Detailed Vegetation Descriptions

Note: Syntaxa (formal vegetation units) follow the Braun-Blanquet nomenclature system (Weber et al. 2000, Westhoff and Van der Maarel 1973) and are recognized worldwide by the International Botanical Congress.

Barrens

B1

B1. Cryptogam, herb barren

Dry to wet barren desert-like landscapes mainly in Subzone A and on some coarse-grained, often calcareous sediments in subzones B and C. Sparse (2-40%) horizontal plant cover, and very low vertical structure (generally <2 cm tall) with a single layer of plants where they occur. Dry herb barrens composed of few scattered vascular plants are present over much of the landscape. Snow-flush communities are often a conspicuous component, forming dark streaks on the otherwise barren lands, composed largely of bryophytes and cryptogamic crusts. In upland areas, vascular plant cover is generally very sparse (<2%), mainly scattered individual plants often in crevices between stones or small (< 50 cm diameter) cryoturbated polygons. Sedges (Cyperaceae), dwarf shrubs, and peaty mires are normally absent.
Dominant plants: The most common vascular plants are cushion forbs (*Papaver dahlianum* ssp. *polare, Draba, Potentilla hyparctica*[a], *Saxifraga oppositifolia*[n]) and graminoids (*Alopecurus alpinus, Deschampsia borealis/brevifolia, Poa abbreviata, Puccinellia angustata, Phippsia, Luzula nivalis*[a], *L. confusa*[a]), lichens (*Caloplaca, Lecanora, Ochrolechia, Pertusaria, Mycobilimbia, Collema, Thamnolia, Cetraria, Flavocetraria, Cetrariella, Stereocaulon*), mosses (*Racomitrium, Schistidium, Orthothecium*[n], *Ditrichum*[n], *Distichium*[n], *Encalypta, Pohlia, Bryum, Polytrichum*), liverworts (e.g., *Gymnomitrion, Cephaloziella*), and cyanobacteria.
Representative syntaxa: Communities of the classes *Thlaspietea rotundifolii* Br.-Bl. et al. 1947 (e.g., *Papaveretum dahliani* Hofm. 1968) and *Salicetea herbaceae* Br.-Bl. et al. 1947 (e.g., *Phippsietum algidae-concinnae* Nordh. 1943).

B2

B2. Cryptogam barren complex (bedrock)

Bedrock covered with lichens, usually mixed with many lakes and the zonal vegetation. The largest areas are on Precambrian granite and gneiss bedrock of the Canadian Shield, but also in the high elevation areas of Siberia, northeast Asia, Greenland, and Svalbard, which are mapped as part of the mountain complex (Units B3 and B4). Areas between bedrock outcrops commonly have dwarf shrubs and fruticose lichens. Found in Subzones C and D.
Dominant plants: Saxicolous lichens (*Lecidia, Lecanora, Buellia,* [illegible]) [illegible]
Representative syntaxa: Communities of the class *Rhizocarpetea geographici* Wirth 1980 (Canada, on granite bedrock).

B3a B3b B3c B3d B3e B3n

B3. Noncarbonate mountain complex

Dry acidic tundra complexes on mountains and plateaus with noncarbonate 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 Figure 2). The color of the polygon hatch pattern denotes the bioclimate subzone at the base of the mountains. For example B3a occurs in Subzone A, B3b in Subzone B, etc. B3n denotes nunatak areas, with many noncarbonate 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.
Representative syntaxa for each elevation belt: [illegible]

B4b B4c B4d B4e B4n

B4. Carbonate mountain complex

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 Figure 2). 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.
Representative syntaxa for each elevation belt: 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 North-ern America).

Graminoid tundras

G1

G1. Rush/grass, forb, cryptogam tundra

Moist tundra on fine-grained, often hummocky soils in subzones A and B. Plant cover is moderate (40-80%), and the vegetation forms a single layer generally 5-10 cm tall. This is the zonal vegetation in Subzone A, often occurring in somewhat more protected areas with moderate snow cover. Except for the greater diversity of plants, particularly rushes and grasses, it is similar in composition to cryptogam, cushion-forb barrens (Unit B1).
[illegible]

G2

G2. Graminoid, prostrate dwarf-shrub, forb tundra

Moist to dry tundra in Subzone C and warmer parts of Subzone B on fine-grained, often hummocky circumneutral soils with moderate snow. This is the zonal vegetation on nonacidic soils of Subzone C. Plant cover is moderate (40-80%) and 5-15 cm tall. The diversity of plant communities is much greater than in Unit G1 and includes *Cassiope tetragona* snowbeds, well-developed mires, and streamside plant communities.
Dominant plants: Sedges (*Carex misandra, C. lugens/arctisibirica/bigelowii, C. rupestris, Eriophorum triste, Kobresia myosuroides, C. aquatilis* ssp. *stans* (moister sites)), rushes (*Luzula nivalis*[a], *L. confusa*[a]), and prostrate dwarf-shrubs (*Salix polaris, S. rotundifolia, S. arctica, S. reticulata, Dryas*). Other common plants include grasses (*Alopecurus alpinus, Puccinellia vahliana, P. wrightii, Poa arctica*), forbs (*Potentilla hyparctica*[a], *Cardamine bellidifolia*[a], *Draba nivalis, Saxifraga cernua, S. hirculus, Stellaria, Pedicularis capitata, Papaver*), mosses (*Racomitrium lanuginosum*[a], *Oncophorus wahlenbergii, Campylium stellatum, Aulacomnium turgidum, Warnstorfia sarmentosa, Hylocomium splendens, Polytrichum*), liverworts (*Tetralophozia setiformis*[a], *Anastrophyllum minutum*[a]), and lichens (*Sphaerophorus globosus*[a], *Cladina rangiferina*[a], *Cladonia pyxidata, Thamnolia, Dactylina arctica, Flavocetraria, Masonhalea richardsonii*).
Representative syntaxa: Communities of the class *Carici-Kobresietea*, e.g., *Carici-Dryadetum integrifoliae* Dan. 1982 (Greenland).

