AN ECOLOGICAL LAND SURVEY IN THE NORTHEAST PLANNING AREA OF THE NATIONAL PETROLEUM RESERVE – ALASKA, 2002

FINAL REPORT

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INTRODUCTION

Although oil exploration in the National Petroleum Reserve–Alaska (NPRA) and the Colville Delta has been occurring for decades, only recently have sufficient oil reserves been discovered in the NPRA to warrant commercial development. ConocoPhillips Alaska, Inc. (CPAI) is currently evaluating the technical and economic feasibility of developing three oil prospects between the Colville Delta and Judy Creek, on the Arctic Coastal Plain in the Northeastern Planning Area of the NPRA. The area's dynamic physical processes, its diverse and abundant biological resources, and its importance for the local subsistence economy, all provide significant challenges for minimizing the potential ecological impacts of oil development. In recognition of the complexity of the coastal plain environment, ConocoPhillips initiated in 2001 a broad range of pre-development studies to inventory and evaluate the physical, chemical, biological, and cultural resources in the area. As part of this effort, this report presents the results of an ecological land survey (ELS) conducted in the area during 2001–2002.

In an ELS, landscapes are viewed not as aggregations of independent biological and physical resources, but as ecological systems with functionally related parts (Rowe 1961; Wiken and Ironside 1977; Bailey 1980, 1996; Driscoll et al. 1984). The goal of an ELS is to provide a consistent conceptual framework for modeling, analyzing, interpreting, and applying ecological knowledge. To provide the information required for such a wide range of applications, an ELS includes three phases: (1) an ecological land inventory that surveys and analyzes data obtained in the field, (2) an ecological land classification that classifies and maps ecosystem distribution, and (3) an ecological land evaluation that assesses the capabilities of the land for various land management practices. This three-phased approach of linking ecological characteristics within a spatial database improves our ability to predict the response of ecosystems to human impacts and facilitates the production of thematic maps for specialized engineering and environmental applications.

The structure and function of natural ecosystems are regulated largely along gradients of energy, moisture, nutrients, and disturbance. These gradients are affected by climate, physiography, geomorphology, soils, hydrology, vegetation, and fauna, which are referred to as ecological components (in this report) or 'state factors' (Barnes et al. 1982, ECOMAP 1993, Bailey 1996). We used the state-factor approach (Jenny 1941, Van Cleve et al. 1990, Vitousek 1994, Bailey 1996, Ellert et al. 1997) to evaluate relationships among individual ecological components and to develop a reduced set of local ecosystems (ecotypes) based on these relationships (Figure 1a). Parallel to evaluation of landscape relationships from the "ground up," we used an integrated-terrain-unit approach to mapping that used key identifiable components of the landscape from the "top down." The resulting maps convey the integration of ecological components into ecotypes with co-varying biological and physical characteristics, and thus provide a much broader range of information that is useful for ecosystem management.

An ecological land classification also involves the organization of ecological components within a hierarchy of spatial and temporal scales (Wiken 1981, Allen and Starr 1982, O'Neil et al. 1986, Delcourt and Delcourt 1988, Klijn and Udo de Haes 1994, Forman 1995, Bailey 1996). Local-scale features (e.g., vegetation) are nested within regional-scale components, (e.g., climate and physiography) (Figure 1b, Appendix Table1). Climate, particularly temperature and precipitation, accounts for the largest proportion of global variation in ecosystem structure and function (Walter 1979, Vitousek 1994, Bailey 1998). Within a given climatic zone, physiography (characteristic geologic substrate, surface shape, and relief) controls the rates and spatial arrangements of geomorphic processes and energy flows. These processes result in the formation of geomorphic units with characteristic lithologies, textures, and surface forms, which in turn affect soil properties and the movement of water (Wahrhaftig 1965, Swanson et al. 1988, Bailey 1996). Water movement through soil is a critical factor in determining the distribution of vegetation (Fitter and Hay 1987, Oberbauer et al. 1989), due to its influence on both water balance and nutrient

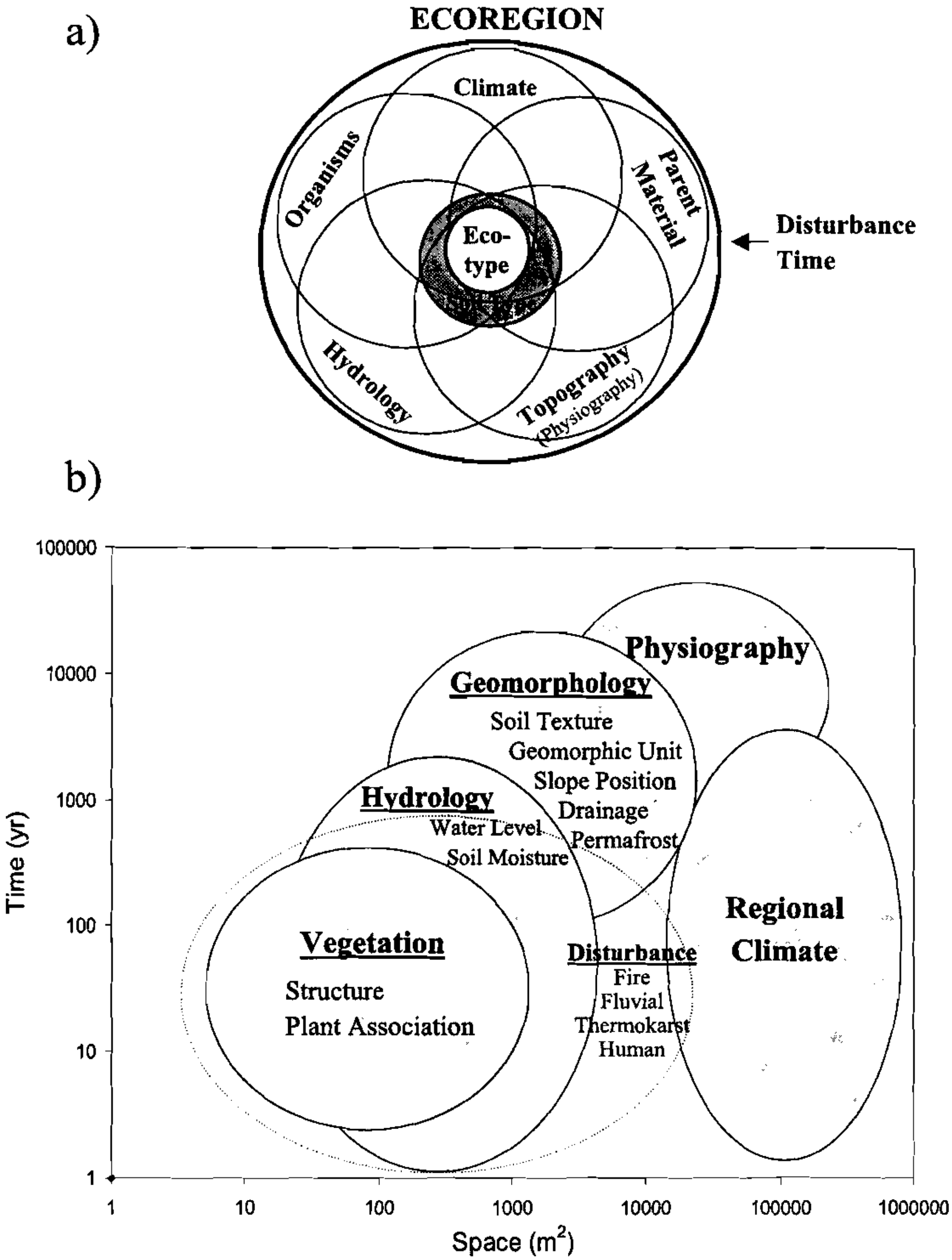


Figure 1. Interaction of interrelated state factors that control the structure and function of ecosystems (a) and the scales at which they operate (b).

availability for plants. Finally, vegetation provides structure and energy that affect the distribution of many wildlife species. The interrelated patterns and processes that operate across these components at the various scales can also be a source of disturbance that greatly influence the timing and development of ecosystems (Watt 1947, Pickett et al. 1989, Walker and Walker 1991, Forman 1995,).

