Legacy IPY Hierarchic GIS Database for the Arctic Observatory at Toolik Lake

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Abstract

The Arctic Geobotanical Atlas (AGA) is a web-based multi-scale GIS database that focuses on the research sites at the Toolik Lake Field Station (Fig. 1), and also covers the Kuparuk River Basin, northern Alaska, Arctic Alaska, and the Circumpolar Arctic – 7 scales in all (Fig. 2).

The map themes, legends, and colors are consistent across scales. The maps can be viewed by a variety of tools to enhance downloading, and use of the maps, including PDF versions, downloads of the GIS databases, and various viewing options including the GINA SwathViewer, GINA Map Server, and EarthSLOT software.

The AGA is part of a regional GIS node at the University of Alaska Fairbanks (UAF) and a circum-Arctic GIS network. The site is in progress and currently includes maps covering the circumpolar Arctic, and arctic Alaska. This poster shows the latest addition to the hierarchy of maps – The vegetation of the Upper Kuparuk River Region and Toolik Lake Alaska. Inset maps contain the satellite image and maps of glacial geology, surficial geology, and NDVI/Biomass. It is anticipated that the hierarchy of maps for Toolik Lake will be completed in 2007.

Toolik Lake is an Arctic Observatory of the United States Arctic Research program during the International Polar Year (IPY, 2007-2008). The AGA is an IPY legacy dataset for future research and monitoring in the Toolik Lake region. Future use of the maps and data products are key to several ongoing and proposed IPY projects. The AGA is one of the primary outreach and education components for the Greening of the Arctic (GOA) IPY initiative.

The maps and website (www.arcticatlas.org) are being developed at the Alaska Geobotany Center in collaboration with other groups at the University of Alaska Fairbanks, including the Toolik Field Station, the Geographic Information Network of Alaska (GINA), and the Water and Environmental Research Center (WERC). Funding was provided by National Science Foundation (ARC-0425517). The Alaska Geobotany Center is located within the Institute of Arctic Biology, University of Alaska Fairbanks, www.iab.uaf.edu.

Fig. 1. Toolik Lake Field Station in the Foothills of the Brooks Range, Alaska. Photo courtesy of IARC Photo Gallery. Photographer: J. Cherry.

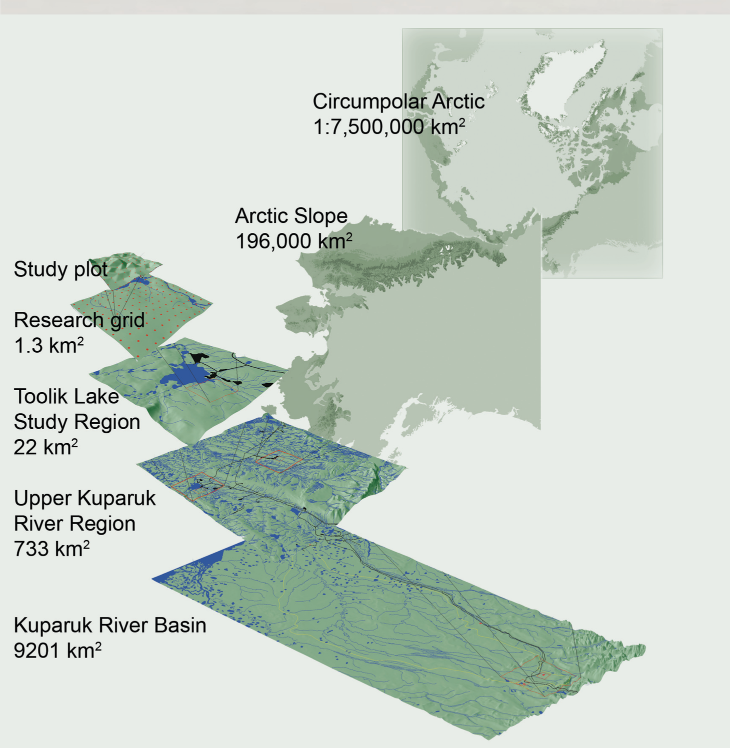

Fig. 2. Hierarchy of digital terrain models of the Arctic Geobotanical Atlas.