G3

G3. Nontussock sedge, dwarf-shrub, moss tundra

Moist tundra mainly in Subzone D on peaty nonacidic soils; also found in Subzones C and E. Frost boils (barren patches of cryoturbated soil) are common on silty soils ("spotted tundra" in the Russian literature). This is the zonal vegetation for much of Subzone D. Plant cover varies from 50 to100%. Plant heights are generally 10-20 cm. Hemiprostrate and erect shrubs, such as *Salix richardsonii, S. reptans, S. glauca, S. pulchra, S. krylovii* and *Rhododendron lapponicum*, are common but generally do not form a closed canopy, and some may grow up to 40 cm high at the southern Subzone D boundary. Low-shrub (40-200 cm tall) and some tall (>2 m) willow thickets occur along stream margins. Well-developed moss layers (5-20 cm thick) are common.
[illegible]

G4

G4. Tussock-sedge, dwarf-shrub, moss tundra

Moist tussock tundra, mainly in Subzones D and E, on cold acidic soils. This is the zonal vegetation in Subzone E on unglaciated landscapes with ice-rich permafrost and shallow active layers, e.g., northern Alaska and Chukotka. Plant cover is nearly continuous (80-100%). The height of the plant canopy varies from about 20 cm to 40 cm. A less robust form of tussock tundra grows in Subzone D, with smaller tussock sedges and less abundant and shorter shrubs that do no overtop the tussocks.
Dominant plants: Tussock sedges (*Eriophorum vaginatum, Carex lugens*) with other sedges (*Carex bigelowii/arctisibirica/consimilis, Eriophorum triste*), and prostrate and erect dwarf-shrubs (*Ledum decumbens, Betula nana/exilis, Salix pulchra, Vaccinium vitis-idaea, V. uliginosum* ssp. *microphyllum, Arctous alpina, Rubus chamaemorus, R. arcticus, Cornus suecica*), and mosses (*Sphagnum, Hylocomium splendens, Oncophorus wahlenbergii, Aulacomnium turgidum, Dicranum, Polytrichum*). Other common plants include grasses (*Arctagrostis latifolia*), forbs (*Pedicularis lapponica, P. labradorica, Bistorta plumosa, P. tripterocarpum, Saxifraga nelsoniana, Nardosmia frigida*), and lichens (*Flavocetraria, Cladina rangiferina, Cladonia amaurocraea, Ochrolechia frigida, Alectoria nigricans, Bryocaulon divergens*).
Representative syntaxa: *Sphagno-Eriophoretum vaginati* Walk. et al. 1994 (Alaska); *Carici arctisibiricae-Hylocomietum alaskani* vicariant of *Pinguicula villosa* Matv. 1994 (Taimyr Peninsula) (cf. *Ledo decumbentis-Betuletalia glandulosae* Rivas-Martinez et al. 1999).

[a] = acidic, [n] = nonacidic

Prostrate-shrub tundras

P1

P1. Prostrate dwarf-shrub, herb tundra

Dry tundra of the Middle Arctic (*sensu* Polunin 1951; polar semideserts of Bliss 1997). This is the zonal vegetation of Subzone B and also covers large dry areas in Subzone C. The vegetation is open or patchy (20-80% cover), with plants 5-10 cm tall. Vascular plants cover about 5-25%, lichens and mosses cover 30-60%. On nonacidic substrates of Subzone B the dominant zonal vegetation is *Dryas - Salix arctica* communities; on acidic substrates it is *Luzula - Salix arctica*.
Dominant plants: Prostrate dwarf-shrubs (*Dryas*[n], *Salix arctica, S. polaris, S. rotundifolia, S. phlebophylla*[a]) are dominant. Other common plants include sedges (*Eriophorum triste, Carex rupestris*[n]), rushes (*Luzula confusa*[a], *L. nivalis*[a], *Juncus biglumis*), grasses (*Alopecurus alpinus*[a] (Subzone B), *Deschampsia*), forbs, (*Saxifraga hirculus, S. caespitosa*[a], *S. oppositifolia*[n], *Novosieversia glacialis*[n], *Oxytropis*[n]), mosses (*Ditrichum flexicaule*[n], *Distichium*[n], *Sanionia uncinata, Encalypta, Pohlia, Polytrichum, Hylocomium splendens, Aulacomnium turgidum, Tomentypnum nitens*[n]), and lichens (*Thamnolia, Flavocetraria*). In Subzone C this vegetation is much richer in vascular species, particularly sedges, grasses, and forbs.
Representative syntaxa: Communities of the class *Carici-Kobresietea*, e.g., *Carici-Dryadetum integrifoliae* Dan. 1982 (Greenland, North America), and *Loiseleurio-Vaccinietea*, e.g., *Gymnomitrio-Loiseleurietum* Dan. 1982 (Greenland).

P2

P2. Prostrate/hemiprostrate dwarf-shrub tundra

Moist to dry tundra in acidic-bedrock portions of Subzone C where hemiprostrate dwarf-shrub (*Cassiope tetragona*) communities occupy a large portion of the landscape. In nonacidic areas *Cassiope* communities occur in sites with somewhat deeper than average winter snow cover. In acidic areas, *Cassiope* communities are dominant on zonal sites. This type is common on granite- and gneiss-bedrock of Svalbard, Greenland, Baffin Island, and Ellesmere Island. Plants cover 40 to 100% of the surface. The height of the plant canopy is 10-20 cm.
Dominant plants: Prostrate and hemiprostrate dwarf shrubs (*Cassiope tetragona, Dryas*[n], *Rhododendron lapponicum*[n], *Salix arctica, S. polaris*) and mosses (*Aulacomnium turgidum, Tomentypnum nitens*[n], *Hylocomium splendens, Sanionia uncinata, Polytrichum juniperinum*), rushes (*Luzula confusa*[a], *L. nivalis*[a]), forbs (*Oxyria digyna, Bistorta vivipara, Silene acaulis*) and lichens (*Peltigera aphthosa, Cetrariella delisei, Stereocaulon rivulorum, Solorina,* and *Thamnolia*).
Representative syntaxa: Communities of the class *Loiseleurio-Vaccinietea*, e.g., *Cassiopetum tetragonae* (Böch. 1933) Dan. 1982 (Greenland, noncarbonate soil) and *Carici-Kobresietea*, e.g., *Dryado-Cassiopetum tetragonae* (Fries 1913) Hadac 1946 (Svalbard).