A hierarchical approach to mapping vegetation and land cover was developed for northern Alaska by Everett and Walker (Everett et al. 1978; Walker 1983, 1999). They also applied an integrated geobotanical approach to mapping ecosystem components in the Prudhoe Bay region, but did not group the integrated units hierarchically (Walker et al. 1980). Recently, an integrated-terrain-unit approach has been used for large-scale mapping of ecosystems on the Arctic Coastal Plain (Jorgenson et al. 1997, Anderson et al. 2001), the entire North Slope (Walker 1999), western Alaska (Jorgenson 2000), and in interior Alaska at Fort Wainwright (Jorgenson et al. 1999) and Fort Greely (Jorgenson et al. 2001).

A nationally accepted approach to classifying ecosystems is lacking, although recent efforts have been made to develop a consensus among federal agencies (ECOMAP 1993) and among nations (Klijn and Udo de Haes 1994, Uhling and Jordan 1996). In this report, we generally have followed the scales and differentiating criteria described by Klijn and Udo de Haes (1994), which combine elements of both the Canadian (Wiken and Ironside 1977) and U.S. systems (ECOMAP 1993).

In implementing the ecological land classification for mapping, we used an integrated-terrain-unit (ITU) approach that incorporated three components that have readily identifiable photo-characteristics, geomorphic units (surficial geology, geomorphology), surface forms (primarily ice-related features), and vegetation. Because this approach generates a large number of ITU combinations, we aggregated the ITUs into a reduced set of ecosystem classes (ecotypes) based on the landscape relationships developed from the analysis of the field survey information. This integrated approach has several benefits: it recognizes the important effects of geomorphic processes on natural disturbance regimes (e.g., flooding, thermokarst) and the flow of energy and material, it preserves the diversity of environmental characteristics, and it uses a systematic approach to classifying landscape features for applied analyses. The ITU map then can serve as the spatial database for land evaluations that use differing components of the terrain. Specifically, results from this ELS can be used to help situate facilities to avoid sensitive terrain and high value habitat, develop appropriate oil spill response strategies, assess hydrologic patterns and cross-drainage concerns related to facility placement, and develop land rehabilitation strategies appropriate to diverse landscape.

Accordingly, the specific objectives of this ELS were to

1) conduct a field survey of ecosystem components, including geomorphology (surficial geology), topography, soils, hydrology, and vegetation within the study area;
2) evaluate the relationships among ecosystem components;
3) classify and map ecological components through an integrated-terrain-unit approach;
4) aggregate ecological components into a reduced set of ecosystems at two scales; and
5) use the ecological information to evaluate land capabilities or sensitivities (e.g., wildlife habitat, flooding regime, oil spill sensitivity, and winter traffic sensitivity).

METHODS

FIELD SURVEYS

TOPOSEQUENCES AND GROUND REFERENCE PLOTS

Field surveys were conducted near Fish Creek in northeastern NPRA during early August 2001 and 2002 (Figure 2). A gradient-directed sampling scheme (Austin and Heyligers 1989) was followed to sample the range of ecological conditions and provide the spatial relationships necessary to interpret ecosystem development. Sampling was done primarily along transects (toposequences) that were selected to encompass the range of physiographic environments, including coastal,

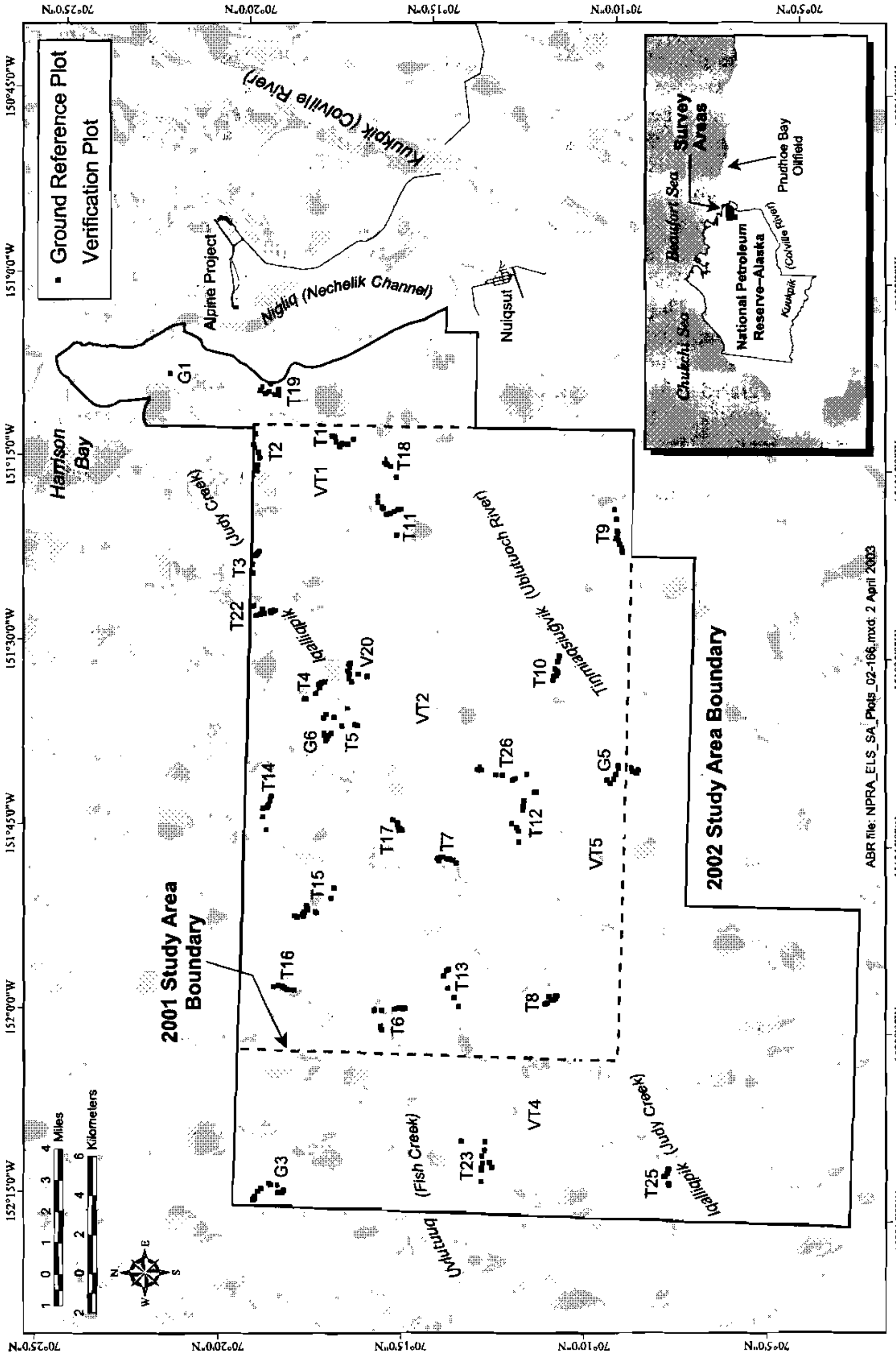


Figure 2. Sampling locations for the ecological land survey in the 2001 and 2002 study areas within the Northeastern Planning Area of the NPRA.

riverine, lacustrine, lowland, and upland areas. Along each transect, 8–12 plots were sampled, each in a distinct vegetation type or spectral signature identifiable on aerial photographs. Data were collected at 221 plots along 24 toposequences, and an additional 64 plots were sampled off transects to increase sample sizes of under-represented or rare classes. All plots were located on aerial photographs, and coordinates (including approximate elevations) were obtained with a Global Positioning System (GPS) receiver (accuracy ±15 m). At each plot (~10-m radius), descriptions or measurements of geology, surface form (micro- and macro-topography), hydrology, soil stratigraphy, and vegetation cover were recorded. Digital photos were taken at all plots (data and photos are archived at ABR). Data file listings are provided in Appendix Tables 2 and 3.