Vegetation of the Upper Kuparuk River Region and Toolik Lake, Alaska

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Web site: http://www.geobotany.uaf.edu/

Explanation

The series of maps on the front side of this sheet portrays the vegetation and important related geobotanical factors within the 750 km^2 upper Kuparuk River region. The reverse side shows more detailed maps of the 22 km^2 area centered on Toolik Lake and a 1.3 km^2 intensive research grid on the south side of the lake. The major research areas at Toolik Lake and Imnavait Creek are shown by the red boundaries on Map A.

The mapping process
Vegetation and other geobotanical features were mapped using a combination of field information and photo-interpretation. The upper Kuparuk River region (Maps A-E) was mapped in 1994; the Toolik Lake region was made in 1989 (Map F); and the Toolik Lake grid (Map G) was mapped in 1990. Helicopter-assisted transects were used to visit 320 polygons in the Upper Kuparuk River region (which correspond to 3.2% of the total map polygons (16% of the total map area). Walking transects were used to visit most of the map polygons on both of the Toolik Lake maps. The integrated terrain unit mapping (ITUM) method was used for all maps (Walker et al. 1980, Walker et al. 1986, Walker et al. 1989, Dangermond and Harnden 1990). Geobotanical variables coded for each map polygon in the Upper Kuparuk River region include: primary vegetation, secondary vegetation, tertiary vegetation (secondary and tertiary units were recorded if they covered more than 30% of a map polygon) landform, surface deposit, primary surficial geomorphology, and secondary surficial geomorphology.

Vegetation (Map A)
The vegetation of the region was studied and mapped as part of the Arctic Long-Term Ecological Research (LTER) project at Toolik Lake (Walker et al. 1994, Walker and Walker 1996), and the Department of Energy R4D (Response, Resistance, Resilience and Recovery of vegetation from Disturbance) project at Imnavait Creek (Walker and Walker 1996). Fifty plant communities and land-cover types were recognized during the mapping of the upper Kuparuk River region and are designated by the numeric GIS codes in the second column of the legend. These were grouped into the 16 physiognomic map units shown on Map A. The legend and color schemes have been standardized and are compatible with the Circumpolar Arctic Vegetation Map (CAVM Team et al. 2003)and the Alaska Arctic Tundra Vegetation Map (Raynolds et al. 2005) which will aid efforts to extrapolate plot-based research to broader regions.

False-color Infrared Image (Map B)
The false-color infrared image provides a view of the mapped region from space. This image was taken by the French SPOT (Système Probatoire d'Observation de la Terre) satellite on 28 July 1989. This image was also used to produce the NDVI/biomass map (Map E).

Glacial Geology (Map C)
The glacial history of the region has major consequences to a wide variety ecosystem properties including plant production, spectral reflectance, biodiversity, trace gas fluxes, heat flux of these landscapes. The map shown here is a simplified version of Thomas Hamilton's glacial geology map of the upper Kuparuk River region (Hamilton 2003). Glacial deposits within the Upper Kuparuk River region are assigned to Sagavanirktok (middle Pleistocene, about 780-125 ka), Itkillik I (late Pleistocene, about 120- 50 ka, and Itkillik II (late Pleistocene, about 25-11.5 ka) glaciations of the central Brooks Range glacial succession (Hamilton 2003).

Surficial Geomorphology (Map D)
The surfaces of the landscapes in the Toolik Lake region have been modified by a variety of geomorphological processes including alluviation (movement of material by water), colluviation (movement of material by gravity), and periglacial processes (freezing and permafrost-related phenomena). Many of the surface forms have been described for the Imnavait Creek region (Walker and Walker 1996). An expanded version of the legend can be found on the web site http://www.arcticatlas.org/. Common surficial geomorphological features within the mapped area include sorted and nonsorted circles (frost boils), turf hummocks, gelifluction lobes and terraces, water tracks, high- and low-centered ice-wedge polygons, wetland features (strangmoor, aligned hummocks, palsas), and thermokarst features.

NDVI and Plant Biomass (Map E)
The Normalized Difference Vegetation Index (NDVI) is an index of vegetation greenness that can be linked to plant biomass and other properties of the vegetation. The relationship between NDVI and plant biomass was calculated from ground measurements of NDVI and clip harvest data at the same points. The NDVI/Biomass map was derived from the SPOT image (Map B). The image and legend are revised somewhat from an earlier map (Shippert et al. 1995). The NDVI = (IR – R)/(IR + R), where NIR is the specral reflectance in the SPOT near infrared channel (790-890 nm) and R is the reflectance in the red channel (610-680 nm).