Erect-shrub tundras

S1

S1. Erect dwarf-shrub tundra

Moist to dry tundra in Subzone D on acidic soils, dominated by hemiprostrate and erect dwarf shrubs less than 40 cm tall. This is the zonal vegetation in acidic and oceanic areas of Subzone D in Greenland and the Canadian Shield. Drier, lichen-rich dwarf-shrub tundras are common in many areas, e.g., the sandy soils of the Yamal and Gydan peninsulas in Russia, and in a matrix with lichen-covered bedrock on the Canadian mainland and Baffin Island. Plant cover is continuous (80-100%) on zonal sites to sparse (5-50%) on dry ridges.
Dominant plants: Dwarf-shrubs (*Betula nana/exilis, B. glandulosa, Vaccinium uliginosum* ssp. *microphyllum, V. vitis-idaea, Ledum palustre* spp. *decumbens, Empetrum, Salix glauca, S. callicarpaea, Arctous, Cassiope tetragona*). Mosses (*Hylocomium splendens, Aulacomnium turgidum, Dicranum, Racomitrium lanuginosum*) and lichens (*Stereocaulon, Cladonia, Flavocetraria, Alectoria ochroleuca, Masonhalea richardsonii, Bryocaulon divergens*) are common.
Representative syntaxa: Communities of the class *Loiseleurio-Vaccinietea, Phyllodoco-Vaccinion myrtilli* Nordh. 1936, e.g., *Phyllodoco-Salicetum callicarpaeae* (Böch. 1933) Dan. 1982 and *Empetrum-Vaccinium* community Dan. 1982 (Greenland).

S2

S2. Low-shrub tundra

Moist tundra in Subzone E dominated by low shrubs greater than 40 cm tall sometimes on permafrost-free soils. Peatlands with permafrost are common in wet areas. This highly variable unit includes some areas with scattered *Pinus pumila* "stlaniks" in the Anadyr-Penzhina subprovince, but excludes areas of continuous stlaniks.
Dominant plants: Upland areas have mainly oligotrophic hypoarctic shrubs (e.g., *Betula nana/exilis, B. middendorffii/glandulosa, Spiraea* [illegible]

Wetlands

W1

W1. Sedge/grass, moss wetland

[illegible]

W2

W2. Sedge, moss, dwarf-shrub wetland

[illegible]

W3

W3. Sedge, moss, low-shrub wetland

[illegible]

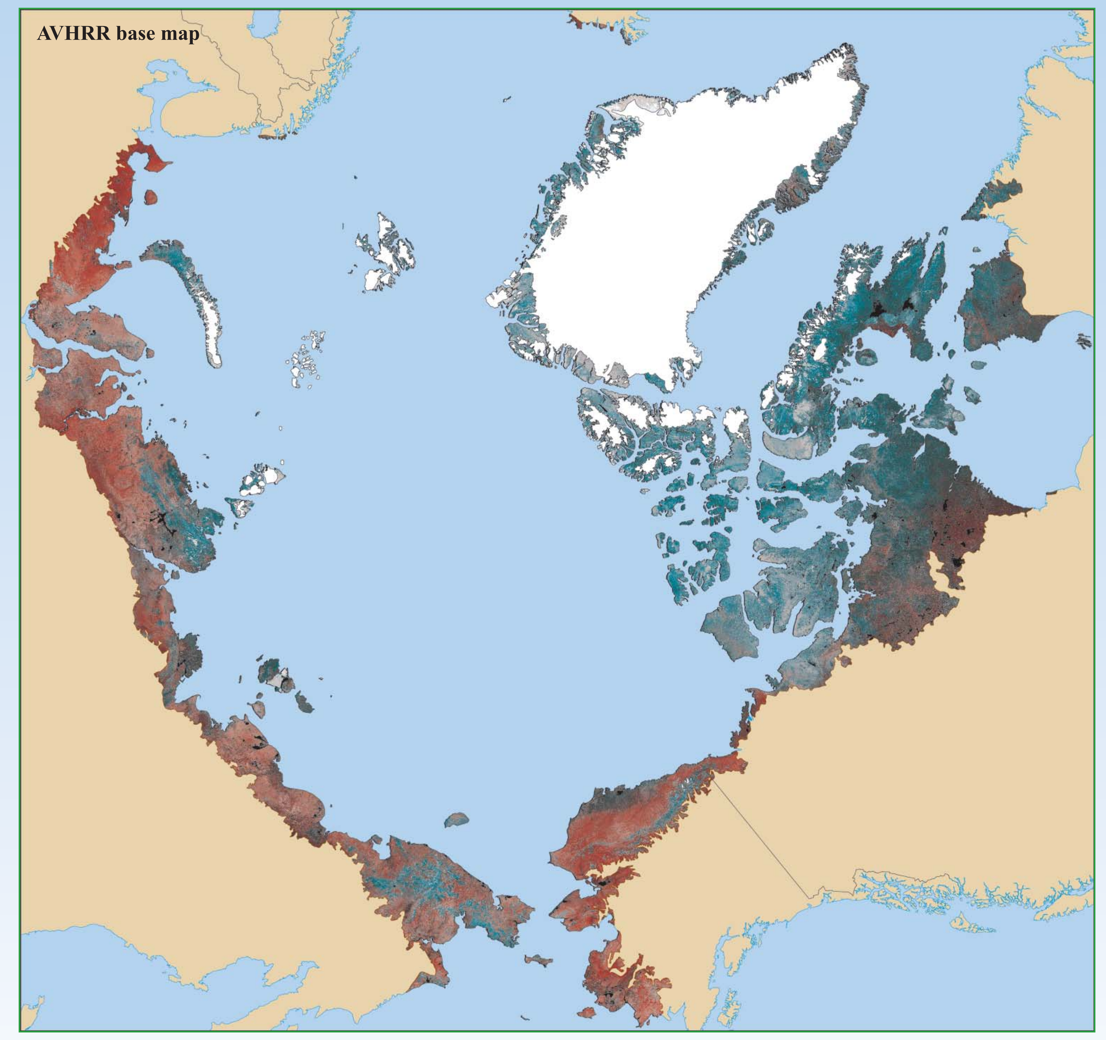
Making the Circumpolar Arctic Vegetation Map

The idea of the Circumpolar Arctic Vegetation Map (CAVM) originated at the Arctic Vegetation Classification Workshop in Boulder, Colorado, in 1992 (Walker et al. 1995). A map of arctic vegetation with a unified legend was needed for global and regional computer models of climate change, land-use planning, conservation studies, resource development, and education. Scientists from Russia, Norway, Iceland, Greenland, Canada and the United States (see other side) collaborated on the map (Walker et al. 2002).

