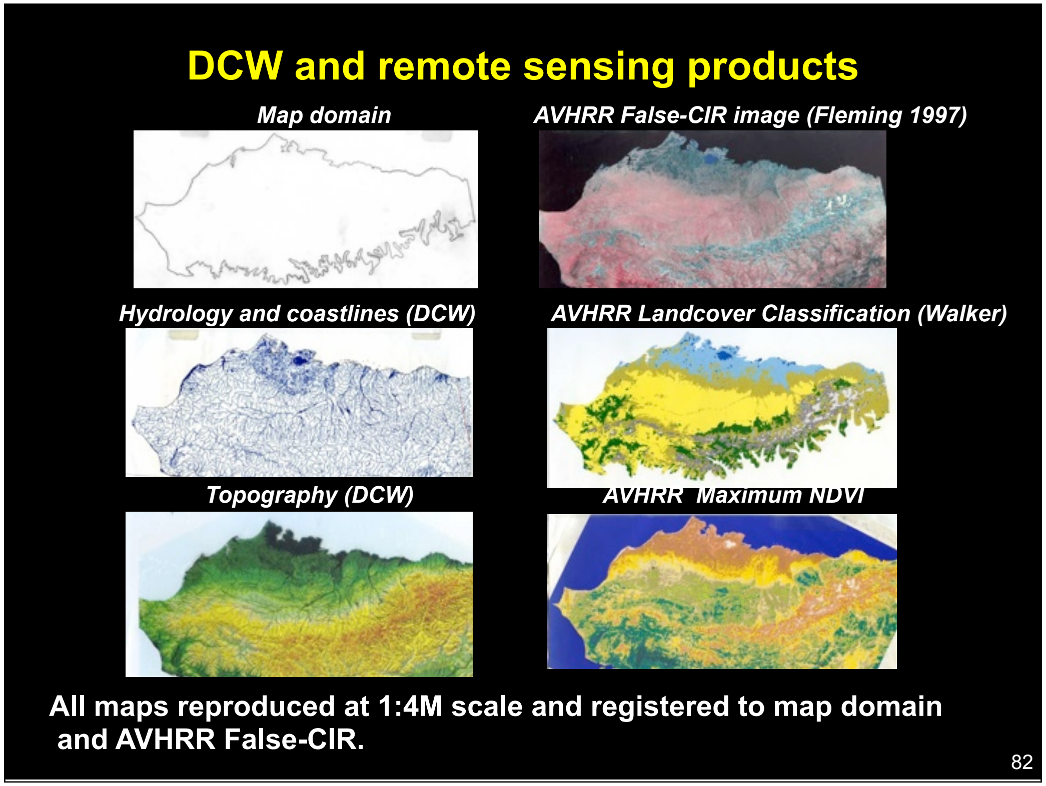


Bioclimate subzones: Adopted primarily from Russian subzones (Yurtsev 1994) as modified by Elvebakk (1999), but boundaries were adjusted somewhat to conform landscape boundaries that clearly affect climate.

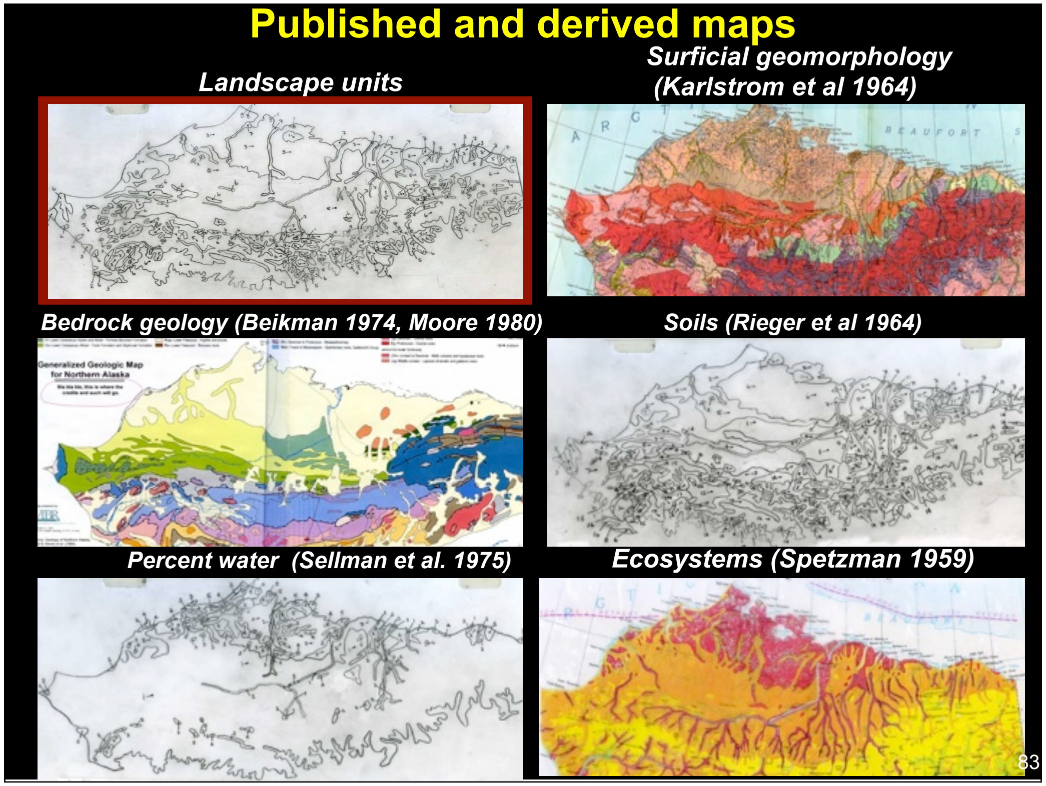


MaxNDVI: Used to help define areas of high or low vegetation productivity. Particularly for defining extent of Low Arctic shrublands and High Arctic barrens.

Digital chart of the World: Used to define coastlines, lake boundaries, and positions of rivers.



Northern Alaska portion of the AVHRR base map.



