A HIERARCHICAL TUNDRA VEGETATION CLASSIFICATION ESPECIALLY DESIGNED FOR MAPPING IN NORTHERN ALASKA

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This paper presents a tundra vegetation classification scheme that is designed for describing vegetation at four levels: (1) very-small-scale maps, (2) LANDSAT-derived maps, (3) photo-interpreted maps, and (4) plant community descriptions. A system of nomenclature is described that links the four levels.

INTRODUCTION

Land-use planning in tundra regions utilizes knowledge of vegetation more than any other terrain factor. The vegetation gives insight to a host of environmental variables, many of which are related to permafrost, including soil properties, depth of the active layer, temperature regime and snow regime. There are three primary methods of interpreting vegetation: (1) plant community descriptions at ground level, (2) aerial photographs, and (3) multi-spectral satellite data. Currently there is no classification system that relates the map units from one method to those of the other two. Viereck and Dyrness (1980) developed a hierarchical method of vegetation classification for Alaska, but it is not specifically designed for mapping and is particularly difficult to apply to LANDSAT-dervived classifications. The classification scheme presented here (Table 1) meets three basic criteria:

- At the LANDSAT level, the land cover units are based on those characteristics of the vegetation that can be classified consistently from LANDSAT data.
- At lower levels, the classification system is consistent yet flexible enough to describe the great variety of tundra communities. At the community level, the system is open-ended so that units that do not accurately describe the vegetation of a given area need not be used.
- The lower level units can be grouped within the higher level units with a minimum of overlap so that there is clear compatibility between levels.

The highest classification level, Level A, is very general and useful for very-small-scale vegetation maps of Alaska. Level B consists of LANDSAT-level land cover units that can be interpreted using digital multi-spectral satellite data. Level C consists of vegetation subunits that can be interpreted from aerial photographs if supplemented with adequate ground truth. Level D consists of individual plant communities, determined by ground surveys. The following discussion presents the classification system "from the ground up," starting with level D.

LEVEL D--PLANT COMMUNITY NAMES AND UNITS FOR VERY-LARGE-SCALE MAPS

Level D units describe specific vegetation classes that correspond approximately to the stand types of Marr (1967) the associations of Daubenmire (1952) or Braun-Blanquet (1932), and the plant community or community type of Whittacker (1967). At this level there are many units and the system is open, such that any newly described vegetation community can be easily added. The nomenclature used for describing vegetation at this level always follows fixed guidelines. The following discussion explains the nomenclature system for plant communities and noncomplex map units and then for complex map units. Complex map units contain two or more distinct vegetation communities, and each community covers at least 30% of the map unit. Level D is appropriate for very-large-scale maps of small areas (e.g. a 1:1,000-scale map of a 5 acre ecology study site).

Noncomplex Units

Plant community names have four parts that are always arranged in the following sequence: (1) a site moisture term, (2) the dominant plant taxa, (3) the dominant plant growth forms, and (4) an overall physiognomic descriptor. The site moisture term can be dry, moist, wet or aquatic. These are subjective terms based on the soil moisture at the end of the growing season. The site moisture term is followed by the names of the dominant plant taxa, one or more from each of the representative shrub, herb, and cryptogam layers of the canopy. The number of taxa is kept to the minimum required to adequately distinguish the community from others on the map; the total normally does not exceed six.

The dominant growth forms follow next and can be any of the following: (1) tall shrub (>1.5 m), (2) low shrub (0.2 to 1.5 m), (3) dwarf shrub (<0.2 m), (4) sedge, (5) grass, (6) rush, (7) tussock sedge, (8) forb, (9) moss, (10) crustose lichen, and (11) fruticose lichen. The term graminoid is used when two or more of the dominant

TABLE 1 Hierarchical Classification Scheme for Tundra on the Arctic Coastal Plain and Foothills of Northern Alaska.