Geologic and surface-form variables recorded included physiography, surface geomorphic unit, slope, aspect, surface form, and depth of microrelief. Along five transects, topography was measured in detail, to obtain more precise information on microtopography and relative elevations of ecotypes. Elevations were obtained at frequent intervals by differential leveling using an autolevel and stadia rod. Measurements were taken at all major breaks in slope (mesosite variation) and periodically at low and high microsites (e.g., polygon centers and rims; microsite variation). Surveys provided only relative elevations; they were not referenced to established benchmarks because of the distances involved.

Hydrologic variables measured at each sampling site included water-surface elevation (transect plots only), depth of water above or below ground surface, depth to saturated soil, pH, and electrical conductivity (EC). Water-surface elevations were obtained during differential leveling, as described above. Water depths were measured with a ruler. Water-quality measurements (pH and EC) were made with Oakton or Cole-Palmer portable meters that were calibrated daily with standard solutions.

Soil stratigraphy was described from a shallow soil core or soil pit at each plot. Most soil profiles were limited to the seasonally thawed layer (~0.5–1 m) above the permafrost and these samples were obtained from soil plugs dug with a shovel. Deeper soil cores (up to 2.5 m deep) in permafrost were obtained using a 7.5-cm diameter SIPRE corer with a portable power head. Several additional profiles were described from cutbanks after unfrozen material was removed with a shovel to expose undisturbed frozen sediments. Descriptions of all profiles were recorded using standard methods (SSDS 1993), and included the texture and color of each horizon, the depth of organic matter, type and percentage of coarse fragments, depth to rock (>15% by volume), redoximorphic characteristics, depth of thaw, and ice volume and structure. Cryogenic structure (forms, distribution, and volumes of ice) was classified in the field according to a modified system (Jorgenson et al. 1996), based on systems developed by Katasonov (1969) and Murton and French (1994). Similar horizons or sequences of repeating textures were grouped into lithofacies for depiction on toposequences. A single simplified texture (i.e., loamy, sandy, organic) was assigned to characterize the dominant texture in the top 40 cm at each plot for ecotype classification.

Vegetation structure and composition were assessed semi-quantitatively. Cover of each species was visually estimated to the nearest 1%, if cover was <10%, to the nearest 5% for cover between 10 and 30%, and to the nearest 10% where cover was >30%. Species with isolated individuals with very low coverage were assigned a cover value of 0.1%. A species list was compiled that included all vascular plants and the dominant nonvascular plants observed in the plot. Total cover of each plant growth form (e.g., tall shrub, dwarf shrub, lichens) was estimated independently of the cover estimates for individual species. Data were then cross checked to ensure that the cover values for individual species within a growth form added up to the total cover estimated for that growth form. Taxonomic nomenclature followed Viereck and Little (1972) for shrubs and Hultén (1968) for other vascular plants. Nomenclature for bryophytes and lichens followed the National Plants Database (NRCS 2001). Identification of mosses and lichens during field sampling was limited to dominant, readily identifiable species. Dominant cryptogams that could not be identified in the field were collected and sent to Mikhail Zhurbenko and Olga Afonina, Komarov Botanical Institute, Russia, for identification. Nomenclature used by Zhurbenko and Afonina was revised to that used by the National Plants Database.

ACCURACY ASSESSMENT

As part of the field survey in 2002, data were collected for an accuracy assessment of the ecological land classification and derived wildlife habitat map. Sampling was done along four long transects (~8 km each) distributed across the study area. Along each transect, ~40 verification plots were established at 250-m intervals for a total of 190 plots. If a plot did not fall in an area of uniform vegetation consistent with the minimum size for a map unit (0.5 ha), it was moved slightly to place it in a homogeneous area. At each plot, information was collected on GPS location, surface form, Viereck vegetation class, ecotype, and dominant plant species (if needed to resolve uncertainties between vegetation classes). Photographs also were taken at each plot. To ensure consistency in classification, field data, and photographs for all plots were reviewed in the office by a single observer, who determined the final vegetation type, ecotype, and habitat type for each plot. While data were gathered to evaluate map accuracy for both the 2001 and 2002 study areas, mapping has only been completed for the 2001 study area to date. Only 118 of the 190 plots were within the 2001 area and available for analysis. Omission and commission errors then were tabulated for vegetation types, ecotypes, and habitats by comparing ground identifications with map polygon identifications (Congalton 1991).

CLASSIFICATION

Ecosystem classification was undertaken at two levels. First, individual ecological components were classified and coded using standard classification systems developed for Alaska (Table 1). Second, these ecological components were integrated to classify ecotypes (local-scale ecosystems) that best partitioned the range of variation for all the measured components.

ECOLOGICAL COMPONENTS

Geomorphic (terrain) units were classified according to a system based on landform-soil characteristics for Alaska, originally developed by Kreig and Reger (1982) and the Alaska Division of Geological and Geophysical Survey (1983) and modified for this study. We relied on the classification of surficial deposits by Rawlinson (1993) and on the surficial geology map of the Harrison Bay quadrangle by Galloway and Carter (1985). We emphasized materials near the surface (<2 m) because they have the greatest influences on ecological processes. For example, we differentiated several types of alluvial deposit (active, inactive, and abandoned floodplains) that were not differentiated by Carter and Galloway (1985). Within the geomorphic classification, we also classified waterbodies based on their depth, connectivity, salinity, and genesis.

Surface forms (macrotopography) were classified according to a system modified from that of Schoeneberger et al. (1998). Microtopography was classified according to the periglacial system of Washburn (1973). Surface form characteristics also were assigned to waterbodies, to differentiate waterbodies with islands or polygonized margins. Soil characteristics were classified according to *Keys to Soil Taxonomy*, Eighth Edition (Soil Survey Staff 1998).

Vegetation initially was classified in the field using the Alaska Vegetation Classification (AVC) developed by Viereck et al. (1992), with slight modifications to include information from Walker and Acevedo (1987). We also included an additional salt-affected class created for the Colville Delta (Jorgenson et al. 1997). After fieldwork was completed and unknown specimens were identified, floristic associations were assigned using a three-step process. First, TWINSPAN analysis (MjM Software Design 1999) was conducted to differentiate plant associations. Second, sorted table analysis was used where needed to reassign plots that fell near boundaries between classes, or to improve consistency with physiography, geomorphic units, or soil chemistry. Dominant and differential species for each class then were identified. The dominant is a species consistently present at moderate to high cover values in a particular association. The differential is a species that, in combination with a particular dominant, is highly diagnostic of a particular plant association, although its cover may be low. A dominant and a differential species comprise the name of each plant association.

Table 1. Coding system for classifying and mapping geomorphic units, surface forms and vegetation in the Northeastern Planning Area of the NPRA, 2002.

