Geobotanical maps in the vicinity of the Toolik Field Station, Alaska

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Explanation

Overview
The Toolik Field Station in northern Alaska is a primary arctic research facility for the University of Alaska and a flagship US Arctic Observatory. The maps presented here were prepared to support research in the area, including the Arctic Long-Term Ecological Research (LTER) program. The front side contains five maps of a 751-km^2 region surrounding the upper Kuparuk River watershed, including the Toolik Lake and the Imnavait Creek research areas, as well as a stretch of the Dalton Highway and Trans-Alaska Pipeline from the Galbraith Lake airstrip to Slope Mountain. The reverse side shows more detailed vegetation and surficial geomorphology maps of the 20-km^2 area centered on Toolik Lake and a 1.2 km^2 intensive research grid on the south side of Toolik Lake (red rectangles on Map A). All the maps are part of a hierarchical geographic information system (GIS) and the web-based *Arctic Geobotanical Atlas* (http://www.arcticatlas.org/). The atlas also includes other map themes for all three areas and a previously published hierarchy of maps of the Imnavait Creek area (Walker et al. 1989; Walker and Walker 1996) (black rectangles on Map A). Photos and explanations of the geobotanical mapping units and the supporting field data and metadata can also be found on the web site.

Maps of the upper Kuparuk River Region
The upper Kuparuk River region has terrain typical of the Southern Foothills of the Brooks Range, including landscapes affected by three major glacial events. Map A shows the vegetation of the upper Kuparuk River region at 1:63,360 scale (mapped at 1:25,000) . The other maps shown here include a false color-infrared satellite image (Map B), glacial geology (Map C), surficial geomorphology (Map D), and NDVI/biomass (Map E) - all at 1:226,576 scale. Maps A and C were derived from a geobotanical map of the region. The base map for the geobotanical map was a 1:25,000-scale black-and-white orthophoto-topographic map that was prepared especially for this project by Vexcel Corp., Denver, CO in 1994 from stereo pairs of 1:60,000-scale 9 x 9-inch color-infrared aerial photographs that were obtained by NASA in 1982. The base map was prepared without ground-control points, but was registered as closely as possible to the 1:63,360 USGS map of the region. Vegetation and other geobotanical features were mapped by photo-interpretation onto 1:25,000-scale enlargements of the 1982 NASA aerial photographs. The minimum mapping unit was approximately 0.6 ha (1/8" at 1:25,000). No formal accuracy assessment was performed, but 320 of the map polygons representing 3.2% of the total map polygons, and about 16% of the total map area were checked on the ground during helicopter-assisted transects in 1994. Geobotanical variables coded for each map polygon included: primary vegetation, secondary vegetation, tertiary vegetation, landform, surface deposit, primary surficial geomorphology, and secondary surficial geomorphology. Secondary and tertiary types are subdominant types that cover more than 30% of a map polygon. The geobotanical map was made using methods and legends specially developed for northern Alaska (Walker et al. 1980, 1986, 1989). The GIS was developed following the integrated terrain-unit mapping approach (Dangermond and Harnden 1990). The resulting geobotanical maps were presented at conferences in 1996 (e.g., Walker et al. 1996) but remained unpublished until now. In 2007 the map boundaries were modified to register with a recent digital elevation model (DEM) of the Kuparuk River region (Nolan 2003) and the 1989 SPOT image of the region (Map B). The legends were also modified to better fit the hierarchy of maps in the *Arctic Geobotanical Atlas*.

Map A: Vegetation
The vegetation of the region was studied and mapped as part of the Arctic Long-Term Ecological Research (LTER) project at Toolik Lake, and the Department of Energy R4D (Response, Resistance, Resilience and Recovery of vegetation from Disturbance) project at Imnavait Creek (Walker et al. 1994, Walker and Walker 1996). Fifty-seven 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 14 physiognomic map units shown on Map A, which are compatible with the Circumpolar Arctic Vegetation Map (CAVM Team 2003) and the Alaska Arctic Tundra Vegetation Map (Raynolds et al. 2005).

Map B: False Color-Infrared Satellite Image
This French SPOT (Système Probatoire d'Observation de la Terre) satellite image (20 m resolution) was obtained on 28 July 1989, and provides a view of the mapped region from space. The false color-infrared image shows more densely vegetated areas as brighter red colors. When compared with the glacial geology map (Map C), the older Sagavanirktok-age glacial landscapes have few lakes and redder tones indicating more dense vegetation, and the younger Itkillik-age glacial surfaces that have more lakes and grayer colors. This image was also used to produce the NDVI/biomass map (Map E).