The map on the front side portrays the vegetation based on the dominant plant growth forms. A false color-infrared (CIR) image of Advanced Very High Resolution Radiometer (AVHRR) data (at right) was used as a base map for drawing map polygons on a 1:4 million-scale Lambert's azimuthal equal area projection. The image is composed of 1 x 1-km picture elements (pixels). The color of each pixel was determined by its reflectance at the time of maximum greenness, selected from biweekly images from 1 April to 31 October in 1993 and 1995. These periods cover the vegetation green-up-to-senescence period during two relatively warm years when summer-snow cover was at a minimum in the Arctic. The resulting image shows the Arctic with minimum snow and cloud cover. Reddish areas represent greater amounts of green vegetation; blue and gray areas represent sparse vegetation; black areas represent fresh water, and white areas represent ice. Most boundaries on the vegetation map correspond to features that can be seen on the image when it is enlarged to 1:4 million scale. The image data were obtained from the USGS Alaska Geographic Science Office. Glaciers and oceans were masked out by using information from the *Digital Chart of the World* (ESRI 1993).

Key environmental and biological factors control the plant communities that can grow across the Arctic. The most important environmental control in the Arctic is summer temperature. Temperature data and vegetation data together define bioclimate subzones (see Bioclimate subzone map). Topographic information (see Elevation map) and landscape maps were used to define landscape units (see Landscape map). Lake cover was calculated from the AVHRR image (see Lake cover map). Bedrock geology and surface geology were used to determine the general chemistry of the substrate on which plant communities grow (see Substrate pH map). East-west variations in species distribution were defined by floristic provinces (see Floristic provinces map). Plant biomass was estimated from the normalized difference vegetation index (NDVI) (see Aboveground plant biomass map). All of these factors were combined to determine the type of vegetation found in a polygon. The map polygon boundaries combine the terrain information and follow features visible on the 1:4 million AVHRR base image. The polygons have a minimum size of 14 km diameter (8 km for linear features).

Polygons at this scale contain many vegetation types. Common dry, moist, wet, snowbed and riparian plant communities (Figure 1) were described for each bioclimate subzone and floristic region. Generally, the dominant zonal vegetation was mapped. Zonal sites are areas where the vegetation develops under the prevailing climate, uninfluenced by extremes of soil moisture, snow, soil chemistry, or disturbance. Zonal sites are flat or gently sloping, moderately drained, with fine-grained soils. The vegetation of extensive nonzonal areas such as mountain ranges, large wetlands, and river systems was also mapped.



Color representations described in text at left.

Bioclimate Zonation

As one moves from north to south across the Arctic, the amount of warmth available for plant growth increases. The mean July temperatures are near 0°C on the northernmost islands. At these temperatures, plants are at their metabolic limits, and small differences in the total amount of summer warmth make large differences in the amount of energy available for maintenance, growth, and reproduction. Warmer summer temperatures cause the size, horizontal cover, abundance, productivity, and variety of plants to increase (Table 1). Woody plants and sedges are absent in Subzone A, where mean July temperatures are less than 3°C. Woody plants first occur in Subzone B (mean July temperatures about 3-5° C) as prostrate (creeping) dwarf shrubs, and increase in stature to hemiprostrate dwarf shrubs (<15 cm tall) in Subzone C (mean July temperatures about 5-7°C), erect dwarf shrubs (<40 cm tall) in Subzone D (mean July temperature about 7-9°C), and low shrubs (40-200 cm tall) in Subzone E (mean July temperature about 9-12°C). At treeline, where the mean July temperatures are between 10 and 12°C, woody shrubs up to 2 m tall are abundant. The number of plants in local floras available to form plant communities increases from fewer than 50 species in the coldest parts of the Arctic to as many as 500 species near treeline. A fundamental problem in creating the map was how to characterize the transitions in vegetation that occur across the roughly 10°C difference in mean July temperature. Different geobotanical traditions have divided the Arctic into bioclimatic regions using a variety of terminologies (Table 2). The origins of these different terms and approaches have been reviewed for the Panarctic Flora (PAF) Initiative. The PAF and CAVM have accepted the five-subzone approach used here (Elvebakk et al. 1999).