Code	Class	Code	Class
	GEOMORPHIC UNIT		SURFACE FORM (cont)
Cs	Solifluction Deposit	Fb	Bar (point, lateral, mid-channel) (not mapped)
Cl	Landslide Deposit (not mapped)	Fh	Hummocks (not mapped)
Esa	Eolian Active Sand Deposit	Fr	Ripples (not mapped)
Esi	Eolian Inactive Sand Deposit	Lp	Polygonized Pond Margins (can include islands)
Fdoa	Delta Active Overbank Deposit	Mg	Gelifluction Lobes
Fdoi	Delta Inactive Overbank Deposit	Ms	Strang
Fdob	Delta Abandoned Overbank Deposit	Mu	Undifferentiated Mounds
Fdra	Delta Active Channel Deposit	N	Nonpatterned
Fdra	Delta Inactive Channel Deposit	Pd	Disjunct Polygon Rims
Fhl	Lowland Headwater Floodplain	Phh	High-centered, High-relief Polygons
Fmoa	Meander Active Overbank Deposit	Phl	High-centered, Low-relief Polygons
Fmoi	Meander Inactive Overbank Deposit	Plhh	Low-centered, High-relief, High-density Polygons
Fmob	Meander Abandoned Overbank Deposit	Plhl	Low-centered, High-relief, Low-density Polygons
Fmraf	Meander Fine Active Channel Deposit	Pllh	Low-centered, Low-relief, High-density Polygons
Fmrif	Meander Fine Inactive Channel Deposit	Plll	Low-centered, Low-relief, Low-density Polygons
Fto	Old Alluvial Terrace	Pm	Mixed High- and Low-centered Polygons
Ltiu	Thaw Basin, Ice-rich Undifferentiated	Sb	Bluffs and Streambanks (Lake banks)
Ltic	Thaw Basin, Ice-rich Center	Tb	Beads (as beaded stream)
Ltim	Thaw Basin, Ice-rich Margin	Tm	Mixed Thermokarst Pits and Polygons
Ltip	Thaw Basin Pingo	W	Water
Ltnc	Thaw Basin, Ice-poor Center	Wi	Lake with Islands
Ltnm	Thaw Basin, Ice-poor Margin	Xb	Basin Complex
Ltnu	Thaw Basin, Ice-poor Undifferentiated (not mapped)	Xr	Riverine Complex
Ltdn	Delta Thaw Basin, Ice-poor	Xd	Dune Complex
Mta	Active Tidal Flat		
Mti	Inactive Tidal Flat		VEGETATION CLASS
Mp	Alluvial–Marine Deposit	Bbg	Barrens (<5% veg)
Wldit	Deep Isolated Thaw Lake	Bpv	Partially Vegetated (5–30%)
Wlsit	Shallow Isolated Thaw Lake	Hgmss	Moist Sedge–Shrub Tundra
Wldir	Deep Isolated Riverine Lake	Hgmt	Tussock Tundra
Wlsir	Shallow Isolated Riverine Lake	Hafm	Common Marestail Marsh (not mapped)
Wldirt	Deep Isolated Riverine–Thaw Lake	Hgwfg	Fresh Grass Marsh
Wlsirt	Shallow Isolated Riverine–Thaw Lake	Hgwfs	Fresh Sedge Marsh
Wldcr	Deep Connected Riverine Lake	Hgwst	Wet Sedge Meadow Tundra
Wldcrt	Deep Connected Riverine–Thaw Lake	Sddt	Dryas Dwarf Shrub Tundra
Wldcrh	Deep Tapped Riverine Lake, High-water Connection	Sdec	Cassiope Dwarf Shrub Tundra
Wlscrh	Shallow Tapped Riverine Lake, High-water Connec.	Slobe	Open Low Shrub Birch–Ericaceous Shrub (not mapped)
Wlscr	Shallow Connected Riverine Lake	Slcw	Closed Low Willow Shrub
Wlsct	Shallow Connected Thaw Lake	Slow	Open Low Willow Shrub
Wlsid	Shallow Isolated Dune Lake	Stow	Open Tall Willow Shrub
Weldl	Brackish Deep Lake, Low-water Connection	Stcw	Closed Tall Willow Shrub
Welsl	Brackish Shallow Lake, Low-water Connection	Hgwhs	Halophytic Sedge Wet Meadow
Welt	Tidal Lake	Hgwhk	Salt-killed Wet Meadow
Wrhl	Lowland Headwater Stream	Sdwgh	Halophytic Willow Dwarf Shrub Tundra
Wrln	Lower Perennial Non-glacial River	W	Water
Wert	Tidal River	Xbo	Old Basin Wetland Complex
Wmn	Nearshore Water	Xby	Young Basin Wetland Complex
		Xr	Riverine Complex
	SURFACE FORM	Xd	Dune Complex
Dt	Water Tracks	Xp	Deep Polygon Complex
Ek	Streaked Dune		
Es	Small Dune		EXAMPLE OF ITU CODING SYSTEM
			Geomorphic Unit/ Surface Form/ Vegetation
			Ltim/Ms/Hgwst or Wsir/W/Hgwfg

ECOTYPES AND ECODISTRICTS

Classification of ecotypes was accomplished in three general steps: (1) the detailed ground descriptions were individually classified, (2) graphic profiles (toposequences) were developed to illustrate trends in ecosystem components along transects, and (3) contingency tables were used to identify the common relationships and central tendencies. In developing the ecotype classes, we tried to use ecological characteristics (primarily geomorphology, surface form, and vegetation structure) that could be interpreted from aerial photographs. We also developed a nomenclature for ecotypes that explicitly relates ecological characteristics (physiography, moisture, vegetation structure, and dominant species) in a terminology that can be easily understood.

To reduce the number of ecotype classes, we aggregated the field data for individual ecological characteristics (e.g., soil stratigraphy and vegetation composition), using a hierarchical approach (Figure 3). For geomorphology, we aggregated classes, textures, layers, and lithofacies into geomorphic units (architectural elements) using the approaches of Miall (1985) and Brown et al. (1997). Geomorphic units were assigned to physiographic settings based on their erosional or depositional processes (Appendix Table 4). Surface-forms were aggregated into a reduced set of slope elements (crest, upper slope, lower slope, toe, and flat). For vegetation, we used the structural levels of the Alaska Vegetation Classification (Viereck et al. 1992), because they are readily identifiable on aerial photographs. Some textural classes were grouped (e.g., sandy and loamy) because the vegetation classes were similar, and some similar vegetation structures (e.g., open and closed shrub) were grouped because species composition was similar. Ecotype names were based on the aggregated ecological components.

Common relationships among ecosystem components were identified by visual examination of graphic profiles, use of contingency tables, and multivariate ordination. Graphical presentation of topographic sequences provided an overview of successional relationships among vegetation classes and landscape features. The contingency tables sorted plots by physiography, soil texture, geomorphic unit, drainage, soil chemistry (pH and salinity), and vegetation type. From these tables, common associations were identified and unusual associations either were lumped with those having similar characteristics or excluded as unusual (outliers). Detrended correspondence analysis (DCA) was conducted to identify the principal environmental factors affecting the distribution of plants. After the reduced set of ecotypes was finalized, we calculated descriptive statistics for vegetation (means and frequencies in floristic tables) and environmental factors (means and standard deviations) to compare ecotypes. Our goal was to identify strong relationships that could be used for prediction and mapping, while avoiding the creation of additional classes that would lead to confusion and decrease accuracy.

For classification of ecosystems at smaller spatial scales, geomorphic and physiographic criteria were used to differentiate ecodistricts and ecosubdistricts (Appendix Table 1). The name for each unique ecodistrict or ecosubdistrict was based on a general physiographic descriptor (e.g., lowland or highland) and a prominent nearby geographic feature (e.g., a specific creek or mountain).

MAPPING

Ecosystems were mapped at two spatial scales. Individual ecological components, which were later aggregated into ecotypes, were mapped at a large scale (1:10,000). Ecodistricts and ecosubdistricts were mapped at a small scale (1:250,000), to differentiate regions with recurring geomorphic units and vegetation types on the landscape.