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

Map D: Surficial Geomorphology
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). 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.

Map E: NDVI and Plant Biomass
The Normalized Difference Vegetation Index (NDVI) is an index of vegetation greenness that can be linked to plant biomass and other biophysical properties of the vegetation, such as CO_2 and photosynthesis. The NDVI = (NIR – R)/(NIR + R), where NIR is the spectral reflectance in the SPOT near-infrared channel (790-890 nm) and R is the reflectance in the red channel (610-680 nm). This map is derived from the SPOT image shown in Map B. It is modified from an earlier version (Shippert et al. 1995) using more recent biomass information (Walker et al. 2007 submitted). Blue areas are generally water, barrens, dry tundra, and sparsely vegetated areas. Green areas are generally low-biomass mires and areas with few erect shrubs including nonacidic tundra areas. Yellow areas are mainly well-vegetated tussock-tundra areas; orange and red areas are more densely vegetated areas with abundant dwarf and low erect shrubs. Black areas have dense shrub vegetation, mostly in water tracks and along rivers and some south-facing slopes.

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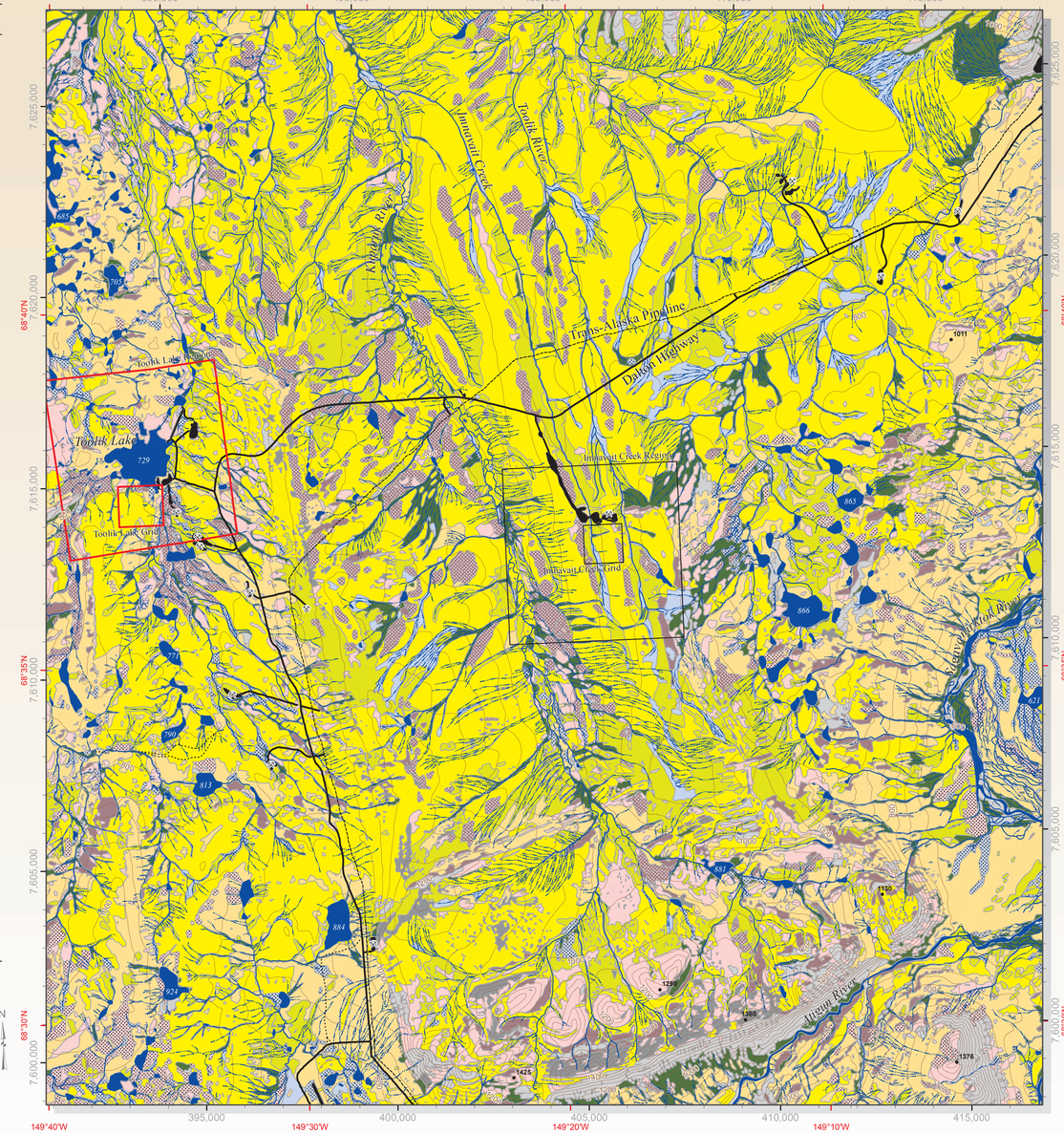
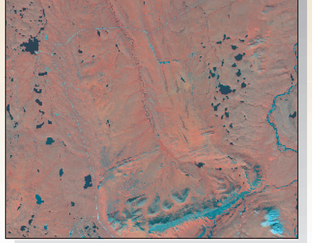
A: Upper Kuparuk River Region Vegetation