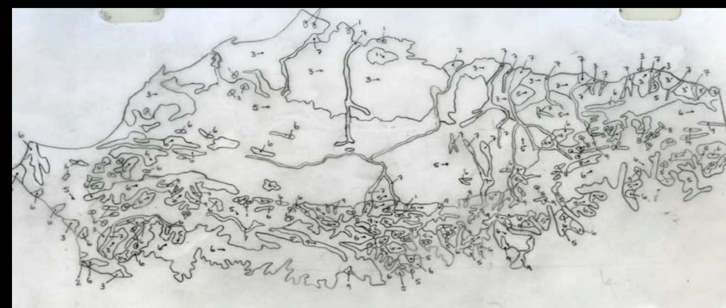
Northern Alaska portion of the AVHRR base map.

Landscape Unit map

- **Photo-interpreted from the AVHRR CIR image.**
- **Shows the major landscape units (mountains, hills, plains, floodplains.**
- **The landscape units are based on Russian “Landschaft” units (Minkin et al. 2001).**
- **The most important terrain map of the lot because it fixed many of the boundaries for vegetation and other units.**

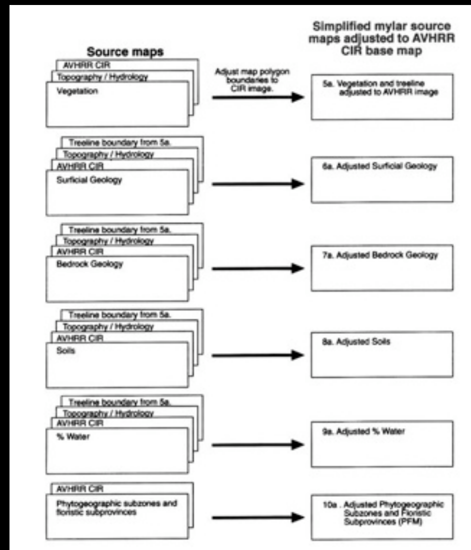
Landscape units:

- **Lakes**
- **Ocean**
- **Plains**
- **Plateaus**
- **Hills and low mountains without altitudinal belts**
- **Mountains with altitudinal belts**
- **Floodplains and deltas**



Northern Alaska portion of the AVHRR base map.

Step 2: Simplify source maps



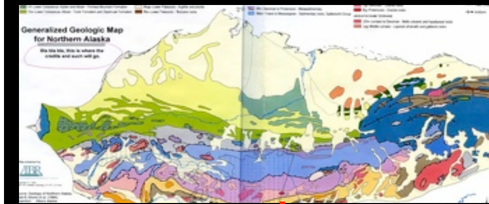
Legends and detail simplified to contain only information of known relevance to the vegetation (e.g. acidic and nonacidic bedrock types from geology maps).

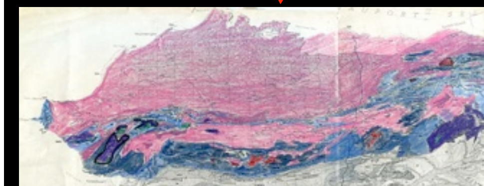
All boundaries are adjusted to conform with the AVHRR base map.

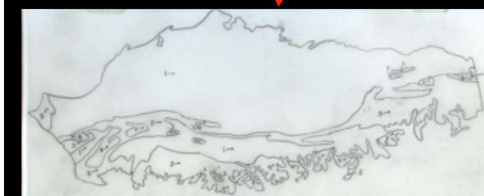
Polygon boundaries drawn on mylar overlays of the source maps at 1: 4M scale.

Minimum polygon size 3.5 mm except for linear features (2 mm).

Example of simplified map







Bedrock geology Map, 1:3M scale (Moore 1980 generalized by ABR)

•Many units, many unimportant to vegetation

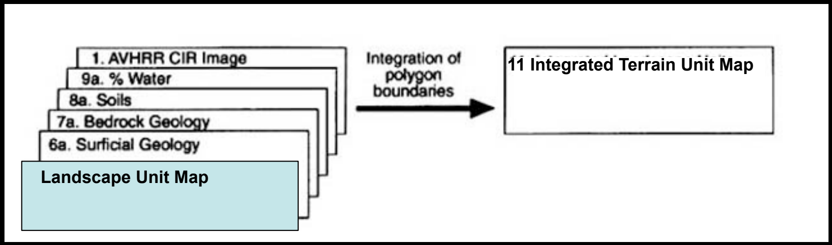
Retain geology important to vegetation:

1. Acidic sedimentary rocks (sandstones, conglomerates, shales, etc.)
2. Acidic felsic rocks, primarily intrusives
3. Nonacidic sedimentary rocks or mixtures with nonacidic sources (mainly limestones, dolomites, etc.)
4. Ultramafic rocks, primarily basic intrusives
5. Volcanic rocks.

Adjusted and simplified bedrock geology map, 1:4M scale

- Boundaries adjusted to terrain on AVHRR image.
- Units grouped in units important to vegetation.

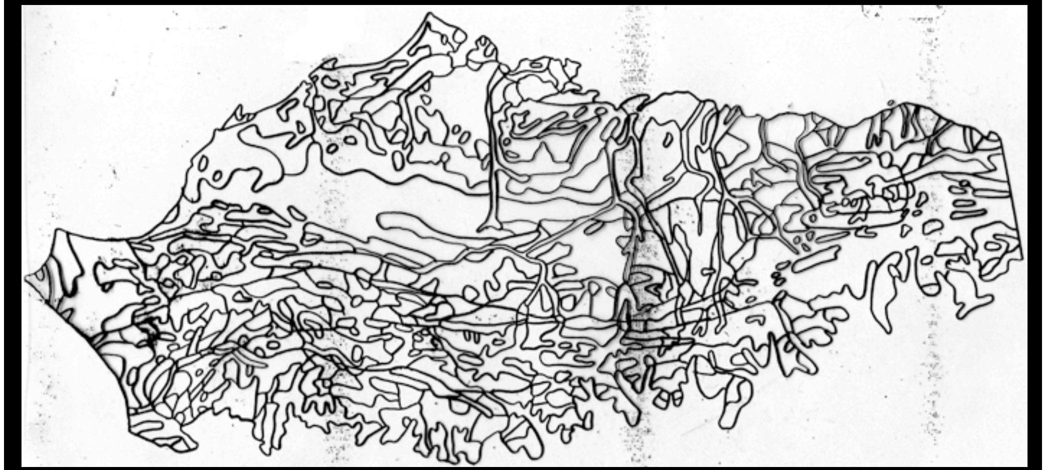
Step 3: Create Integrated Terrain Unit Map (ITUM)



1. All maps were photographically reproduced at 1: 4M scale.

2. Boundaries were all adjusted to the AVHRR CIR image and DEM coastlines, lakes and rivers and landscape unit boundaries.