ECOLOGICAL COMPONENTS

Individual ecological components were mapped simultaneously at 1:10,000 as compound codes called integrated terrain units (ITUs). ITUs were mapped by assigning a four-parameter code to each polygon describing geomorphology, surface form, vegetation, and disturbance type (e.g., Fmoi/Pd/Hgwst). Delineation was done on-screen using a true color, orthorectified, photo-mosaic developed from 2001 aerial photography and produced by AeroMap, Inc. (Anchorage, AK). This mosaic provided the geometric control for mapping and all linework

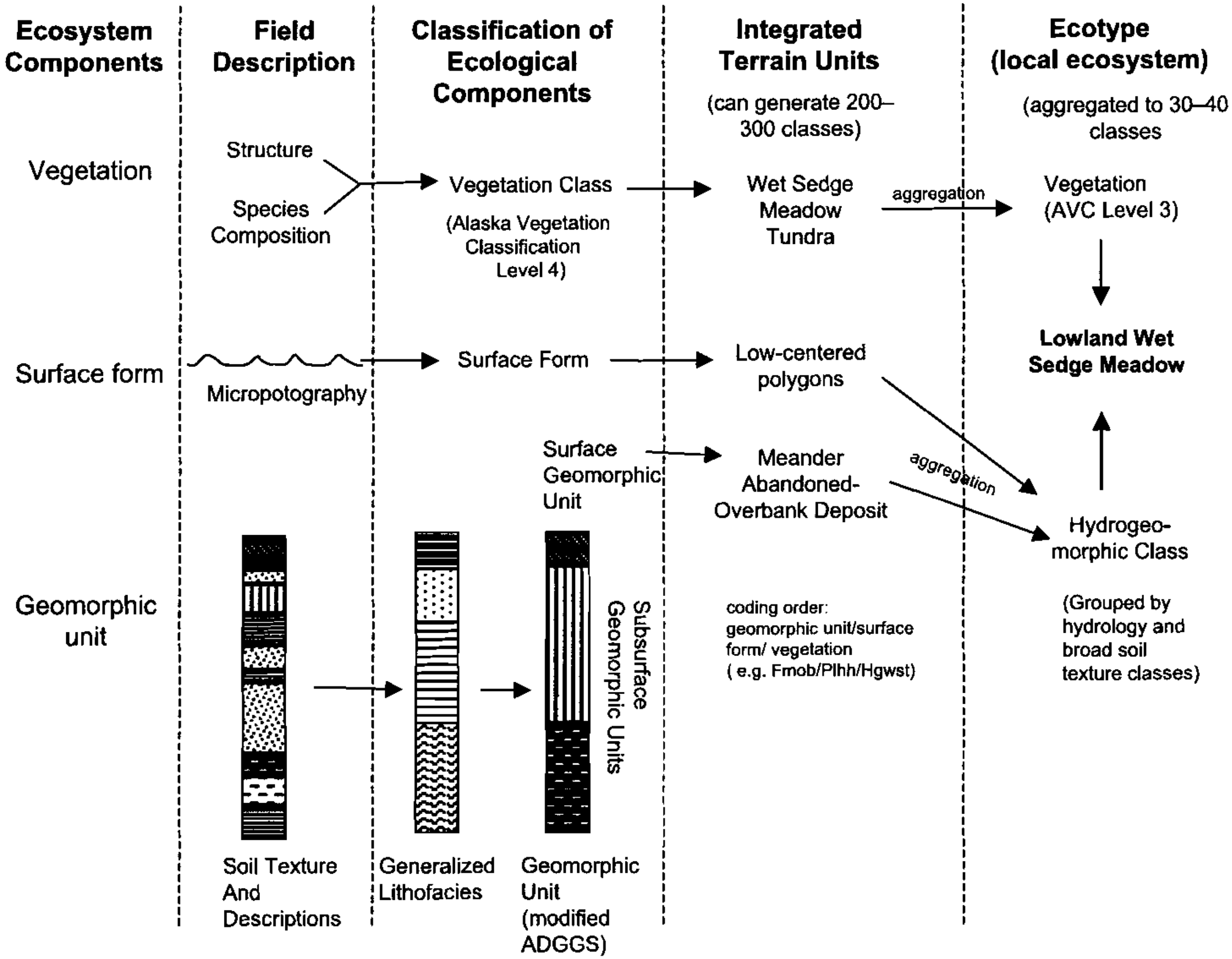


Figure 3. System for integrating vegetation, surface form and geomorphic units into integrated terrain units (ITU) and then grouping ITUs into ecotypes.

was registered to this base. We also referred to paper copies of the 2001 color photography (1:14,400 scale) and 1980 CIR photography (1:60,000 scale) using a stereoscope to help improve interpretation of difficult terrain. The minimum mapping size for polygons (for mapping purposes a 'polygon' is defined as an area delineated on the map as a single unit, it does not refer to polygons in the sense of polygonized landforms) was 0.25 ha for waterbodies, 2.0 ha for complexes, and 0.5 ha for all other classes. We created four complex surface vegetation classes to map highly heterogeneous areas associated with dynamic geomorphic processes. The complexes were used for polygons where at least three vegetation types were present, the dominant cover type occupied <70% of the polygon, and inclusions were below the minimum size for mapping. Individual maps were produced for each of the ecological components used to create the ITUs: geomorphology, waterbodies, surface forms, and vegetation.

ECOTYPES AND ECODISTRICTS

Based on relationships among ecological components developed from analysis of field survey data, we aggregated the 325 different ITU code combinations into 43 ecotypes (Appendix Table 4). In many instances, small differences in soil characteristics associated with terrain units or in surface forms could be combined within the broader concept of an ecotype. For example, the ITUs "Meander Inactive Overbank Deposit/ Nonpatterned/Wet Sedge Meadow Tundra," "Meander Inactive Overbank Deposit/Disjunct Polygons/Wet Sedge Meadow Tundra," and "Meander Inactive Overbank Deposit/ Low-centered, Low-relief, Low-density Polygons/Wet Sedge Meadow Tundra" were aggregated into Riverine Wet Sedge Meadow. This approach preserved characteristics related to both geomorphic processes and vegetation development and allowed us to systematically reduce the data to a manageable number of classes.

Ecodistricts were delineated on-screen over a 1:100,000-scale view of a Landsat TM image mosaic created by NASA. During delineation we referred to the surficial geology map for the NPRA (Galloway and Carter 1985), a map of marine transgressions (Carter and Galloway 1982), land resource areas used in the exploratory soil survey of Alaska (Rieger et al. 1979), and the map of ecoregions of Alaska (Nowacki et al. 2002) to try to provide consistency in boundaries. Ecodistrict mapping encompassed a much larger area than the study area to identify smaller scale relationships of the landscape.

EVALUATION AND MODELING

In this report, we present four uses of the integrated-terrain-unit map for evaluating the ecological capabilities of the land: wildlife habitat characterization, flood distribution, oil spill sensitivity, and winter travel sensitivity. In developing these land evaluations we used analyses from other studies to evaluate or rank the capabilities of geomorphic units or ecotypes associated with the ITUs. The ITU map allowed us to develop spatially explicit models of the distributions of these capabilities.

The wildlife habitat classification was based on landscape properties that we considered most important to wildlife: shelter, security (or escape), and food. These factors may be directly related to the quantity and quality of vegetation, plant species composition, surface form, soils, hydrology, and/or microclimate. We emphasize here that wildlife habitats are not equivalent to vegetation types. In some cases, dissimilar vegetation types may be combined because selected wildlife species either do not distinguish between them or use them similarly. Conversely, wildlife may distinguish between habitats with similar vegetation on the basis of relief, soil characteristics, invertebrates, or other factors not reflected in plant species composition. We also emphasize that wildlife habitat classifications for the same region may differ, depending on the wildlife species or species groups being considered. In our study, we concentrated on (1) breeding waterbirds that use waterbodies and wet and moist tundra types, and (2) mammals and upland birds that use shrublands and dry tundra types. We consolidated 325 ITUs into a set of 27 wildlife habitat types from a hierarchical classification of wildlife habitats (Appendix Table 5) that has been used in bird-habitat studies in the Prudhoe, Kuparuk, and Alpine oilfields (Jorgenson et al. 1989, Murphy et al. 1989, Johnson et al. 1990, Anderson et al. 1992, Murphy and Anderson 1993, Johnson et al. 1997).

We developed a simple model for mapping flood distribution and frequency across the study area based on sedimentation characteristics of the various geomorphic units:

- fluvial deposits consisting entirely of mineral sediments = frequent flooding,
- fluvial deposits with interbedded mineral and organic layers = infrequent flooding,
- fluvial deposits consisting entirely of organic material = rare flooding, and
- non-fluvial deposits = not flooded.