Level A VERY SMALL SCALE UNITS	Level B LANDSAT LAND COVER UNITS (suggested map colors)	Level C PHOTO-INTERPRETED MAP UNITS	Level D TYPICAL PLANT COMMUNITIES
A. Water	I. Water (light blue)	Ia. Water	No vegetation
B. Wet Tundra	II. Very Wet Tundra (dark blue)	IIa. Shallow Water (pond margins)	No vegetation
		Noncomplex subunits: IIb. Aquatic Graminoid Tundra	Aquatic Arctophila fulva Grass Tundra Aquatic Carex aquatilis Sedge Tundra
		IIc. Aquatic Forb Tundra	Aquatic Hippuris vulgaris, Caltha palustris, Menyanthes trifoliata Forb Tundra (aquatic tundra, inland areas)
		Common complex subunits: IId. Water/ Tundra Complex: (pond complex)	Typical communities listed under Ia, IIa, IIIa, IIIb, and Va
	III. Wet Tundra (dark green)	Noncomplex subunits: IIIa. Wet Sedge Tundra	Wet Carex aquatilis, Scorpidium scorpioides Sedge Tundra (wettest facies of wet alkaline tundra) Wet Carex chordorrhiza, Eriophorum scheuchzeri, Potentilla palustris Sedge Tundra (wet acidic tundra - inland areas) Wet Carex aquatilis, Eriophorum angustifolium, Pedicularis sudetica ssp. albolabiata, Drepanocladus brevifolius Sedge Tundra (wet alkaline tundra) Wet Eriophorum angustifolium, Dupontia fisheri, Campylium stellatum Graminoid Tundra (wet acidic tundra, coastal areas)
		IIIb. Wet Graminoid Tundra (wet saline Tundra)	Wet Carex subspathacea, Puccinellina phryganodes, Stellaria humifusa, Cochlearia officinalis Sedge Tundra
		Common Complex Subunits: IIIc. Wet Sedge Tundra/ Water Complex (pond complex)	Typical communities listed under Ia, IIa and IIIa
		IIId. Wet Sedge/ Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned-ground complex)	Typical communities listed under IIIa and Va
C. Moist Tundra	IV. Moist/ Wet Tundra Complex (light green)	Common Complex Subunits: IVa. Moist Sedge, Dwarf Shrub/ Wet Graminoid Tundra Complex (moist patterned-ground complex)	Typical communities listed under Va and IIIa
	V. Moist or Dry Tundra (tan)	Noncomplex Subunits: Va. Moist Sedge, Dwarf Shrub Tundra	Moist Carex bigelowii, Eriophorum angustifolium ssp. triste, Dryas integrifolia, Salix reticulata, Tomenthypnum nitens, Thamnolia subuliformis Sedge, Dwarf Shrub Tundra (moist alkaline tundra) Moist Luzula arctica, Poa arctica, Saxifraga cernua, Salix planifolia ssp. pulchra, Dicranum elongatum, Ochrolechia frigida Graminoid, Dwarf Shrub, Crustose Lichen Tundra (moist coastal acidic tundra) Moist Carex aquatilis, Eriophorum angustifolium ssp. triste, Salix planifolia ssp. pulchra, Campylium stellatum Sedge, Dwarf Shrub Tundra (moist acidic tundra, wetter facies) Moist Carex bigelowii, Dryas integrifolia, Lupinus arcticus, Salix lanata ssp. richardsonii, Arctagrostis latifolia, Equistetum arvense, Tomenthypnum nitens, Sedge, Dwarf shrub, Forb Tundra (moist non-tussock alkaline tundra)
		Vb. Moist Tussock Sedge, Dwarf Shrub Tundra	Moist Eriophorum vaginatum, Dryas integrifolia, Salix reticulata, S. arctica, Tomenthypnum nitens, Thamnolia subuliformis, Tussock Sedge, Dwarf Shrub Tundra (alkaline tussock tundra) Moist Eriophorum vaginatum, Dryas integrifolium, Salix planifolia ssp. pulchra, Salix reticulata, Hylocomium splendens, Ptilidium ciliare, Cetraria cucullata Tussock Sedge, Dwarf Shrub Tundra (neutral to slightly acidic tussock tundra)
		Vc. Dry Dwarf Shrub, Crustose Lichen Tundra (Dryas tundra)	Dry Dryas integrifolia, Carex rupestris, Oxytropis nigrescens, Salix reticulata, Ditrichum flexicaule, Lecanora epibryon Dwarf Shrub, Forb, Crustose Lichen Tundra (Dryas river terraces) Dry Dryas integrifolia, Astragalus alpinus, Oxytropis borealis, Salix reticulata, Distichium capillaceum, Lecanora epibryon Dwarf Shrub, Forb, Crustose Lichen Tundra (Dryas river terraces)
		Vd. Dry Dwarf Shrub, Fruticose Lichen Tundra (Dry acidic tundra)	Dry Dryas octopetala, Arctostaphylos alpina, Empetrum nigrum Salix phlebophylla, Rhytidium rugosum, Alectoria nigricans Dwarf Shrub, Fruticose Lichen Tundra (dry acidic tundra on kames and moraines in foothills) Dry Salix rotundifolia, Pedicularis kanei, Luzula arctica, Polytrichum sp. Alectoria nigricans, Cetraria islandica Dwarf Shrub, Fruticose Lichen Tundra (dry acidic tundra near coast)