ITUM polygon map



Simplified Legend for North Slope Integrated Terrain Units

Mountains
1. Acidic mountain complex with coarse deposits, extensive bedrock
2. Nonacidic mountain complex with coarse deposits, extensive bedrock
3. Acidic plateau, basin, or plain complex
4. Nonacidic plateau, basin, or plain complex
5. Glaciated valley and moraine complex

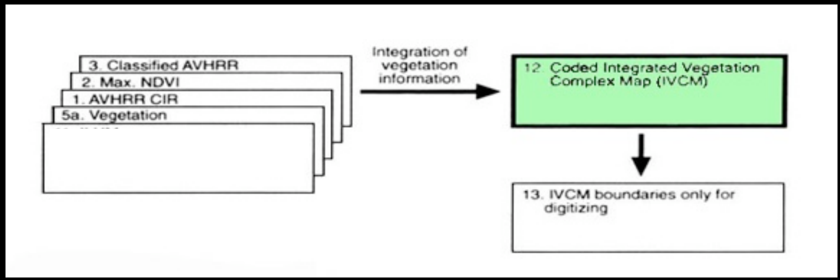
Hills
6. Acidic hill complex with rare bedrock outcrops
7. Acidic hill complex with occasional bedrock outcrops
8. Nonacidic hill complex with rare bedrock outcrops
9. Nonacidic hill complex with occasional bedrock outcrops,

Plains
10. Acidic plains, <25% lakes
11. Acidic plains, 25-75% lakes
12. Nonacidic plains, <25% lakes
13. Nonacidic plains 25-75% lakes
14. Deltas and coastal wetlands (saline)

Riparian areas
15. River floodplain complex

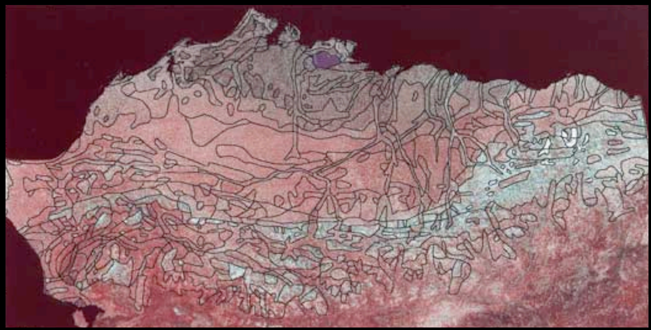
Water and glaciers
16. Water or lake complex (>75% water cover)
17. Glacier complex (>75% glacier cover)

Step 4: Create Integrated Vegetation-Complex Map (IVCM)



Vegetation map units are derived from information on the ITUM plus information from the various vegetation map sources (landcover classification, NDVI, vegetation maps).

IVCM boundaries



IVCM overlaid on the AVHRR image

Clean IVCM polygon map ready for digitizing

- Each polygon assigned a unique polygon ID number.
- Attribute file created containing string of geobotanical attributes for each polygon.

Vegetation Complex legend

Mountains

1. Acidic mountain vegetation complex with coarse rubbly deposits, extensive bedrock, and vertical zonation
2. Nonacidic mountain vegetation complex with coarse rubbly deposits, extensive bedrock, and vertical zonation
3. Acidic plateau, basin, or plain vegetation complex
4. Nonacidic plateau, basin, or plain vegetation complex
5. Glaciated valley and moraine vegetation complex

Hills

6. Acidic hill vegetation complex with rare bedrock outcrops, no vertical zonation
7. Acidic hill vegetation complex with occasional bedrock outcrops, no vertical zonation
8. Nonacidic hill vegetation complex with rare bedrock outcrops, no vertical zonation
9. Nonacidic hill vegetation complex with occasional bedrock outcrops, no vertical zonation
10. Low- to high-shrub vegetation tundra complex on uplands
11. Subalpine shrubland vegetation complex
12. Mixed evergreen and deciduous forest complex on uplands (border area with Canada)