Maps on the reverse side (Maps F and G)
The vegetation of the Toolik Lake region and the Toolik Lake grid are on the backside of this map. The map units for the Toolik Lake region are at the physiognomic level – essentially the same as those for the upper Kuparuk River region. The map units for the Toolik Lake grid are at the plant community level. The GIS numbering scheme for the map units is unique to each map. Maps of the landforms, surficial geomorphology, lake cover and photos of the various map units, and plant species can be found on the web site of the *Arctic Geobotanical Atlas*, http://www.arcticatlas.org/.

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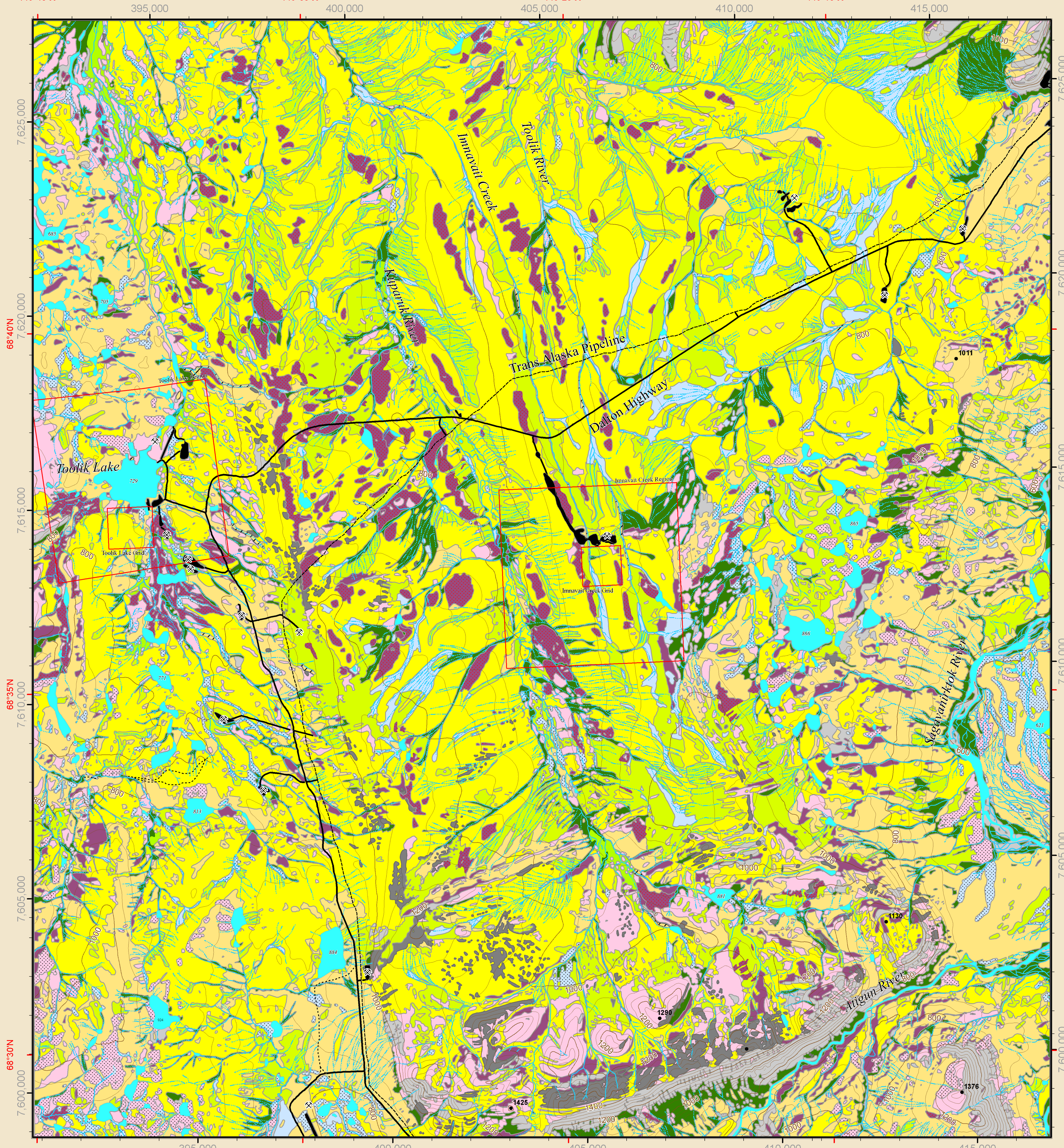
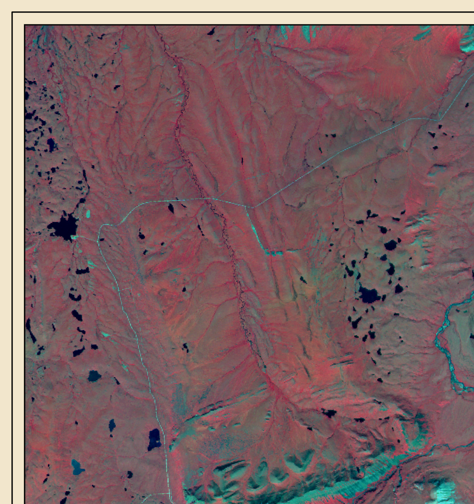
A: Vegetation