TABLE 1 (Continued)

Level A VERY SMALL SCALE UNITS	Level B LANDSAT LAND COVER UNITS (suggested map colors)	Level C PHOTO-INTERPRETED MAP UNITS	Level D TYPICAL PLANT COMMUNITIES
		Common Complex Subunit: Ve. Moist Graminoid, Dwarf Shrub Tundra/ Barren Complex (frost-scar complex)	Typical communities listed under Va and Vb plus either completely barren, frost-scars or communities such as: Dry Saxifraga oppositifolia, Dryas integrifolia, Chrysanthemum integrifolium, Juncus biglumis, Arctagrostis latifolia, Ochrolechia frigida Barren (alkaline frost scars)
	VI. Moist Tussock Sedge, Low Shrub Tundra (brown)	Noncomplex Subunit: VIa. Moist Tussock Sedge, Low Shrub Tundra (acidic tussock tundra)	Moist Eriophorum vaginatum, Salix planifolia ssp. pulchra, Betula nana ssp. exilis, Ledum palustre ssp. decumbens, Vaccinium spp., Sphagnum spp., Cladonia spp. Tussock Sedge, Low Shrub Tundra
		Complex Subunits: VIb. Moist Tussock Sedge, Low Shrub Tundra/ Tall Shrub Complex (alder tundra savanna)	Typical communities listed under Vb and VIa plus widely spaced Alnus crispa
		VIc. Moist Tussock Sedge, Low Shrub/ Wet Low Shrub Tundra Complex (water track complex) Note: This complex may appear as subunit of VI or VII depending on the density of water tracks.	Typical communities listed under VIa and VIIIa
	VII. Moist Shrub-rich Tundra (dark brown)	Noncomplex Subunits: VIIa. Moist Low Shrub, Tussock Sedge Tundra (shrubby tussock tundra)	Moist Salix planifolia ssp. pulchra, Betula nana ssp. exilis, Eriophorum vaginatum, Ledum palustre ssp. decumbens, Vaccinium spp., Sphagnum spp. Low Shrub, Tussock Sedge Tundra
		VIIb. Moist Dwarf Shrub, Moss Tundra (Sphagnum-rich dwarf shrub tundra)	Moist Rubus chamaemorus, Ledum palustre spp. decumbens, Betula nana, spp. exilis, Vaccinium spp., Sphagnum spp., Cladonia spp. Dwarf Shrub, Moss Tundra
		Complex Subunit: VIIc. Moist Tussock Sedge, Low Shrub/ Wet Low Shrub Tundra Complex (water track complex -- see note under VIc.)	Typical communities listed under VIa and VIIa
D. Shrubland	VIII. Shrubland or Shrub Tundra (red)	VIIIa. Wet Low Shrub Tundra	Wet Salix planifolia pulchra, Betula nana ssp. exilis, Sphagnum spp. Low Shrub Tundra (wet willow tundra) Wet Betula nana ssp. exilis, Sphagnum spp. Low Shrub Tundra (wet birch tundra)