Wetlands

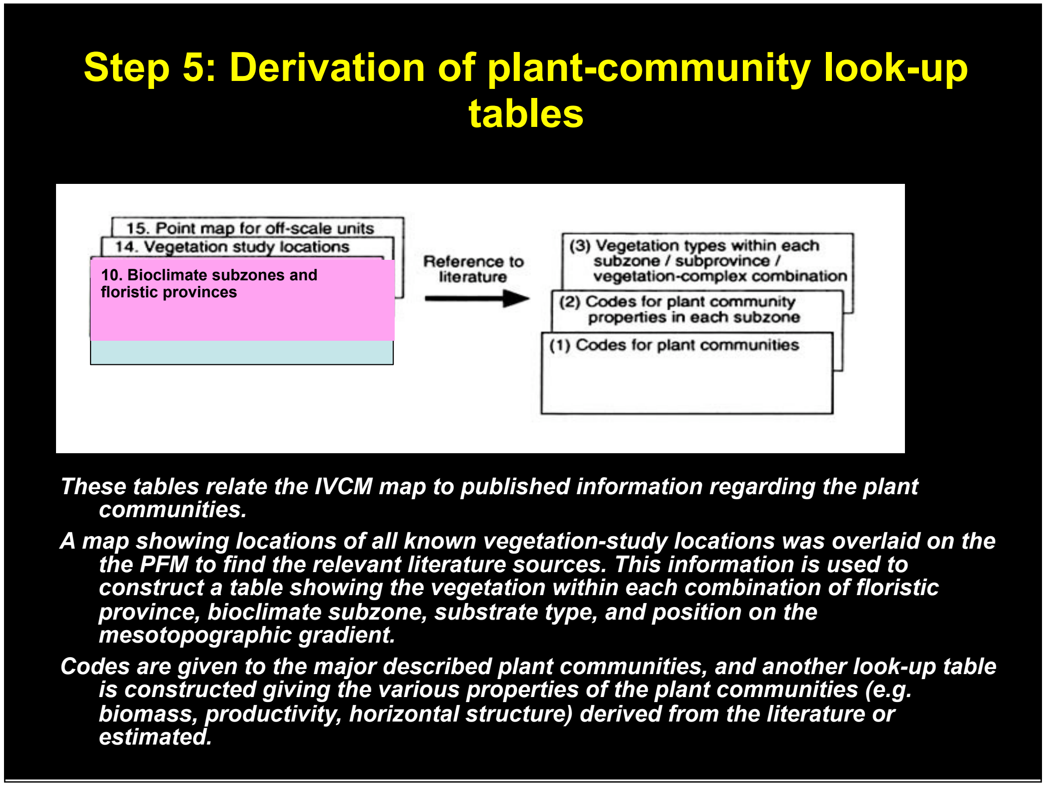
13. Acidic mire vegetation complex, <25% lakes
14. Acidic mire vegetation complex, 25-75% lakes
15. Nonacidic mire vegetation complex, <25% lakes
16. Nonacidic mire vegetation complex 25-75% lakes
17. Coastal mire vegetation complex (saline)

Riparian areas

18. River floodplain vegetation complex
19. Bottomland evergreen forest vegetation complex
20. Bottomland deciduous forest vegetation complex

Water and glaciers

21. Water or lake vegetation complex (>75% water cover)
22. Glacier complex (>75% glacier cover)

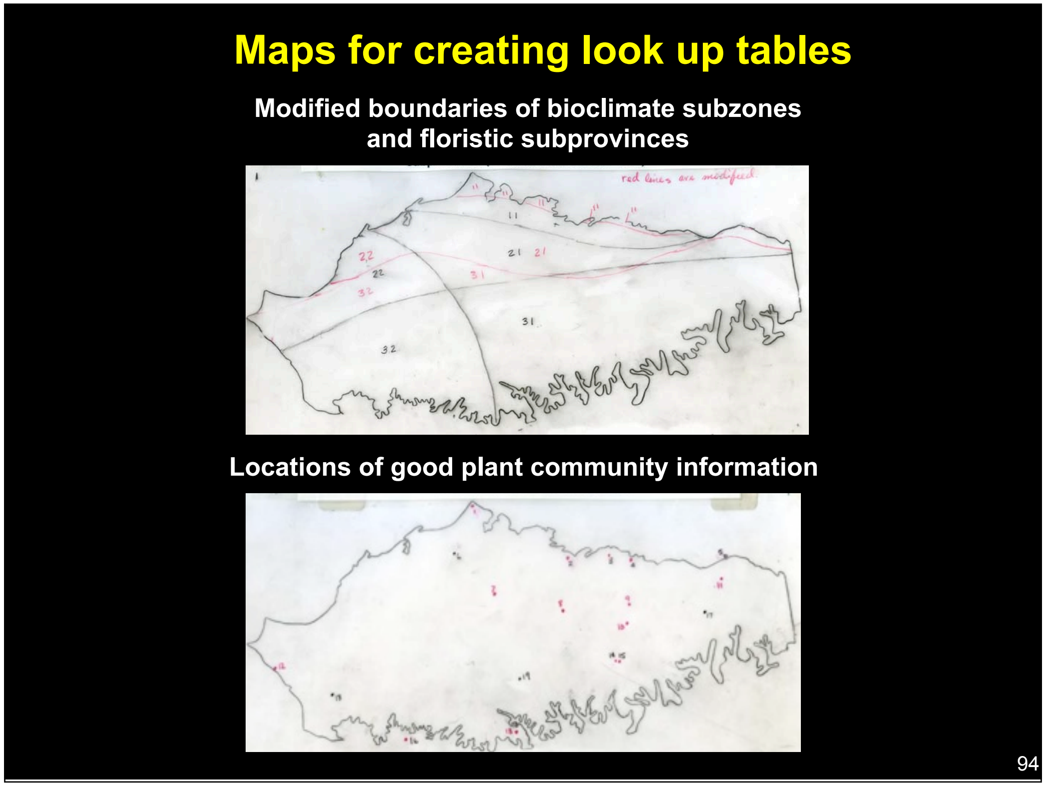


Step 5: Derivation of plant-community look-up tables

These tables relate the IVCM map to published information regarding the plant communities.

Map showing locations of all known vegetation-study locations was overlaid on the the PFM to find the relevant literature sources to construct a table showing the vegetation within each combination of floristic province, bioclimate subzone, substrate type, and position on the mesotopographic gradient.

Codes are given to the major described plant communities, and another look-up table is constructed giving the various properties of the plant communities (e.g. biomass, productivity, horizontal structure) derived from the literature or estimated



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Vegetation tables (Walker 1999)

Plant communities from literature

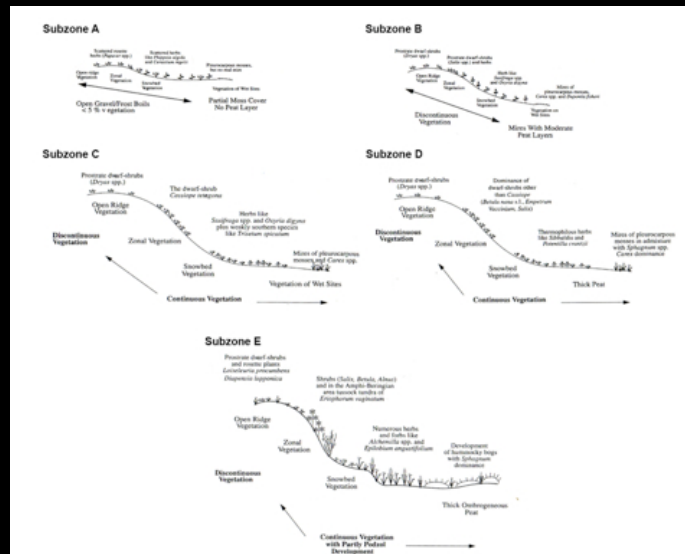
Look-up table 1. Partial list of plant communities, habitats and literature sources.