The estimated return periods for these general classes of flooding frequency were assigned based on relationships developed for the Colville Delta (Jorgenson et al. 1996). These relationships were developed from a more rigorous analysis of (1) the relative elevations of terrain units, (2) the areas flooded at various flood stages using flood distribution maps from a limited number of years, (3) analysis of sediment deposition and driftwood occurrence, and (4) comparison of stage-discharge and flood-frequency relationships at the head of the delta with relative elevations of terrain units. The flood-frequency map was produced by recoding the geomorphic map.

The sensitivities of ecotypes to oil spills and cleanup activities were ranked based on (1) potential for oil to infiltrate the soil, (2) microrelief associated with surface forms, (3) the abundance of evergreen shrubs, and (4) the results of case histories at past spill locations. The potential for oil infiltration was ranked from high to low based on the depth to water, assuming that oil will infiltrate more deeply in well-drained soils than in saturated soils. Areas with flatter microrelief were considered less sensitive because cleanup operations would be easier. The abundance of evergreen shrubs is important because these plants are adapted to slow growth in nutrient poor environments and recover slowly from damage. The sensitivity map was produced by recoding the ecotype map.

The map depicting the sensitivity of ecotypes to winter travel also was produced from the ecotype map. The winter travel map was based on parameters similar to those of the oil spill sensitivity map, but rankings for ecosystems were slightly different, based on case histories of past disturbances.

RESULTS AND DISCUSSION

ECOLOGICAL COMPONENTS

CLIMATE

Northeastern NPRA falls within two climatic zones: the Arctic Coastal zone that extends about 20 km inland from the ocean, and the Arctic Inland zone that extends 100–200 km southward from the Arctic Coastal zone to the lower foothills of the Brooks Range (Zhang et al. 1996). The Arctic Coastal zone has cool summers and cold winters with less extreme variations in temperature, due to the moderating influence of the ocean. The Arctic Inland zone has a mean annual air temperature similar to the Arctic Coast zone, but the winter temperatures are colder and summer temperatures are warmer. Precipitation is slightly higher than in the Arctic Coastal zone.

Based on long-term climatic records for Kuparuk (elevation 20 m), the nearest station in the Arctic Coastal zone to the study area, mean annual air temperature is –11.7°C, with mean monthly temperatures ranging from –28.2°C in January to 8.6°C in July (Figure 4). The thawing season lasts approximately 110 days, beginning in late May and ending in mid October. Mean annual precipitation is 95 mm, with mean monthly precipitation ranging from 1 mm in May to 29 mm in August. About 50% of the precipitation falls as snow, and snow covers the ground for 8–10 months each year.

Climatic records for Umiat, in the Arctic Inland zone, represent climatic conditions just beyond the southern edge of the study area. At Umiat, mean annual air temperature is –11.9°C, with mean monthly temperatures ranging from –29.4°C in January to 12.4°C in July. The thawing season lasts approximately 110 days beginning in late May and ending in mid October. Mean annual precipitation is 139 mm, with mean monthly precipitation ranging from 2 mm in May to 27 mm in August. While Umiat has approximately the same mean annual temperature as Kuparuk in the Arctic Coastal zone, it has colder winters and warmer summers. Precipitation is slightly higher

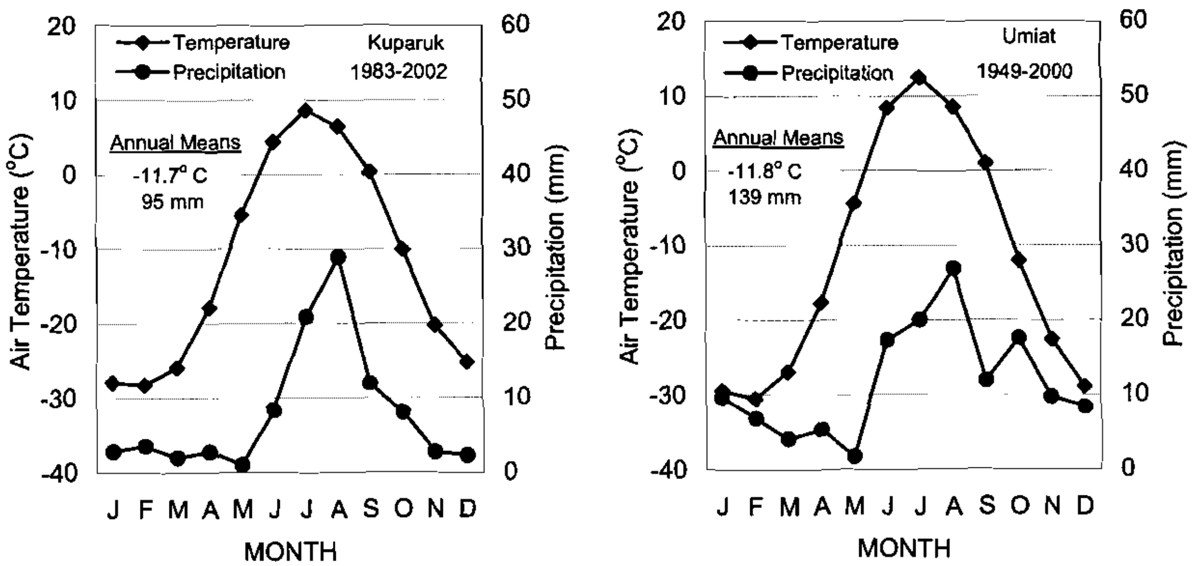


Figure 4. Climate diagram for the Kuparuk and Umiat Stations adjacent to the Northeastern Planning Area of the NPRA.

than in the Arctic Coastal Zone, particularly during early summer and early winter.

GEOMORPHIC UNITS

Twenty-seven terrestrial geomorphic units were identified within the delta and the adjacent coastal plain (Table 2). Two of these units (Slump Deposits and Loess) were too small in extent to map. A map of geomorphic units (at the surface) revealed large differences in the distribution of geomorphic units between the coast and the adjacent coastal plain (Figure 5, Table 3). Geomorphic units that were common along the coast included: Active Tidal Flat (1.2% of total area), Delta Inactive Overbank Deposits (0.6%), and Delta Active Channel Deposits (0.2%). In contrast, common geomorphic units on the adjacent coastal plain included Ice-rich Margins of Thaw Basins (25.9%), Alluvial–Marine Deposits (21.3%), Ice-rich Centers of Thaw Basins (10.5%), Eolian Inactive Sand Deposits (7.3%), and Old Alluvial Terrace (2.3%). Floodplains were dominated by Meander Inactive Overbank Deposits (5.9%) and Meander Abandoned Overbank Deposits (1.1%).

Geomorphic units are ecologically important because they represent areas with differing erosional and depositional environments and thus, have different types of naturally occurring disturbances. For example, Meander Active Overbank Deposits are frequently flooded (every 3–5 years). This frequent sediment deposition prevents development of a moss layer and contributes nutrients that presumably contribute to the vigorous growth of shrubs in the well-drained soils. In contrast, Alluvial–Marine Deposits are old portions of the landscape that are not affected by flooding, but are subject to disturbance associated with cryoturbation and to thermokarst of large ice wedges.

During classification and mapping, we maintained consistency with earlier studies in the area to the greatest extent possible. Surficial deposits in the area have been mapped at both regional (Williams et al. 1977, NPRATF 1978) and local (Carter and Galloway 1985) scales in anticipation of oil exploration. Our more detailed mapping relied on the basic units and concepts mapped by Carter and Galloway (1985), but we modified their classification to better differentiate active and inactive processes associated with

Table 2. Classification and description of geomorphic units in the Northeastern Planning Area of the NPRA, 2002. Geomorphic units modified from Cater and Galloway (1985) and Kreig and Reger (1982).