Physiognomy	Plant communities (GIS codes)	Typical Microsites	Ha	% of Map
Barrens				
1. Barren and disturbed	Roads, gravel pads, and pipeline pads. (Area measurements are not included in total area for natural vegetation.)	Barren roads, airstrips, and pads.	270	0.36
2. Lichens on rocks	Lichen communities on rocks, including *Cetraria nigricans-Rhizocarpon geographicum* (12).	Bedrock and xeric blockfields.	1,009	1.3
3. Partially vegetated barrens	Complexes of vegetation with rock or soil on scree slopes (11), river gravels and other barrens (14), partially vegetated alpine areas (13), and areas dominated by non-sorted circles (15). Dominant plant communities include: *Saxifraga oppositifolia-Saxifraga eschscholtzii* (131); *Epilobium latifolium-Castilleja caudata* (141); revegetated gravel pads with *Festuca rubra* (142); *Anthelia juratzkana-Juncus biglumis* (15).	Partially vegetated barrens.	1,805	2.4
Moist graminoid tundras				
4. Tussock-sedge, dwarf-shrub, moss tundra	Moist acidic tussock-tundra complexes (31, 311). Dominant plant communities include *Eriophorum vaginatum-Sphagnum* (31) and *Carex bigelowii-Sphagnum* (3111).	Mesic to subhygric, stable, acidic sites with shallow to moderate snow.	29,029	38.7
5. Nontussock-sedge, dwarf-shrub, moss tundra	Moist nonacidic tundra complexes (32). Dominant plant communities include *Carex bigelowii-Dryas integrifolia* (321) and subtypes dominated by *Equisetum arvense* (322), *Salix glauca* (324) and *Cassiope tetragona* (no code); *Eriophorum vaginatum-Tomentypnum nitens* (323) and *Carex bigelowii-Sphagnum*, subtype *Cassiope tetragona* (3113).	Mesic to subhygric, circumneutral sites with shallow to moderate snow.	12,963	17.3
6. Miscellaneous graminoid, dwarf-shrub, forb communities	Various graminoid dominated communities on disturbances including those on landslides and thermokarst areas, and drained lake basins. Dominant plant communities include *Festuca altaica-Poa glauca* (Disturbed thermokarst areas) (325); *Deschampsia caespitosa-Carex saxatilis* (drained lakes) (326); and *Carex podocarpa-Salix chamissonis* (snowy streamsides) (515).	Miscellaneous sites including deep-snow stream margins, landslides, and some rocky drained lake basins.	192	0.3
Wet graminoid tundras and water				
7. Sedge, moss tundra (poor fens)	Poor fen wetland complexes (41). Dominant plant communities include: Lower microsties: *Eriophorum scheuchzeri-Sphagnum orientale* (412) and *Eriophorum angustifolium-Sphagnum* (413). Raised microsites: *Sphagnum lenense-Salix fuscescens* (411).	Subhydric to hydric, meadows, ponds, acidic poor fens (pH <4.5) in colluvial basins.	1,934	2.6
8. Sedge, moss tundra (fens)	Rich fen wetland complexes (4, 42). Dominant plant communities include: Lower microsites: *Carex aquatilis-Carex chordorrhiza* (422) and *Eriophorum angustifolium-Carex aquatilis* (423). Raised microsites: *Trichophorum caespitosum-Tomentypnum nitens* (421) and *Carex bigelowii-Tomentypnum nitens*.	Subhydric to hydric, water tracks, stream margins, fens (pH>4.5), flarks on solifuluction slopes.	1,158	1.5