Veg code	B–B class and plant community	Habitat	Source
01000	***Rhizocarpetea geographici***	**Acidic rock lichen communities**	
01010	*Cetraria nigricans-Rhizocarpon geographicum* comm.	Xeric, acidic, sandstone and conglomerate rocks	Walker *et al.* 1994
02000	***Carici rupestris-Kobresietea bellardii***	**Dry, often calcareous, tundra swards**	
02010	*Selaginello sibiricae-Dryadetum octopetalae*	Xeric, exposed, acidic, rocky slopes, mountains, foothills	Walker *et al.* 1994
02011	*Oxytropis bryophila* ssp. *pygmaeus-Dryas octopetala* comm.	Xeric, exposed, acidic, rocky slopes, Cape Thompson	Johnson *et al.* 1966
02012	*Dryas integrifolia-Oxytropis nigrescens* comm.	Xeric, exposed, calcareous sites, coastal plain	Walker and Everett 1991
02020	*Dryas integrifolia-Cassiope tetragona* comm.	Subxeric, well-drained, nonacidic, shallow snowbeds	Walker *et al.* 1994
03000	***Cetrario-Loiseleurietea***	**Dry acidic tundra**	
03010	*Salici phlebophyllae-Arctoetum alpinae*	Subxeric, moderately exposed, acidic, rocky sites, glacial till, foothills, sandstone	Walker *et al.* 1994
03020	*Hierochloë alpina-Betula nana* comm.	Subxeric, somewhat protected, acidic sites	Walker *et al.* 1994
03030	*Carici microchaetae-Cassiopetum tetragonae*	Subxeric, well drained, acidic shallow snowbeds	Walker *et al.* 1994
04000	**Salicetea herbaceae**	**Snow patch communities**	
04010	*Salix rotundifolia* comm.	Mesic, nonacidic, deep snowbeds	Walker *et al.* 1994
05000	***Oxycocco-Sphagnetea***	**Raised bogs, acidic tussock tundra**	
05010	*Sphagno-Eriophoretum vaginati typicum*	Mesic to subhygric, acidic, uplands, moderate snow	Walker *et al.* 1994, Churchill 1955, Bliss 1956, Johnson *et al.* 1966
05011	*Eriophorum vaginatum-Cassiope tetragona* comm.	Coastal plain tussock tundra with short tussocks and few shrubs	Walker unpub.
05020	*Sphagno-Eriophoretum vaginati betuletosum nanae* subass. prov.	Dwarf-birch dominated, mesic margins of water tracks, high-centred polygons	Walker *et al.* 1994
05030	*Sphagnum lenense-Salix fuscescens* comm.	Subhygric, acidic fens	Walker *et al.* 1994
06000	***Scheuchzerio-Caricetea nigrae***	**Small sedge nonacidic mires and moist tundra**	
06010	*Dryado integrifoliae-Caricetum bigelowii*	Mesic to subhygric, non-acidic, uplands foothills	Walker *et al.* 1994
06011	*Eriophorum triste-Dryas integrifolia* comm.	Mesic to subhygric, non-acidic, uplands coastal plain	Walker 1985

Primary, secondary, tertiary plant communities in each combination of subzone, vegetation complex

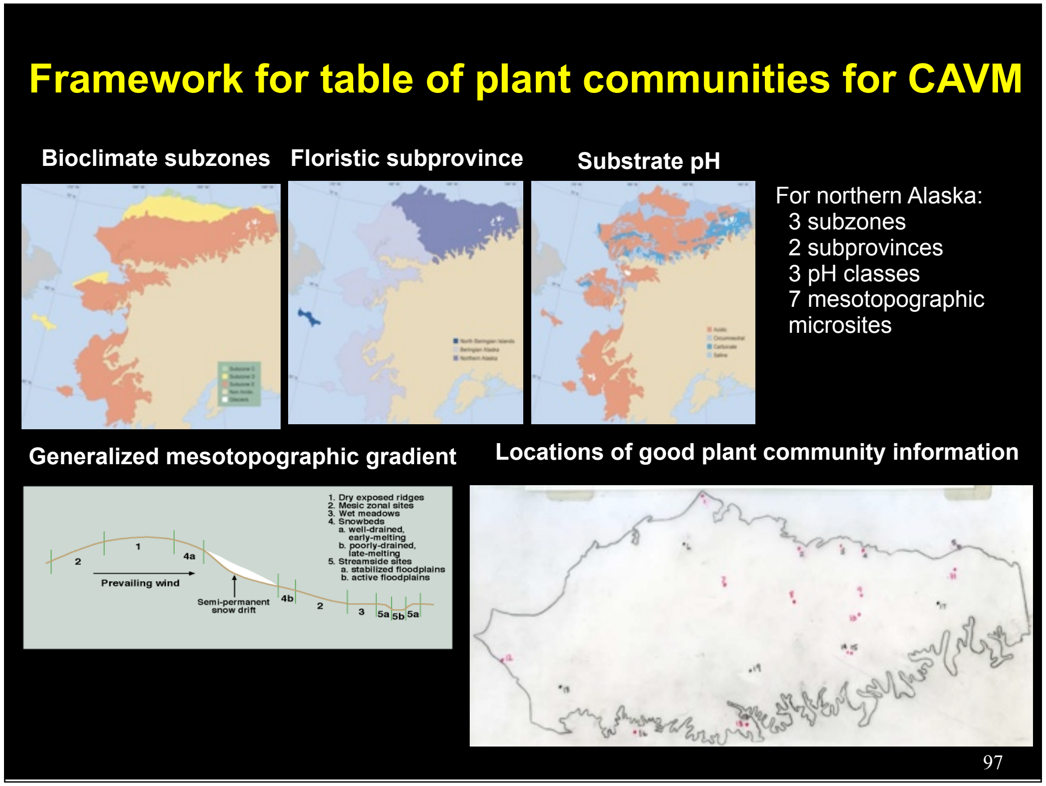
Subzone	Subprovince	Veg. Complex	Veg1	Veg2	Veg3
1	1	1	na	na	na
1	1	2	na	na	na
1	1	3	na	na	na
1	1	4	na	na	na
1	1	5	na	na	na
1	1	6	05011	10010	
1	1	7	na	na	na
1	1	8	06011	10020	
1	1	9	na	na	na
1	1	10	na	na	na
1	1	11	na	na	na
1	1	12	na	na	na
1	1	13	09011	06011	11000
1	1	14	na	na	na
1	1	15	na	na	na
1	1	16	06032	06031	