		VIIIb. Moist Low Shrub Tundra	Moist Betula nana spp. exilis, Ledum palustre ssp. decumbens, Salix planifolia ssp. pulchra, Vaccinium spp., Cladonia spp. Low Shrub Tundra (moist birch tundra) Moist Betula nana ssp. exilis, Vaccinium uliginosum, Potentilla fruticosa, Shepherdia canadensis, Salix spp., Festuca altaica Low Shrub Tundra (south facing shrub tundra in foothills) Moist Alnus crispa, Betula nana ssp. exilis, Salix spp. Low Shrub Tundra (alder shrub tundra)
		VIIIc. Moist Shrubland (closed riparian shrubland)	Moist Salix alaxensis, Salix spp. Tall Shrubland (willow riparian shrubland) Moist Betula nana ssp. exilis, Betula glandulosa Low Shrubland (birch riparian shrubland)
E. Partially Vegetated and Barren	IX. Partially Vegetated (violet)	Riparian areas: IXa. Dry, Barren/ Low Shrub Complex (open riparian shrubland)	Typical communities and ground cover listed under VIIIc and Xa.
		IXb. Dry Barren/ Dwarf Shrub, Forb Grass Complex (forb-rich river bars)	Typical communities listed under Vc, Xa, also mixed forb grass and dwarf shrub communities such as: Dry Bromus pumpellianus, Festuca rubra, Astragalus alpinus, Androsace chamaejasme, Salix ovalifolia Grass, Forb, Dwarf Shrub Tundra (forb-rich river bars) Dry Dryas integrifolia, Artemisia borealis, A. glomerata, Salix ovalifolia, Androsace chamaejasme Dwarf Shrub, Forb Tundra (Dryas river bars near arctic coast)
		IXc. Dry Barren/ Forb Complex	Dry Epilobium latifolium, Artemisia arctica, Wilhelmsia physodes Forb Barren (active river channels)
		IXd. Dry Barren/ Low Shrub Forb Complex (open riparian shrubland)	Dry Salix alaxensis, Salix spp. Hedysarum spp. Astragalus alpinus, Equisetum arvense, Oxytropis campestris, O. borealis, Anemone parviflora Low Shrub, Forb Tundra (river bars inland)
		Sand Dunes: IXe. Dry Barren/ Grass Complex (sand dune grassland)	Dry Elymus arenarius Grass Tundra (sand dune grassland)
		IXf. Dry Barren/ Dwarf Shrub, Grass Complex (sand dune steppe)	Dry Artemesia borealis, A. glomerata, Deschampsia caespitosa Trisetum spicatum Dwarf Shrub, Grass Tundra (sand dune steppe)
		IXg. Dry Barren/ Low Shrub Complex (sand dune scrub)	Dry Salix alaxensis, S. glauca, Elymus arenarius, Carex obtusata, Dryas integrifolia Low Shrub, Tundra (sand dune scrub)

TABLE 1 (Continued)