Physiognomy	Plant communities (GIS codes)	Typical Microsites	Area (ha)	% of Map
Barrens				
1. Anthropogenic barrens	Roads, gravel pads, and pipeline pads. (Disturbances are overlaid on pre-disturbance vegetation, so area of anthropogenic barrens are not included in the total area of the map.)	Barren roads, gravel construction pads, airstrips, and gravel mines.	(270)	(0.4)
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 nonsorted 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 dominated by graminoids (31, 311). Dominant plant communities include *Eriophorum vaginatum-Sphagnum* (31) and *Carex bigelowii-Sphagnum* (3111).	Mesic to subhygric, stable, acidic (pH<5.5) sites with shallow to moderate snow. Flat areas and gentle slopes.	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), *Carex bigelowii-Dryas integrifolia* (subtypes *Equisetum arvense* (322), and *Salix glauca* (324)), *Eriophorum vaginatum-Tomentypnum nitens* (323), and *Carex bigelowii-Sphagnum*, subtype *Cassiope tetragona* (3113). Also includes a few other graminoid-dominated communities, including: *Festuca altaica-Poa glauca* (Disturbed thermokarst areas) (325); *Deschampsia caespitosa-Carex saxatilis* (drained lakes) (326), *Carex podocarpa-Salix chamissonis* (snowy streamsides) (515).	Mesic to subhygric, nonacidic (pH>5.5) sites with shallow to moderate snow. Flat areas and gentle slopes. Also miscellaneous graminoid dominated sites including deep-snow stream margins, landslides, and some rocky drained lake basins.	12,963	17.3
Wet graminoid tundras and water				
6. Sedge, moss tundra (poor fens)	Poor fen wetland complexes (41). Dominant plant communities include: Lower microsites: *Eriophorum scheuchzeri-Sphagnum orientale* (412) and *Eriophorum angustifolium-Sphagnum* (413). Raised microsites: *Sphagnum lenense-Salix fuscescens* (411).	Subhydric to hydric, acidic (pH <4.5). Poor fens, meadows in colluvial basins.	1,934	2.6
7. 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, nonacidic (pH>4.5). Water tracks, stream margins, fens, flarks on solifluction slopes.	1,158	1.5
8. Unvegetated water and herbaceous marsh	Water (6) and/or aquatic vegetation in lakes and streams. 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				
9. 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); and lichen tundra *Cladonia arbuscula-Stereocaulon tomentosum* (215).	Xeric to xeromesic, acidic, wind blown to shallow winter snow cover. Ridge tops, exposed slopes, dry river terraces.	5,820	7.8
10. Prostrate dwarf-shrub, sedge, forb, fruticose – lichen tundra (nonacidic)	Dry nonacidic tundra complexes. *Dryas integrifolia-Oxytropis nigrescens* (24), and *Dryas integrifolia-Astragalus umbellatus* (22).	Xeromesic to mesic, nonacidic. Includes a wide variety of drier nonacidic habitats, including stable river terraces, and nonsorted stripes on slopes.	895	1.2
11. Hemi-prostrate dwarf-shrub, fruticose-lichen tundra	Deeper snowbed complexes (23). Dominant plant communities include: *Cassiope tetragona-Carex microchaeta* (231); *Cassiope tetragona-Dryas integrifolia* (232); and *Salix rotundifolia-Sanionia uncinatus* (233).	Subxeric to mesic, acidic to nonacidic, with deep snow. Snowbeds.	2,164	2.9
12. Hemi-prostrate and prostrate dwarf-shrub, forb, moss, fruticose-lichen tundra	Dry tundra with shallow snowbeds mainly on stripe complexes. Dominant plant communities include *Cassiope tetragona-Calamagrostis inexpansa* (214). Also includes dry areas with hemi-prostrate dwarf birch *Betula nana-Hierochloe alpina* (213).	Subxeric to mesic, acidic to nonacidic, somewhat-deeper-snow areas. Depressions on acidic ridge crests, dry glacial till, and outwas; nonsorted stripes.	2,116	2.8
Erect-shrub tundras				
13. Dwarf- to low-shrub, sedge, moss tundra	Moist acidic tundra complexes dominated by shrubs. Includes shrubby tussock tundra and mainly dwarf-shrub tundra areas (3112). Dominant plant communities include *Betula nana-Eriophorum vaginatum* (312), and *Salix pulchra-Carex bigelowii* (no code). Also acidic shrub tundra dominated by dwarf birch or willows. Dominant plant communities include *Betula nana-Rubus chamaemorus* and *Salix pulchra-Sphagnum* (513)	Mesic to subhygric, moderate snow. Includes a wide variety of habitats with dwarf shrubs, including wet lower slopes, margins of upland water tracks, palsas, and high-centered polygons.	8,445	11.2
14. 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*). 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).	Mesic to subhydric, often with deep snow. Stream margins upland water tracks, and south-facing slopes.	5,344	7.1
		Total (excluding roads and pads)	75,070 ha	100%