Toposequences for each subzone (Elvebakk 1999)

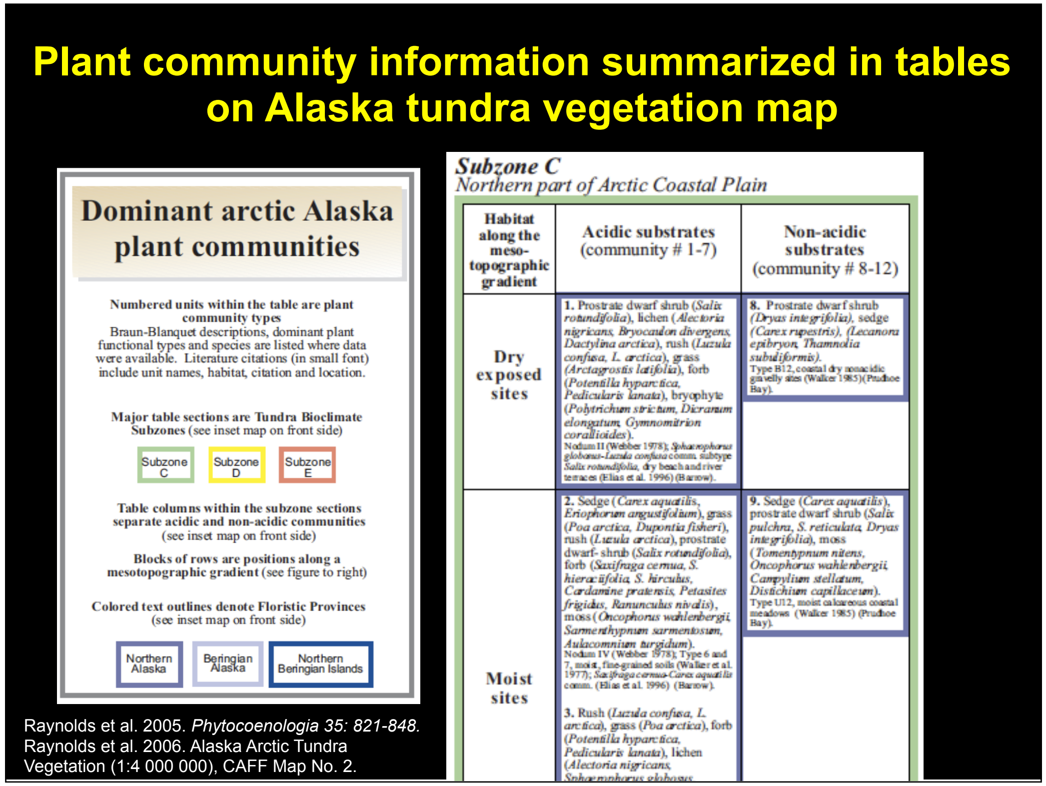


From Elvebakk, A., 1999, Bioclimatic delimitation and subdivision of the Arctic, in Nordal, I., and Razzhivin, V. eds., The Species Concept in the High North - A Panarctic Flora Initiative: Oslo, The Norwegian Academy of Science and Letters, p. 81-112.

The sequence of plant communities along topographic gradients in the Arctic had previously been described generally for each bioclimate subzone by Elvebakk 1999.

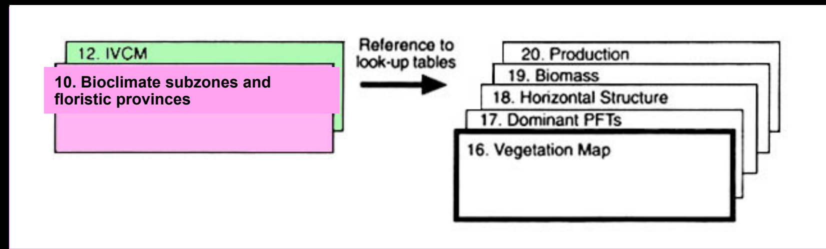


The table on the back of the Alaska map includes the dominant plant communities that are described in the literature for each combination of bioclimate subzone, floristic province, substrate pH, and position along the mesotopographic gradient (toposequences).



The supporting tables for the CAVM contained more detailed reference to specific communities described in the literature and expanded the toposequence concept to include lists of plant communities along the conceptual toposequence for each Bioclimate subzone, floristic province and major substrate type.

Step 6: Final vegetation map and other derived maps



- The draft vegetation maps were produced with reference to look-up tables.
- Legends and colors for the map can be modified considerably based on look-up tables.
- Separate maps can also be derived showing dominant plant growth forms, biomass, horizontal structure also based on information in look-up tables.
- Or any of the other geobotanical attributes that went into making the IVCM.