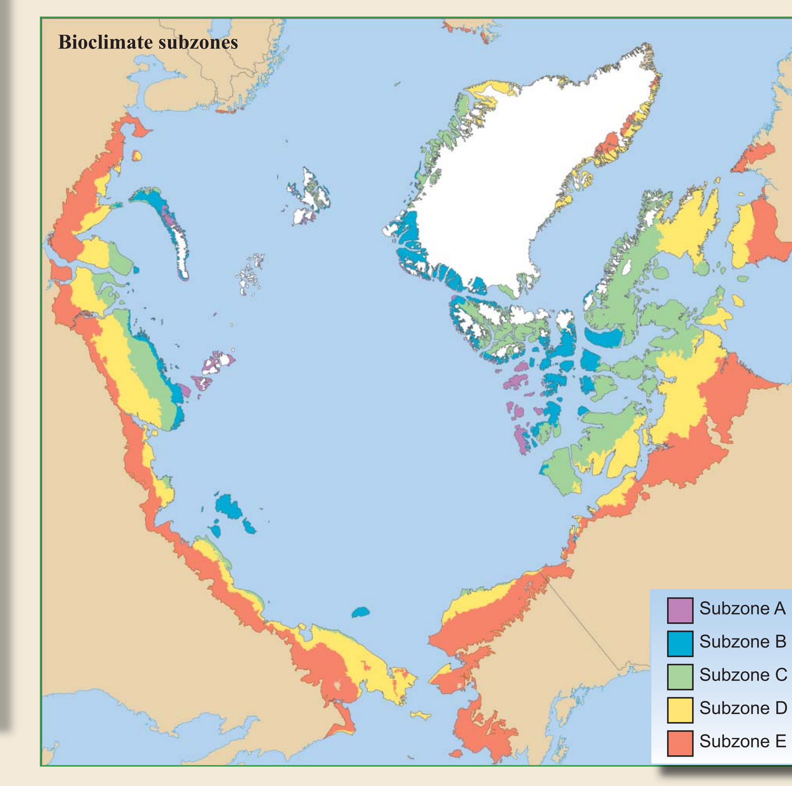


Table 1. Vegetation properties in each bioclimate subzone

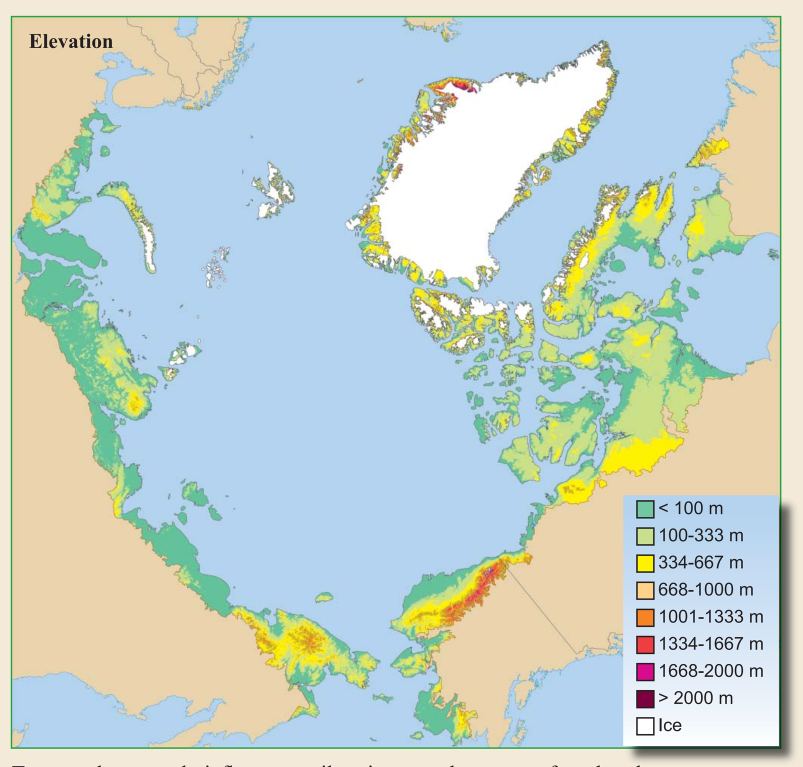
Subzone	Mean July temp[1] (°C)	Summer warmth index[2] (°C)	Vertical structure of plant cover[3]	Horizontal structure of plant cover[3]	Major plant growth forms[4]	Dominant vegetation unit (see Detailed Vegetation Descriptions for species)	Total phyto-mass[5] ($t\ ha^{-1}$)	Net annual production[6] ($t\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

[1] Based on Edlund (1990) and Matveyeva (1998).
[2] Sum of mean monthly temperatures greater than 0°C, modified from Young (1971).
[3] Chernov and Matveyeva (1997).
[4] b - barren; c - cryptogam; cf - cushion or rosette forb; deds - deciduous erect dwarf shrub; dls - deciduous low shrub; dpds - deciduous prostrate dwarf shrub; g - grass; ehds - evergreen hemiprostrate dwarf shrub; nb - nonsphagnoid bryophyte; neds - nondeciduous erect dwarf shrub; npds - nondeciduous prostrate dwarf shrub; ns - nontussock sedge; of - other forb; ol - other lichen; r - rush; rl - reindeer lichen; sb - sphagnoid bryophyte; ts - tussock sedge. Underlined codes are dominant.
[5] Based on Bazilevich et al. (1997), aboveground + belowground, live + dead.
[6] Based on Bazilevich et al. (1997), aboveground + belowground.
[7] Number of vascular species in local floras based mainly on Young (1971).

Table 2. Other bioclimate zonation approaches

	Russia			North America					Fennoscandia	
CAVM Subzone	Alexandrova (1980)	Yurtsev (1994)	Matveyeva (1998)	Polunin (1951)	Edlund (1990) Edlund and Alt (1989)	Bliss (1997)	Daniëls et al. (2000)	Walker et al. (2002)	Tuhkanen (1986)	Elvebakk et al. (1999)
A	Northern polar desert / Southern polar desert	High Arctic tundra	Polar desert	High Arctic	Herbaceous and cryptogam	High Arctic	Arctic herb	Cushion forb	Inner polar / Outer polar	Arctic polar desert
B	Northern Arctic tundra	Arctic tundra: northern variant	Arctic tundra	Middle Arctic	Herb-prostrate shrub transition / Prostrate shrub		Northern Arctic dwarf shrub	Prostrate dwarf shrub	Northern Arctic	Northern Arctic tundra
C	Middle Arctic tundra / Southern Arctic tundra	Arctic tundra: southern variant	Typical tundra		Dwarf and prostrate shrub		Middle Arctic dwarf shrub	Hemi-prostrate dwarf shrub	Middle Arctic	Middle Arctic tundra
D	Northern sub-Arctic tundra / Middle sub-Arctic tundra	Northern hypo-Arctic tundra		Low Arctic	Low erect shrub	Low Arctic	Southern Arctic dwarf shrub	Erect dwarf shrub	Southern Arctic	Southern Arctic tundra
E	Southern sub-Arctic tundra	Southern hypo-Arctic tundra	Southern tundra				Arctic shrub	Low shrub		Arctic shrub-tundra

Topography



Topography strongly influences soil moisture and patterns of tundra plant communities. The topography map was divided into 333-m elevation intervals to show approximate 2°C temperature shifts in the mountainous areas (see explanation of elevation zonation in Figure 2). Areas below 100 m are separated to show low elevation plains. Data are at approximately 1 km spacing, taken from the GTOPO30 global digital elevation model (DEM) (Gesch et al. 1999). The landscape map was based on topographic data and regional landscape maps.