Unit	Description
Solifluction Deposit	Unconsolidated fine-grained, sandy, or gravelly material, resulting from mass movement of saturated materials. Usually associated with gelifluction processes at the base of slopes and in snowbeds.
Slump Deposit (not mapped)	A type of landslide deposit characterized by downward slipping of unconsolidated fine-grained to gravelly material moving as a unit. Slumps typically are associated with cutbanks along river channels. Areas with slumping often have minor amounts of other mass-wasting processes including debris sliding and falling.
Eolian Active Sand Deposit	Fine to very fine, well-sorted sand containing abundant quartz with minor dark minerals. Sand is stratified with large-scale cross bedding in places. Active dunes are barren or partially vegetated and are undergoing active accretion and deflation. Active dunes usually occur adjacent to exposed sandy channel deposits.
Eolian Inactive Sand Deposit	Fine to very fine, well-sorted sand containing abundant quartz with minor dark minerals. Sand is stratified with large-scale cross bedding in places. Often contains buried soils and peat beds in upper few meters. Inactive dunes are well vegetated, typically have thin to thick organic soil horizons at the surface, and are not subject to active scouring or movement. Inactive dunes occur both on the coastal plain and adjacent to river channels. While much of the Arctic Coastal Plain is covered by thin sand sheets, the sandy surface material is usually included as a component of the Alluvial Plain and Alluvial-Marine Deposits.
Delta Active Channel Deposits	Silty and sandy channel or lateral accretion deposits laid down from the bed load of a river in a deltaic setting under low water velocities. This unit includes point bars, lateral bars, mid-channel bars, unvegetated high-water channels, and broad sandbars exposed during low water. Generally, sediment texture becomes finer in a seaward direction along the distributaries. Organic matter, including driftwood, peat shreds, and other plant remains, usually is interbedded with the sediments. Only those riverbed deposits that are exposed at low water are mapped, but they also occur under rivers and cover deposits. Frequent flooding (every 1–2 yr) prevents the establishment of permanent vegetation.
Delta Inactive Channel Deposits	Delta deposits in channels that are only flooded during periods of high flow. Because of river meandering these "high-water" channels are no longer active during low-flow conditions. Generally, there is little indication of ice-wedge development, although a few older channels have begun to develop polygon rims. Very old channels with well-developed low-centered polygons are not included in this unit.
Delta Active Overbank Deposits	Thin (10–50 cm) fine-grained, horizontally stratified cover deposits (primarily silt) that are laid down over sandier channel deposits during flood stages. Relatively frequent (every 3–4 yrs) deposition prevents the development of a surface organic horizon. Supra-permafrost groundwater generally is absent or occurs only at the bottom of the active layer during mid-summer. This unit usually occurs on the upper portions of point and lateral bars and supports low and tall willow vegetation.
Delta Inactive Overbank Deposits	Fine-grained cover or vertical accretion deposits laid down over coarser channel deposits during floods. The surface layers are a sequence (20–60 cm thick) of interbedded organic and silt horizons, indicating occasional flood deposition. Under the organic horizons is a thick layer (0.32 m thick) of silty cover deposits overlying channel deposits. Surface forms range from nonpatterned to disjunct and low-density, low-centered polygons. Lenticular and reticulate forms of segregated ice, and massive ice in the form of ice wedges, are common.
Delta, Abandoned-floodplain Cover Deposit	Peat, silt, or fine sand (or mixtures or interbeds of all three), deposited in a deltaic overbank environment by fluvial, eolian, and organic processes. These deposits generally consist of an accumulation of peat 20–60 cm thick overlying cover and riverbed alluvium. Because these are older surfaces, eolian silt and sand may be common as distinct layers or as intermixed sediments. The surface layer, however, usually lacks interbedded silt layers associated with occasional flood deposition. Lenticular and reticulate forms of segregated ice, and massive ice in the form of ice wedges, are common in these deposits. The surface is characterized by high density, low-relief polygons and represents the oldest surface on the floodplain.
Meander Fine Active Channel Deposits	Sand and mud deposited as lateral accretion deposits in active river channels by fluvial processes. Occassional subrounded to rounded pebbles may be present. Frequent deposition and scouring from flooding usually restricts vegetation to sparse pioneering colonizers. The channel has a meandering configuration characterized by point bars.

Table 2. (Continued).

Unit	Description
Meander Fine Inactive Channel Deposits	Sand and mud deposited as lateral accretion deposits in inactive channels during period of high flow. Because of river meandering these "high-water" channels are no longer active during low-flow conditions. Generally, there is little indication of ice-wedge development, although a few older channels have begun to develop polygon rims. Very old channels with well-developed, low-centered polygons are not included in this unit.
Meander Active Overbank Deposit	Thin (15–30 cm), fine-grained cover deposits (primarily silt) that are laid down over sandy or gravelly riverbed deposits during flood stages. Deposition occurs sufficiently frequently (probably every 3–4 yrs) to prevent the development of a surface organic horizon. This unit usually occurs on the upper portions of point and lateral bars and supports riverine willow vegetation.
Meander Inactive Overbank Deposits	Interbedded layers of peat and silty very fine sand material (15–60 cm thick), indicating a low frequency of flood deposition. Cover deposits below this layer generally consist of silt but may include pebbly silt and sand and usually are in sharp contact with underlying channel deposits. This unit has substantial segregated and massive ice, as indicated by the occurrence ice-wedge polygons.
Meander Abandoned Overbank Deposits	Sediments are a mixure of peat, silt or fine sand. Surface organic horizon is free of fluvial deposits indicating the terrain is no longer affected by riverine processes. Typically, these areas occupy the highest position on the floodplain, and represent the oldest local terrain. Abandoned floodplain deposits typically have at least 20 cm of surface organics over silt-loam or fine sand alluvium. Low center polygons and small ponds are common.
Headwater Lowland Floodplain	Small streams and tributaries in lowland areas that are too small to be delineated apart from their associated floodplains. These low gradient streams carry little sediment and the floodplain generally is restricted to the immediate vicinity of the stream.
Old Alluvial Terrace	Old alluvial deposits, weathered or overlain with eolian and organic material (terrace D of Rawlinson 1993). Soils are cryoturbated loam or sandy loam, buried organics often are present. High-centered polygons are the most common surface form indicating high ice content of surface soils. Thaw basins also are common features.
Alluvial–Marine Deposits	Composition is variable but generally consists of a sequence of eolian, alluvial, and marine deposits. Thickness of pebbly eolian sand is highly variable and sometimes absent. Underlying fluvial deposits include gravelly sand, silty sand, and organic silt and occasionally have buried peat beds and logs. Stratified layers of marine gravelly sand, silty sand, silt and minor clay occur in some locations beneath the fluvial deposits and commonly are fossiliferous. This unit is not subject to river flooding. Surface materials can be differentiated as sandy (Mps) or fine-grained (Mpf). This unit includes both the alluvial sand over marine silt and clay (Qam) and alluvial and eolian sand and marine sand and silt (QTas) units of Cater and Galloway (1985).
Loess (not mapped)	Wind-blown silt and very fine sand in homogeneous, nonstratified deposits. On the coastal plain in the study area, loess typically occurs as a layer too thin (<0.5 m) to map as a surficial material.
Thaw Basin Deposit, Ice-poor Centers	Lacustrine deposits formed by the draining of thermokarst lakes or other lakes. Soils of the basin center typically are fine-grained and organic-rich, with stratigraphy re-formed by subsidence. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently. Ponds in these basins typically have irregular shorelines and are highly interconnected.
Thaw Basin Deposit, Ice-poor Margins	Lacustrine deposits formed by the draining of thermokarst lakes or other lakes. Soils of the basin margins typically are sandy with a thick surface organic horizon. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently. Ponds in these basins typically have irregular shorelines and are highly interconnected.
Thaw Basin Deposit, Ice-rich Centers	The sediments are similar to those of ice-poor thaw lake deposits but have much more ground ice, as indicated by the development of low-centered or high-centered polygons. The centers of basins usually have organic-rich silty sediments that have high-potential for ice segregation and often are raised by ice aggradation. Surface morphology ranges from low-center polygons at early stages of development to high-centered polygons on distinctly raised domes.