Level A VERY SMALL SCALE UNITS	Level B LANDSAT LAND COVER UNITS (suggested map colors)	Level C PHOTO-INTERPRETED MAP UNITS	Level D TYPICAL PLANT COMMUNITIES
		Beaches, river deltas, and estuaries: IXh. Wet Barren/ Wet Sedge Tundra Complex (barren/ saline tundra complex)	Typical ground cover listed under IIIb
		IXi. Dry Barren/ Forb, Graminoid Complex (coastal barrens)	Dry Cochlearia officinalis, Stellaria humifusa, Puccinellia phryganodes, P. andersonii, Salix ovalifolia, Potentilla pulchella Forb, Graminoid Tundra (coastal saline barrens)
		Mountainous areas: IXj. Dry Barren/ Dwarf Shrub, Graminoid Tundra Complex (dry alpine tundra)	Typical ground cover listed under Xd, Vc, or the following, among many others: Dry Dryas octopetala, Salix phlebophylla, Carex microchaeta, Kobresia myosuroides, Saxifraga bronchialis, Hierochloe alpina, Potentilla hyparctica, Minuartia arctica Dwarf Shrub, Graminoid Tundra (dry alpine tundra)
		IXk. Moist Barren/ Moss, Forb, Dwarf Shrub Tundra (moist alpine tundra)	Moist Hylocomium splendens, Saxifraga bronchialis, Saxifraga tricuspidata, Salix phlebophylla, S. chamissonis, Cladonia spp., Moss, Forb, Dwarf Shrub Tundra
	X. Light-colored Barrens (Note: Most areas classed as barrens are likely to have some vegetation but ground cover is less than 30% (black)	Xa. River gravels	Completely barren or with typical communities listed under IXb, IXc, IXd
		Xb. Sand dunes	Typical communities listed under IXe, IXf, IXg
		Xc. Barren gravel outcrops	Typical communities listed under Vd or the following, among many others: Dry Dryas octopetala, Lupinus arcticus, Potentilla biflora, Smelowski calycina, Saxifraga tricuspidata, Salix phlebophylla, Silene acaulis Dwarf Shrub, Forb Barren (gravel outcrops)
		Xd. Talus slopes and blockfields	Dry Rhizocarpon spp., Lecidea spp., Umbilicaria spp., Cetraria spp. Crustose Lichen Barren (blockfields and talus)
		Xe. Gravel roads and pads	Completely barren
	XI. Dark Colored Barrens (gray)	XIa. Wet mud	Completely barren or with communities listed under IIIb
		XIb. Wet or dark-colored gravels	Completely barren
		XIc. Bare peat	Mostly barren areas along the coast caused by storm surges or man-made disturbances, communities listed under IIIb
		XId. Talus slopes and block fields	Same as Xd
F. Ice	XII. Ice (white)	XII. Ice	Completely barren

grass-like plants are in different families. Only the growth forms contributing at least 30% of the readily visible ground cover are included in the community name.

The last portion of the community name is the physiognomic descriptor, which is a term that applies to the appearance of the general vegetation landscape. The term tundra is used for most arctic and alpine nonforested areas with generally continuous ground cover. The term barren is used in areas where there is less than 30% ground cover. The term shrubland applies only to shrub-covered areas that are traditionally not considered tundra, such as dense riparian shrubs along large rivers. Shrub dominated vegetation in water tracks that are common in the foothills are generally considered shrub tundra, as are shrub-dominated units on mountain slopes and on open flat terrain. Examples of community names can be found in the right hand column of Table 1.

Complex Units

Complexes of vegetation are particularly common in the Arctic, where patterned ground is prevalent. Areas where complexes are mapped include ice-wedge polygons, sorted block fields, strangmoor, water tracks, frost-scar areas, and solifluction stripes and lobes. Often one community is consistently associated with a particular element of the surface form, such as polygon rims, while another community is consistently found on another element, such as the polygon basins and troughs. A consistent method of describing complexes utilizes the basic community nomenclature described above. For example, the following description is for a map unit in a foothill area with water tracks.

Water-track complex:

a) Interfluves and upland areas: Moist Eriphorum vaginatum, Salix planifolia ssp. pulchra, Ledum palustre ssp. decumbens, Sphagnum sp., Cladina arbuscula Tussock Sedge, Low Shrub Tundra.

b) Water tracks: Wet Salix planifolia ssp. pulchra, Betula nana ssp. exilis, Carex aquatilis, Sphagnum sp. Low Shrub Tundra.

Note that the community names follow descriptions of the microsites on which they occur, and the complex is named according to the dominant patterned-ground feature or landform. The unit description includes only those plant communities that are associated with distinctive

patterned-ground elements (e.g. polygon rims, water tracks, polygon troughs etc.) and that cover more than 30% of a map unit.