9. Water and deep-water herbaceous marsh	Water (6) and aquatic vegetation in deeper water. Dominant plant communities include *Arctophila fulva-Hippuris vulgaris* and *Sparganium hyperboreum-Hippuris vulgaris* (43).	Hydric, lakes, ponds and streams.	1,595	2.1
Prostrate-shrub tundras				
10. Prostrate dwarf-shrub, forb, fruticose-lichen tundra (acidic)	Dry acidic tundra complexes (21). Dominant plant communities include *Dryas octopetala-Selaginella sibirica* (211), *Arctous alpina-Salix phlebophylla* (212); lichen tundra *Cladonia arbuscula-Stereocaulon tomentosum* (215).	Xeric to xeromesic, acidic, wind blown, no to shallow winter snow cover. Ridge tops, exposed slopes, dry river terraces.	5,820	7.8
11. Prostrate dwarf-shrub, sedge, forb, fruticose – lichen tundra (nonacidic)	Dry nonacidic tundra complexes. *Dryas integrifolia-Oxytropis nigrescens* (24), *Dryas integrifolia-Astragalus umbellatus* (22).	Xeromesic to mesic nonacidic soils on collluvium or recent alluvium, wind-blown to shallow winter snow cover. Slopes, non-sorted stripes, and river terraces.	895	1.2
12. Hemi-prostrate dwarf-shrub, fruticose-lichen tundra	Snowbed complexes (23). Dominant plant communities include *Cassiope tetragona-Carex microchaeta* (231); *Cassiope tetragona-Dryas integrifolia* (232); *Salix rotundifolia-Sanionia uncinatus* (233).	Subxeric to mesic, acidic to nonacidic snowbeds.	2,164	2.9
13. Hemi-prostrate and prostrate dwarf-shrub, forb, moss, fruticose-lichen tundra	Dry tundra with shallow snowbeds. Dominant plant communities include *Cassiope tetragona-Calamagrostis inexpansa* (214). Also includes dry areas with hemi-prostrate birch *Betula nana-Hierochloe alpina* (213).	Subxeric to mesic, acidic to nonacidic, shallow snowbeds. Acidic ridge crests, non-sorted stripes (214), dry glacial till, and outwash (213).	2,116	2.8
Erect-shrub tundras				
14. Dwarf-shrub, sedge, moss tundra	Moist acidic tundra complexes dominated by shrubs (shrubby tussock tundra) (3112). Dominant plant communities include *Betula nana-Eriophorum vaginatum* (312), and *Salix pulchra-Carex bigelowii* (no code).	Mesic to subhygric, moderate snow, lower slopes.	8,445	11.2
15. Dwarf- to low-shrub, moss tundra	Shrub tundra dominated by dwarf birch or willows. Dominant plant communities include *Betula nana-Rubus chamaemorus* and *Salix pulchra-Sphagnum* (513).	Subhygric, moderate snow, margins of upland water tracks, palsas, high-centered polygons.	601	0.8
16. Low to tall shrublands	Shrublands dominated by low and tall shrubs (5) including: 1. Shrublands along streams and water tracks dominated by diamond-leaf willow (*Salix pulchra*) where the dominate plant communities include *Salix pulchra-Eriophorum angustifolium* (511) and *Salix pulchra-Calamagrostis canadensis* (514). 2. Shrublands in riparian complexes (51) dominated by feltleaf willow (*S. alaxensis*), and lanate willow (*S. lanata*) (512); includes tall shrublands (5121) and low shrublands (5122). 3. Upland shrublands dominated by glaucous willow (*Salix glauca*) or alder (*Alnus crispa*) (52).	Stream margins upland water tracks, and south-facing slopes, mesic to subhydric, often with deep snow.	5,344	7.1
		Total	75,070	100