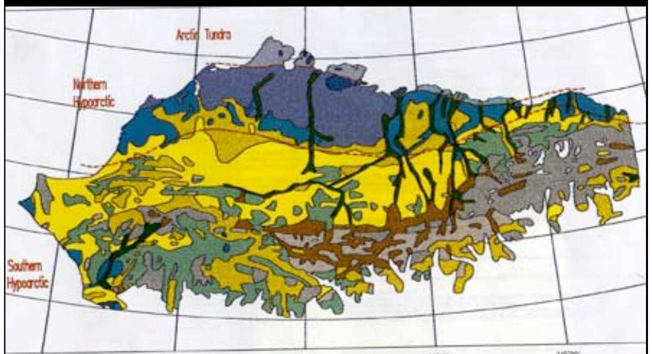
Step 6: Final vegetation map and other derived maps

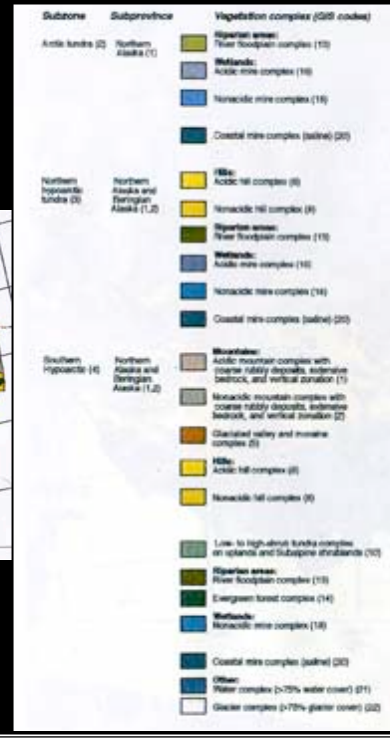
Vegetation map is produced by overlaying the IVCM with the PFM with reference to look-up tables.

Separate maps can also be derived showing dominant plant growth forms, biomass, horizontal structure.

Or any of the other geobotanical attributes that went into making the IVCM.

Draft Vegetation Complex Map

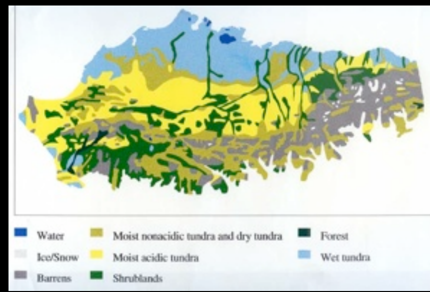




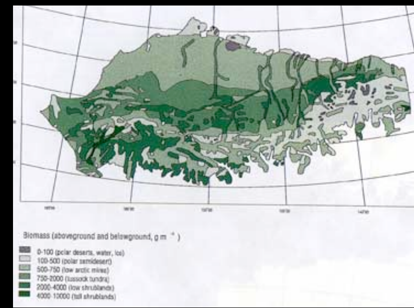
Other types of vegetation maps derived from the look-up tables

Simple Vegetation Map

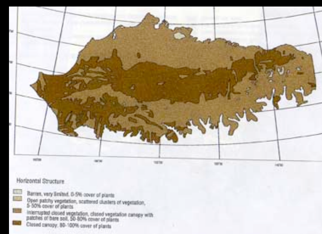
(same classes as Landsat-derived map)