LEVEL C--PHOTO-INTERPRETED MAP UNITS

Level C can be used for photo-interpreted maps at scales from 1:6,000 to 1:63,360. On aerial photographs there are two main characters that are useful for identifying tundra vegetation. The first is color or a gray tone. The darkness of tone is often indicative of the moisture status of the site. Darker areas are normally wet, and lighter areas tend to be moist or dry due to an abundance of erect dead graminoid vegetation and/or crustose lichens. There are, of course, exceptions to this. Sometimes dry areas will also be dark due to barren peat or an abundance of dark-colored fruticose lichens, such as Alectoria nigricans and Cornicularia divergens, or wet areas may be light-toned due to marl on pond bottoms. On color-infrared photographs, color is important. For example, red tones are indicative of deciduous shrubs and are important in interpreting categories of tussock tundra vegetation with varying amounts of shrub cover.

The second useful character is texture. Many textures are indicative of surface forms and thus are useful for recognizing vegetation complexes. The presence of ice-wedge polygons, frost boils, solifluction lobes, strangmoor, blockfields, talus, and rugged rocky terrain can be recognized on the basis of texture. On very-large-scale photographs, texture can also be helpful in identifying shrub vegetation and cottongrass tussocks.

Photo interpretation of tundra vegetation is difficult because nearly all the communities are low growing and the clues for distinguishing units are frequently quite subtle. It should be stressed that the critical element for accurate vegetation maps is extensive ground reference data. With adequate ground experience, site moisture regime and dominant plant growth forms can normally be interpreted.

Noncomplex Units

The species composition of tundra vegetation can very rarely be reliably interpreted from aerial photographs. Thus at Level C, the nomenclature drops the plant taxa names and consistently uses the remaining parts of the nomenclature outlined for Level D, i.e., the site moisture term, the dominant plant growth forms, and the physiognomic descriptor. An example of a Level C unit is Moist Tussock Sedge, Low Shrub Tundra. Other examples may be found in Table 1.

Complex Units

Complex units are treated in a similar fashion with the term complex attached to the end of the unit name and the components of the complex separated by a slash (/). An example for a low-centered ice-wedge polygon complex is Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex. The physiognomic term tundra is included only for the last portion of the complex. The physiognomic term for the first portion of the complex is included only if it is different from the last. The first part of the complex name is the dominant portion. The Level C equivalent of the water track complex mentioned in the previous section is Moist Tussock Sedge, Low Shrub/Wet Low Shrub Tundra Complex. The term water track complex could be used as a shorter synonym in general discussion. For the formal map unit titles, however, every attempt should be made to use the complete names since this increases the amount of information available on the map and makes all the units comparable.

LEVEL B--LANDSAT-INTERPRETED MAP UNITS

LANDSAT methods have certain advantages over photo interpretation. These include the digital format of the data, and the speed with which maps of large areas can be made. The minimum LANDSAT mapping area is one pixel or picture element that corresponds to a ground area of 0.44 ha (1.1 acre). This is considerably smaller than minimum map unit size at all but the very largest photo-interpreted map scales.

The big disadvantage of LANDSAT methods is that the final map units are based solely on surface reflectance. Promising methods that may aid in interpretation of tundra vegetation from LANDSAT data include: 1) using multiple LANDSAT scenes from several seasons, and 2) use of digitized landform and terrain data from geographic information systems. The combination of spectral reflectance and terrain information can be used to produce computer models that are capable of interpreting more vegetation units than can be mapped with spectral data alone. There have been some attempts to use digital elevation data from topographic maps to help model problem categories on the basis of slope aspect and elevation (for example, Justice et al. 1981). These methods have not, however, been used extensively on the Arctic Slope due largely to the very flat landscape where interpolation of elevation values from widely spaced topographic contours can produce inaccurate interpretations.