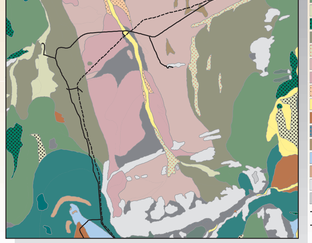
Vegetation mapping was performed in 1994 at 1:25,000 scale from 1982 NASA acquired base photography and is displayed at 1:63,360 scale. The extent of the mapped area is shown as a black rectangle on the location map to the left.



B: False Color Infrared Image

Interpretation:
This false-color infrared image displays vegetated areas as a gradient of red tones. The brightest red areas are densely vegetated shrublands; moderate red areas are generally well vegetated surfaces, often with tussock tundra, and the dull red to brownish areas are more sparsely vegetated including dry tundra, nonacidic tundra, and wet tundra. The darkest black to bluish black areas are water. The lightest areas are light-colored bedrock (dolomite or limestone) or light colored gravel in roads and river floodplains. Lichen covered bedrock (mostly sandstone and conglomerates) is dark grayish green.

Source: SPOT imagery, 28-July-1989



C: Glacial Geology

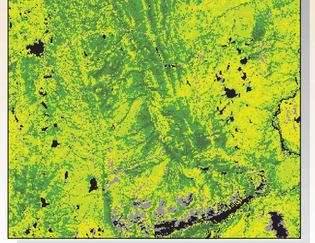
- Drift of Itkillik age, undifferentiated
- Drift of latest Itkillik readvance
- Active kettles
- Outwash of latest Itkillik readvance
- Drift of Itkillik Phase II
- Outwash of Itkillik Phase II
- Ice-contact deposits
- Drift of Itkillik I age
- Outwash of Itkillik Phase I
- Drift of Sagavanirktok, undifferentiated
- Drift of Sagavanirktok, late advance
- Outwash Sagavanirktok, late advance
- Undifferentiated alluvium
- Undifferentiated fan deposits
- Undifferentiated colluvium
- Ice rich silt deposits and colluvial basins
- Undifferentiated lacustrine deposits
- Undifferentiated gravel & beach deposits
- Bedrock
- Bedrock with discontinuous cover
- Roads
- Pipeline

Source: simplified from Hamilton, 2003

D: Surficial Geomorphology

- Featureless
- Stony surfaces
- Non-sorted circles and stripes
- Gelifluction features (including lobes, terraces, and turf hummocks)
- Well-developed hill-slope water tracks
- Indistinct hill-slope water tracks
- High- or flat-centered ice-wedge polygons and palsas
- Wetland surface forms (including low-centered polygons)
- Water (including thermokarsts and beaded streams)
- Irregular microrelief (glacial till, rolling relief, stream channels)
- Disturbed
- Roads
- Pipeline

Source: see vegetation map above, 1994



E: NDVI/Biomass

NDVI	Estimated Biomass (g/m^2)
< 0.14	0-25
0.14-0.32	26-75
0.33-0.40	76-150
0.41-0.45	151-300
0.46-0.48	301-500
0.49 - 0.51	501-1000
> 0.51	> 1000

0 2 4 6 8 10
Kilometers
Maps B-E displayed at 1:266,576 scale.

Source: SPOT imagery, 28-July-1989