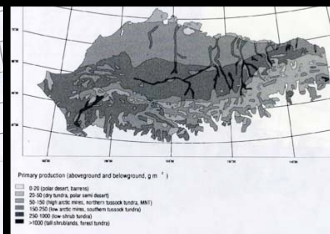
Biomass



Horizontal Structure

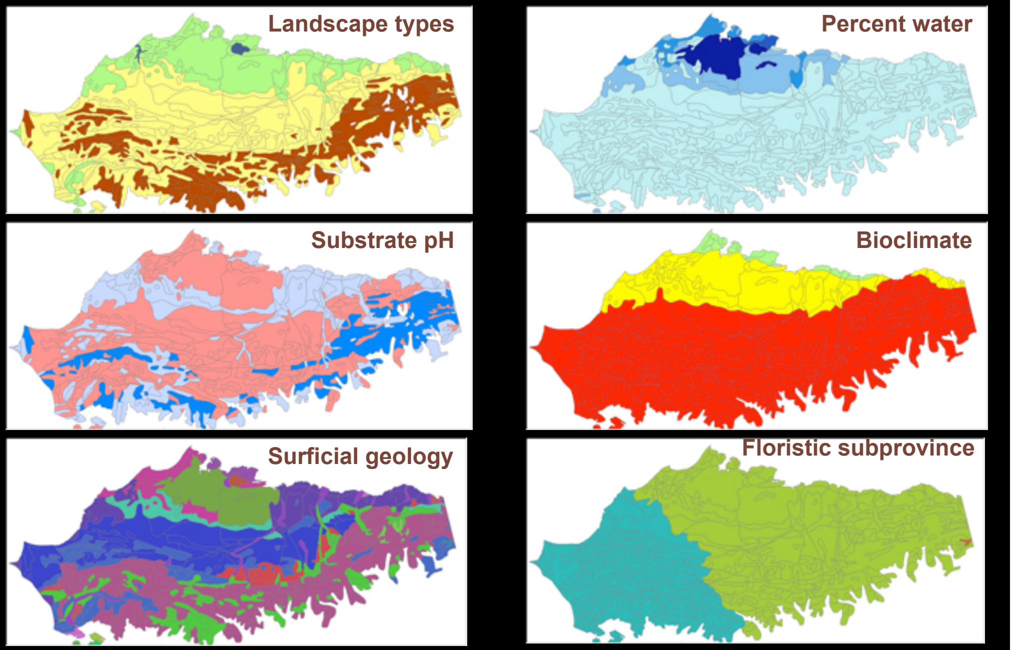


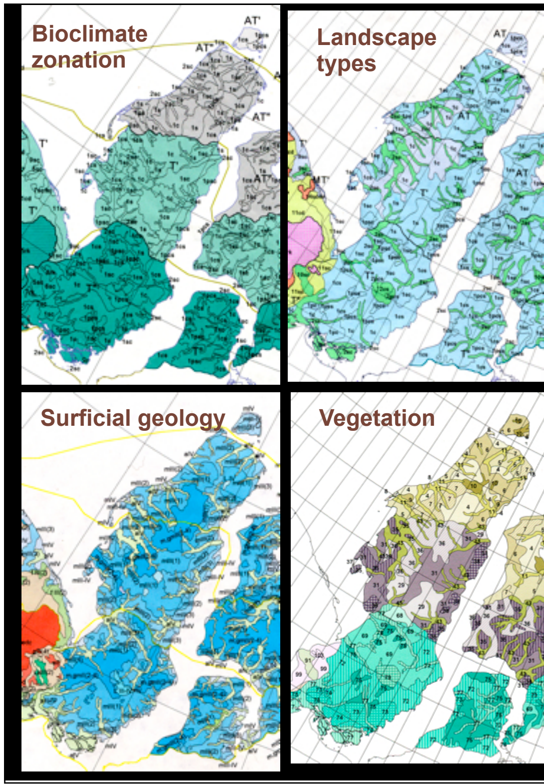
Primary Production



Dominant Plant Functional Types

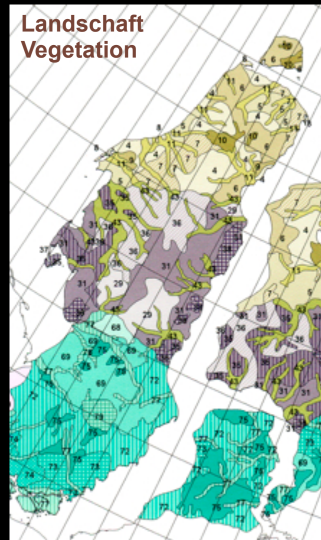
Other types of maps derived from the geobotanical GIS database

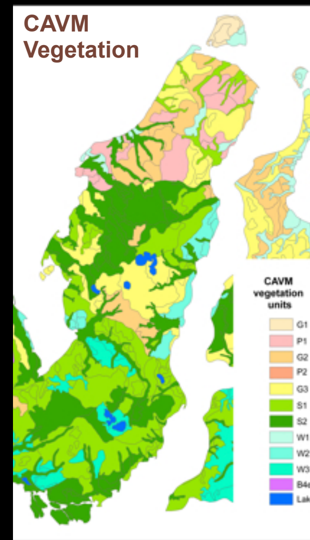




Russian Landschaft maps

1. Zonal, subzonal altitudinal, longitudinal units.
2. Landscape types (hills, mountains, plains, etc.).
3. Types of lithogenic base of landscapes (mainly soil texture).
4. Vegetation map boundaries were adapted and integrated from 1:4M scale maps of Russian vegetation.



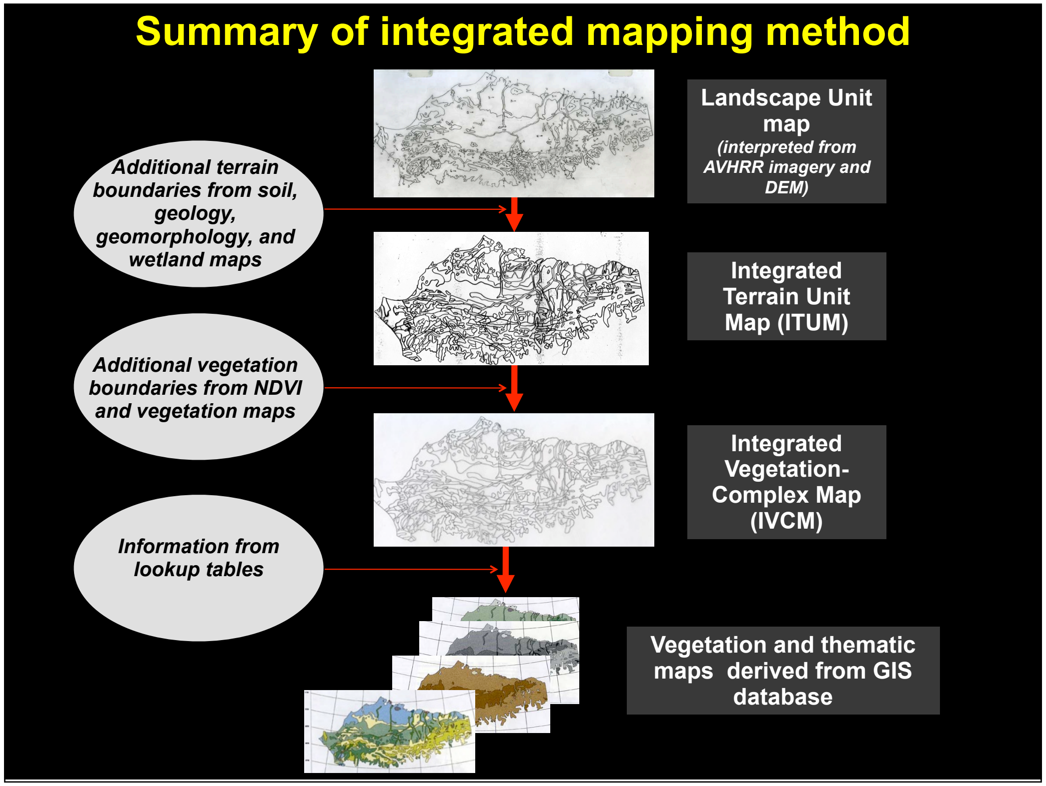


Russian vegetation map units converted to CAVM units.

- 121 vegetation units for Russia.
- Zonation dominates color scheme

- Reduced to 15 units.
- Plant physiognomy dominates color scheme.

- Descriptions of plant communities in Russia followed the same approach used in Alaska (plant communities described for each subzone, floristic province, substrate, mesotopographic position).
- First Russian map followed traditional Russia hierarchical legend with subzones at the highest level.
- Final CAVM legend had only 15 map units, but detail of original communities is in the look-up tables (87 communities in Alaska, about 150 in Russia).


Summary of integrated mapping method
Landscape Unit map
(interpreted from AVHRR imagery and DEM)
Additional terrain boundaries from soil, geology, geomorphology, and wetland maps
Integrated Terrain Unit Map (ITUM)
Additional vegetation boundaries from NDVI and vegetation maps
Integrated Vegetation-Complex Map (IVCM)
Information from lookup tables
Vegetation and thematic maps derived from GIS database