A classification for LANDSAT-derived maps should recognize the limitations of the data. There are two primary characters of the northern Alaskan vegetation that affect its spectral reflectance and are most important with regards to LANDSAT-derived vegetation classifications. These are the amount of water on the surface and the percentage of deciduous shrubs in the vegetation canopy. Numerous other factors, such as the total percentage of plant cover, the amount of erect dead graminoid vegetation, the color of the substrate, the amount of lichen cover, and the nutrient status of the site, also affect the reflectance. Figure 1 is a cluster diagram for a typical LANDSAT scene from northern Alaska illustrating the spectral signatures in two bands for the major Level B classes. The 12 Level B units are based primarily on moisture status, the amount of shrubs in the canopy, and, in the case of the partially vegetated and barren units, the total percentage of plant cover. A full discussion of the units can be found in Walker et al. (in press).

LEVEL A--VERY-SMALL-SCALE MAP UNITS

Level A consists of only six units that are useful for very general vegetation maps of Alaska. The units are Water, Wet Tundra, Moist Tundra, Shrubland, Partially Vegetated and Barren, and Ice. These units are comparable to the classes used for the major ecosystem map of Alaska (Joint Federal-State Land Use Planning Commission 1973) and the USGS land cover classification

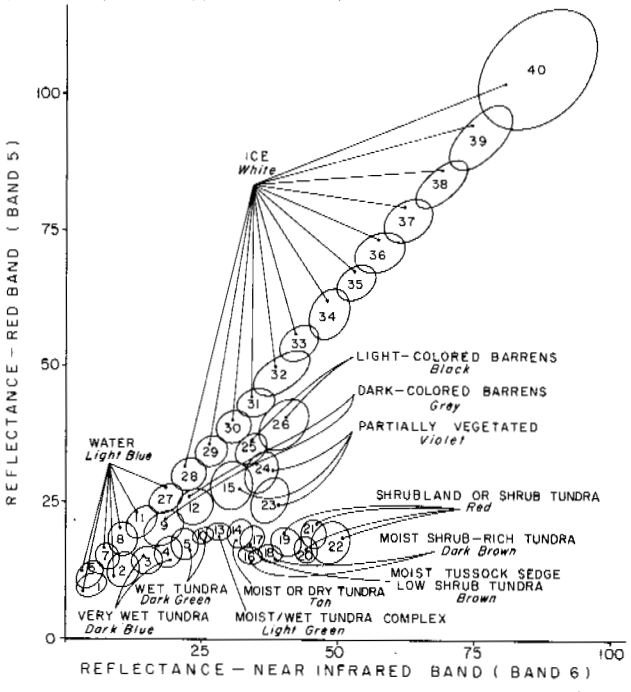

FIGURE 1 Cluster diagram for a LANDSAT scene of the Prudhoe Bay region, Alaska (scene no. 21635-21044), bands 5 and 6. The land cover designations and map colors indicate how the clustered were grouped in the final classification. Each ellipse encloses 80% of the pixels assigned to the respective cluster. The clustering algorithm is part of the EDITOR LANDSAT analysis software system used on the TENEX-DEC System PDP 10 computer available from Bolt Beranex and Newman Inc., Boston, Mass. (Courtesy of USGS Geography Branch, Moffet Field, California.)

system for remote sensor data (Anderson et al. 1976).

CONCLUSION

The hierarchical classification scheme presented here offers a first approximation at a link between two methods of vegetation mapping that are being widely used in northern Alaska--one based on LANDSAT technology and the other based on photo interpretation. It ties both of these methods to a comprehensive means of describing tundra vegetation on the ground. It is presently a flexible system that will undoubtedly continue to evolve as more experience is gained in mapping tundra vegetation.

ACKNOWLEDGMENTS

This work was sponsored by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). The classification system was developed during contracts with CRREL, the Sohio Alaska Petroleum Co., and ARCO Alaska, Inc. The U.S. Fish and Wildlife Service (USFWS), the U.S. Geological Survey (USGS), and the North Slope Borough have provided extensive logistical support and funds. The USGS Geography Branch at Moffet Field, Calif., and Reston, Va., was responsible for the technical expertise required for the LANDSAT classifications. Patrick J. Webber, Director of INSTAAR and others too numerous to mention here have helped me in developing this classification.

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