Gravel Mines
200 m contours
50 m contours
Roads
Pipeline
Trails
Streams
Water tracks

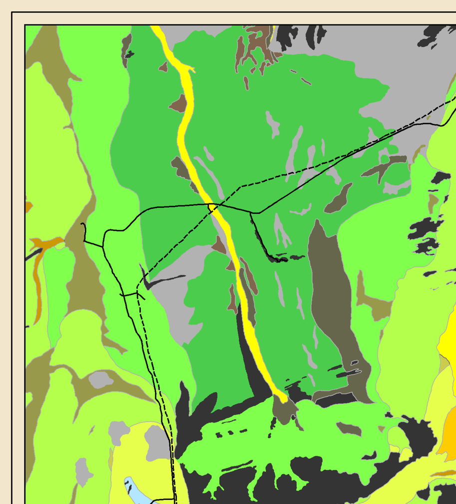


B: False Color Infrared Image



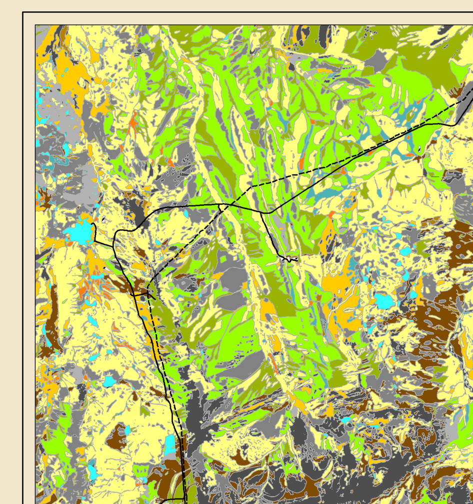
Interpretation:
Black: Water and shadows.
Blue: Turbid water.
Dark Gray: Bedrock, mostly sandstones and conglomerates.
Bluish Gray: Limestone, river gravels, and roads.
Grayish Red: Dry tundra, nonacidic tundra, and wetlands.
Red: Well vegetated, tussock tundra.
Bright Red: Densely vegetated, shrublands.

C: Glacial Geology



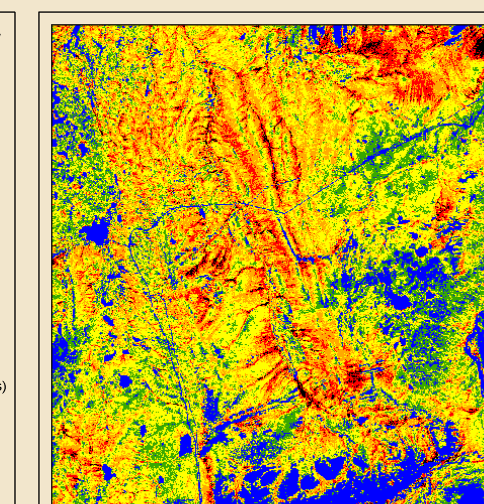
- Drift of latest Itkillik readvance
- Drift of Itkillik Phase II
- Drift of Itkillik Phase I
- Drift of Sagavanirktok River
- Outwash of latest Itkillik readvance
- Outwash of Itkillik Phase II
- Outwash of Itkillik Phase I
- Outwash of Sagavanirktok River
- Subglacial meltwater deposits
- Undifferentiated river alluvium
- Undifferentiated fan deposits
- Undifferentiated lacustrine deposits
- Undifferentiated colluvial deposits
- Bedrock
- Roads
- Pipeline

D: Surficial Geomorphology



- Featureless
- Stony surfaces
- Non-sorted circles
- Sorted and non-sorted stripes
- Turf hummocks
- Gelifluction features
- Well-developed hill-slope water tracks
- Indistinct hill-slope water tracks
- High- or flat-centered ice-wedge polygons and palsas
- Low-centered ice-wedge polygons
- Wetland surface forms
- Water
- Thermokarst and beaded streams
- Irregular microrelief (glacial till, stream channels)
- Disturbed
- Roads
- Pipeline

E: NDVI/Biomass



NDVI	Biomass (g/m^2)
< 0.38	0-100
0.38-0.42	100-300
0.42-0.46	300-500
0.46-0.50	500-800
0.50 - 0.54	800-1500
> 0.54	>1500