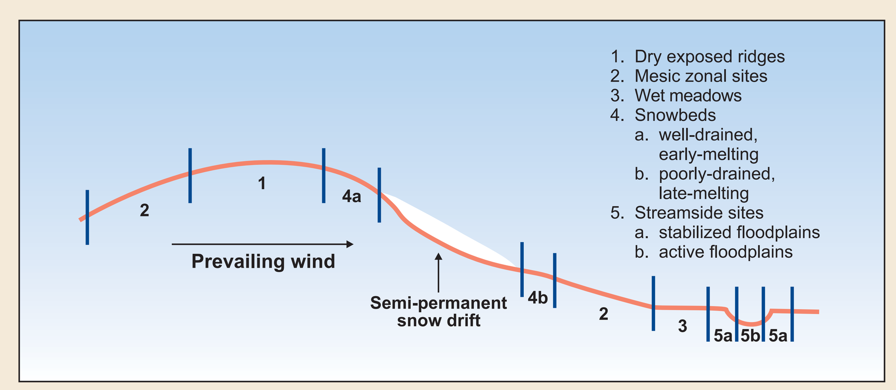
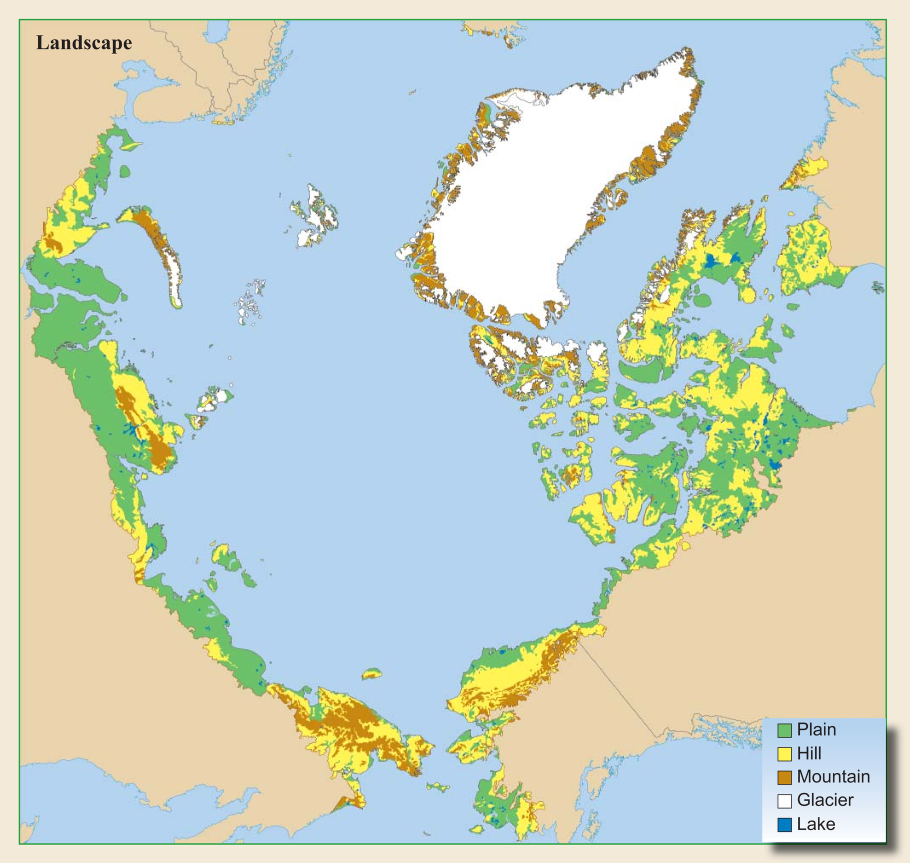
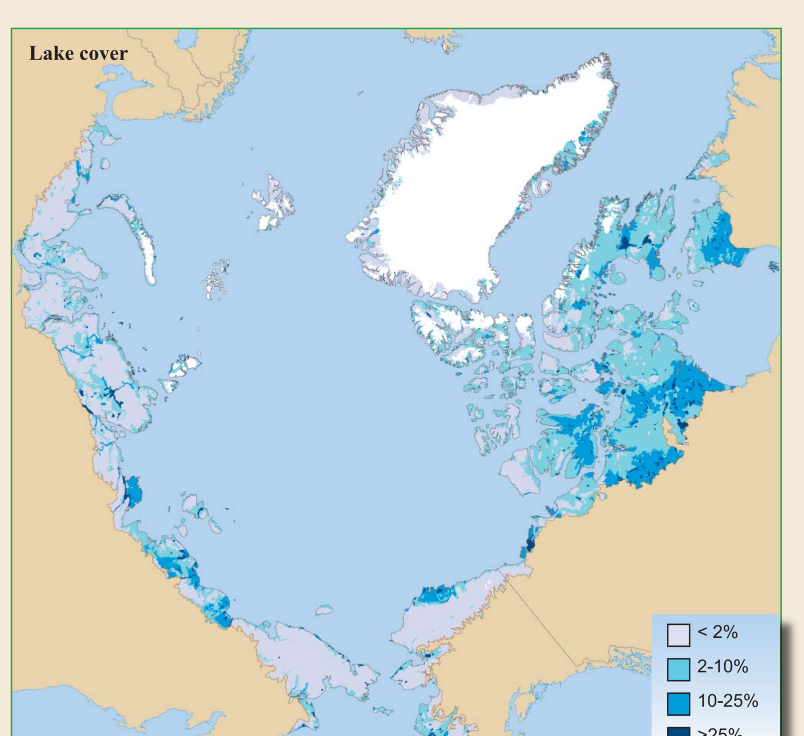


Figure 1. Local topography
Small-scale variations in topography determine the patterns of plant communities that exist within each polygon, though these fine-scale patterns are too small to portray on the map. This idealized mesotopographic gradient shows five microsites commonly found in arctic landscapes. Information regarding the plant communities typically found in these microsites was summarized in tables for each combination of bioclimate subzone and floristic region. This information then formed the underlying database for the map (Walker et al. 2002).





Lake cover strongly affects the albedo, or reflectance, of the land surface over large areas of the Arctic and is useful for delineating extensive wetlands. Lake cover was based on the number of AVHRR water pixels in each mapped polygon, divided by the total number of pixels in the polygon. Since the imagery has a pixel size of 1 km^2, lake cover is underestimated for areas with many small lakes. No pixels were sampled within two pixels (2 km) of the coastline to avoid including ocean pixels.

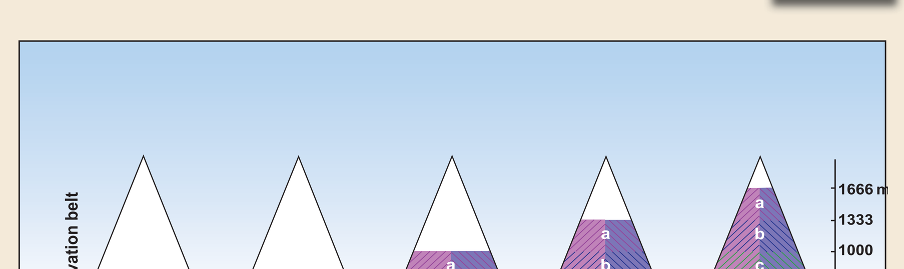
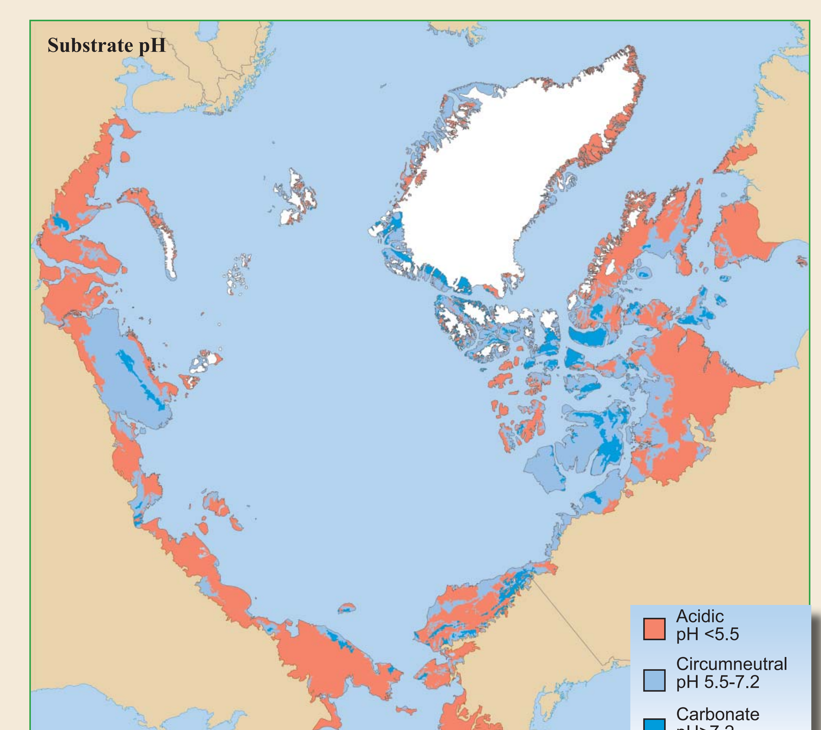


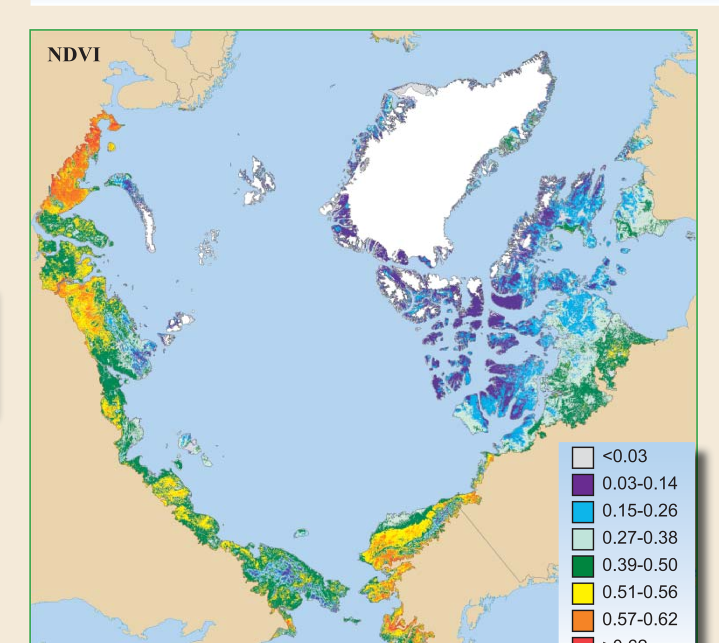
Figure 2. Elevation zonation
Vegetation in mountainous regions changes with elevation, forming distinctive elevational belts which correspond approximately to the bioclimatic subzones. For every 333-m elevation gain, the mean July temperature decreases by about 2°C, as predicted by the adiabatic lapse rate of 6°C per 1000 m. Since only one elevational belt can be represented on each polygon, the color of the lowest belt was used for the polygon, though higher elevational belts may exist in that polygon. Mountain complexes were mapped by using a diagonal hatch pattern. The background color and the orientation of the hatching represent the pH of the dominant bedrock (noncarbonate bedrock - mainly sandstone and granite vs. carbonate bedrock such as limestone and dolomite). The color of the hatching represents the bioclimate subzone. As shown in Figure 2, a mountain in Subzone E could have six elevation belts (if the mountain is high enough). The lowest belt, Belt e is dominated by low-shrub tundra (S2); the next higher belt, Belt d has erect dwarf-shrub tundra (S1); Belt c has prostrate dwarf-shrub, herb tundra (P1); Belt b has rush/grass, forb, cryptogam tundra (G1); Belt a has cryptogam, herb barrens (B1); and the nival belt is snow and ice covered (see Detailed Vegetation Descriptions B3 and B4 at left for community descriptions). Vegetation is modified by local topographic effects such as slope, aspect, and cold-air drainage.

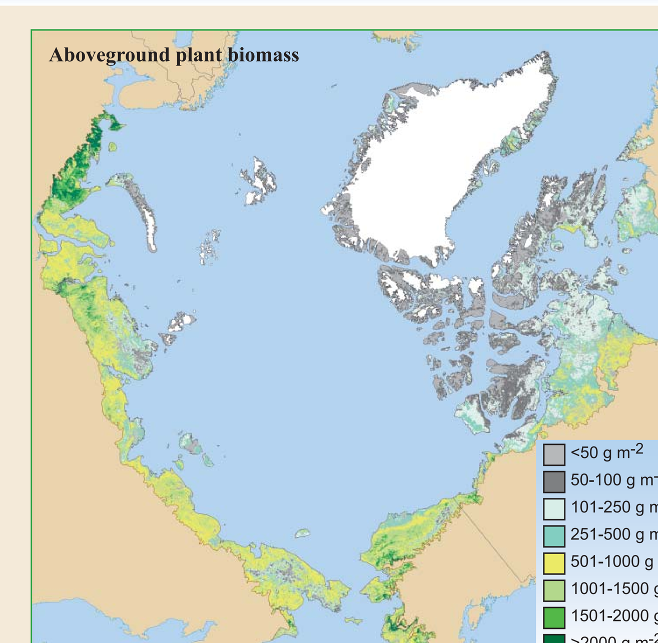
Substrate Chemistry



Differences in substrate chemistry have important effects on dominant plant communities. Some of the most important effects are related to soil pH, which governs the availability of essential plant nutrients. Soils in the circumneutral range (pH 5.5-7.2) are generally mineral rich, whereas the full suite of essential nutrients is often unavailable in acidic soils (pH < 5.5) or in soils associated with calcareous bedrock (pH > 7.2). The latter often have unique assemblages of endemic plant species. There are no common base maps that show this essential difference in substrate chemistry, so the map shown here was derived from a wide variety of available sources including soil, surficial geology, and bedrock geology maps, and from spectral patterns that could be recognized on the AVHRR base image.

Plant Biomass





The normalized difference vegetation index (NDVI) shows relative maximum greenness. This image was created from the same data as the AVHRR base image. Vegetation greenness is calculated as: NDVI = (NIR – R)/(NIR + R), where NIR is the spectral reflectance in the AVHRR near-infrared channel (0.725-1.1 μm) where light-reflectance from the plant canopy is dominant, and R is the reflectance in the red channel (0.5 to 0.68 μm), the portion of the spectrum where chlorophyll absorbs maximally. The NDVI values were grouped into eight classes that meaningfully separate the vegetation according to biomass. Red and orange areas in the NDVI map on the left are areas of shrubby vegetation with high biomass, and blue and purple areas are areas with low biomass.

The relationship between NDVI and aboveground plant biomass was calculated from clip harvest data (Figure 3). The aboveground plant biomass map was created by applying this regression equation to the AVHRR data (Walker et al. 2003). Both the NDVI and the biomass maps aided in the delineation of the vegetation units on the front side.

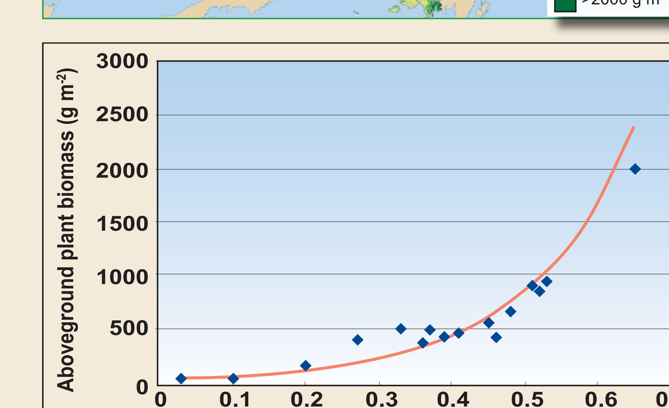
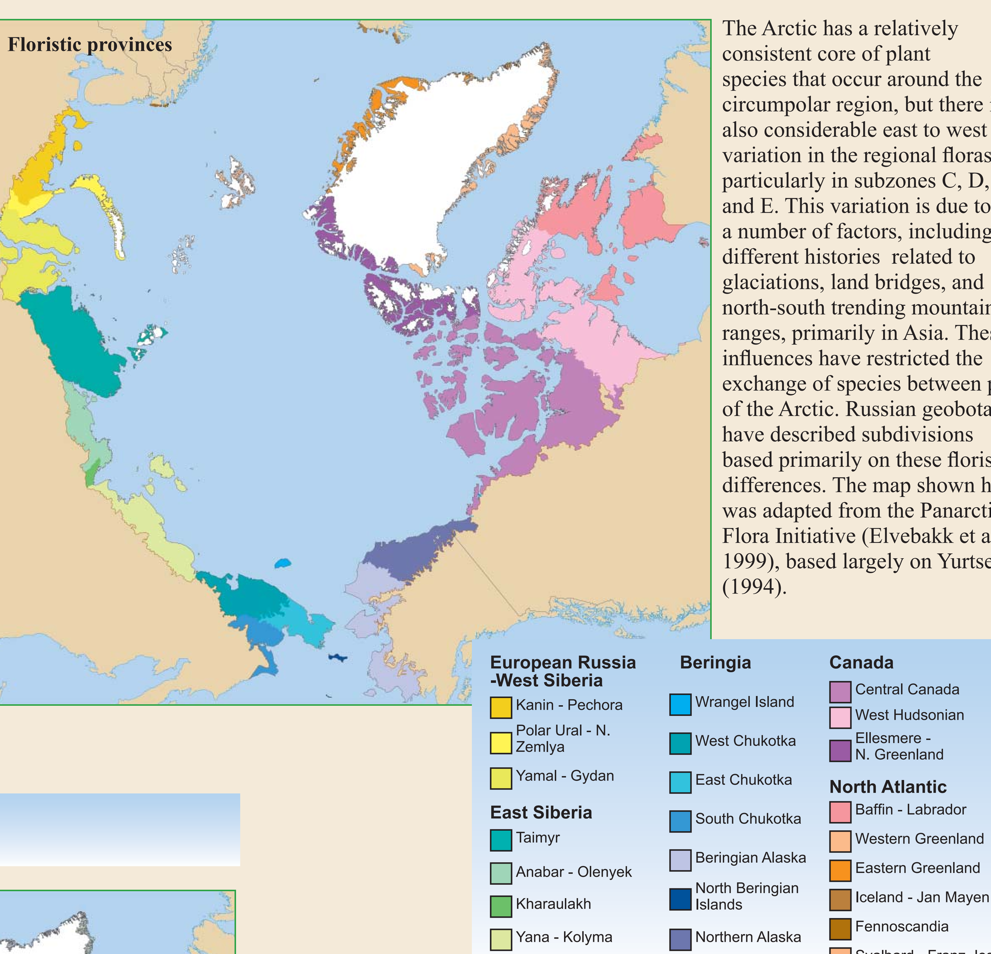


Figure 3. Aboveground plant biomass vs. NDVI.

Floristic Variation



The Arctic has a relatively consistent core of plant species that occur around the circumpolar region, but there is also considerable east to west variation in the regional floras, particularly in subzones C, D, and E. This variation is due to a number of factors, including different histories related to glaciations, land bridges, and north-south trending mountain ranges, primarily in Asia. These influences have restricted the exchange of species between parts of the Arctic. Russian geobotanists have described subdivisions based primarily on these floristic differences. The map shown here was adapted from the Panarctic Flora Initiative (Elvebakk et al. 1999), based largely on Yurtsev (1994).

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