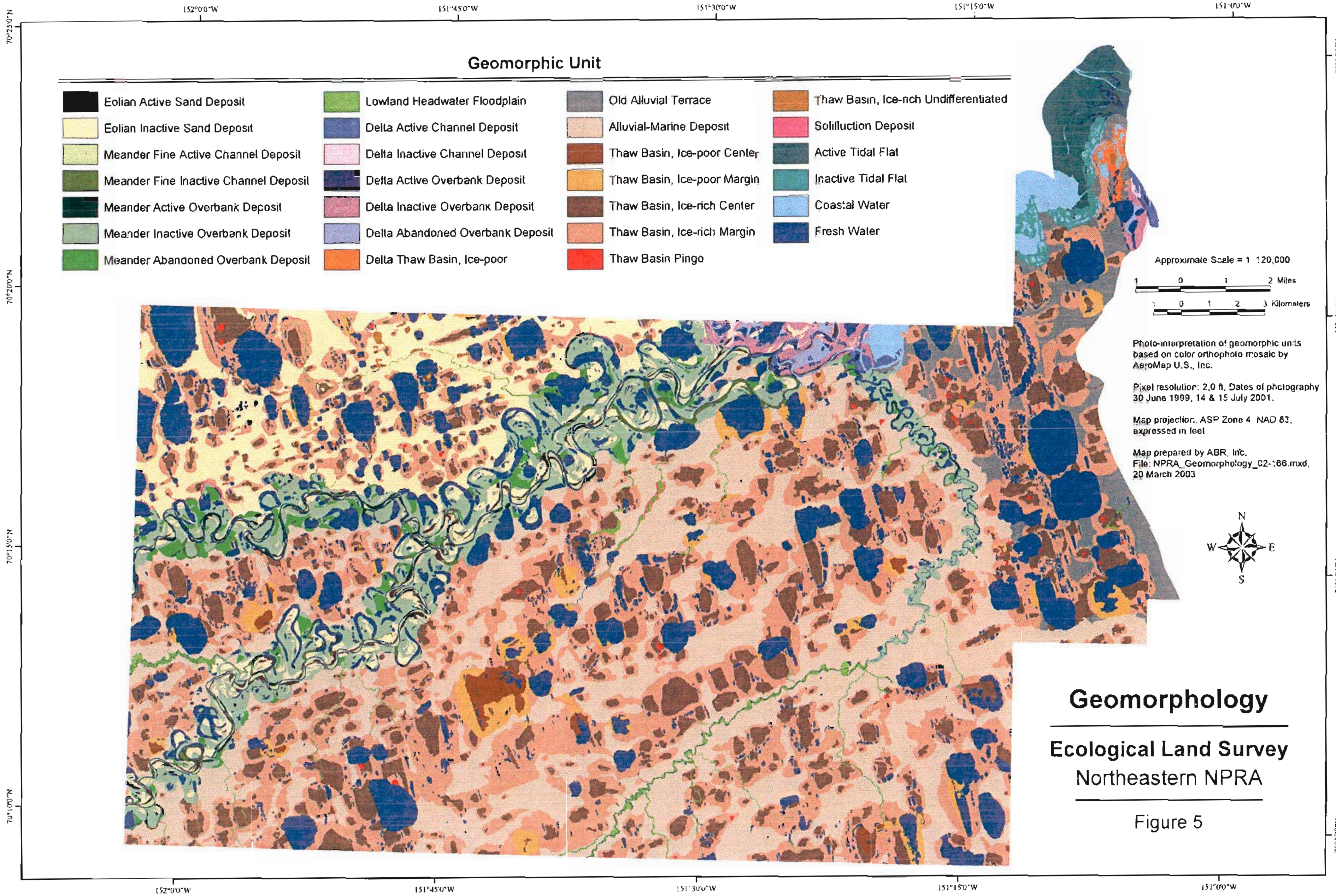
Table 2. (Continued).

Unit	Description
Thaw Basin Deposit, Ice-rich Margins	The sediments are similar to those of ice-poor thaw lake deposits but have much more ground ice, as indicated by the development of low-centered or high-centered polygons. Waterbodies within these basins tend to be rectangular, to have smooth, regular shorelines, and to be poorly interconnected.
Thaw Basin Deposit, Ice-rich Undifferentiated	Sediments similar to ice rich thaw lake deposits but having less ground ice with poorly developed low-centered or high-centered polygons. This type is used when the thaw lake centers and margins are poorly differentiated.
Thaw Basin Deposit, Pingo	Sediments similar to ice-rich thaw basin centers but with much more ground ice indicated by a raised area of well-drained high center polygons.
Delta Thaw Basin, Ice-poor	Deposits in thaw lakes within deltaic deposits. They usually are connected to a river or to nearshore water (tapped lake). Most connections occur when a meandering distributary cuts through a lake's bank; once connected, the lake is influenced by changes in river level. During breakup, large quantities of sediment-laden water flow into the lake, forming a lake delta at the point of breakthrough. Sediments generally consist of fine sands, silts, and clays and typically are slightly saline.
Active Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters and undergoing active sedimentation. Tidal flats occur on seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal flats frequently are associated with lagoons and estuaries and may vary widely in salinity, depending on how exposed the flat is to salt-water incursion and the rate of influx of fresh water. Although similar to delta riverbed/sandbar deposits, they are differentiated by their occurrence as triangular shaped mudflats along the fringe of the delta.
Inactive Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters but sedimentation is infrequent allowing the build up of organic material. The surface is vegetated with halophytic vegetation.

Table 3. Areal extent of terrestrial and aquatic geomorphic units, surface forms, and vegetation classes in the 2001 study area within the Northeastern Planning Area of the NPRA, 2002.

	Area		
Geomorphic Unit	Acres	Ha	%
Terrestrial			
Eolian Active Sand Deposit	705	286	0.4
Eolian Inactive Sand Deposit	12629	5113	7.3
Meander Fine Active Channel Deposit	950	385	0.6
Meander Fine Inactive Channel Deposit	571	231	0.3
Meander Active Overbank Deposit	432	175	0.3
Meander Inactive Overbank Deposit	10131	4102	5.9
Meander Abandoned Overbank Deposit	1809	732	1.1
Lowland Headwater Floodplain	1420	575	0.8
Delta Active Channel Deposit	426	172	0.2
Delta Inactive Channel Deposit	114	46	0.1
Delta Active Overbank Deposit	228	92	0.1
Delta Inactive Overbank Deposit	1051	426	0.6
Delta Abandoned Overbank Deposit	322	130	0.2
Delta Thaw Basin, Ice-poor	268	109	0.2
Old Alluvial Terrace	3984	1613	2.3
Alluvial–Marine Deposit	36635	14832	21.3
Thaw Basin, Ice-poor Center	1036	420	0.6
Thaw Basin, Ice-poor Margin	3743	1515	2.2
Thaw Basin, Ice-rich Center	18047	7307	10.5
Thaw Basin, Ice-rich Margin	44540	18032	25.9
Thaw Basin Pingo	195	79	0.1
Thaw Basin, Ice-rich Undifferentiated	131	53	0.1
Solifluction Deposit	193	78	0.1
Active Tidal Flat	2043	827	1.2
Inactive Tidal Flat	707	286	0.4
Aquatic			
Shallow Isolated Thaw Lake	4330	1753	2.5
Deep Isolated Thaw Lake	15706	6359	9.1
Shallow Connected Thaw Lake	5	2	0.0
Shallow Isolated Riverine Lake	297	120	0.2
Deep Isolated Riverine Lake	2267	918	1.3
Shallow Connected Riverine Lake	42	17	0.0
Deep Connected Riverine Lake	414	168	0.2
Shallow Isolated Riverine–Thaw Lake	481	195	0.3
Deep Isolated Riverine–Thaw Lake	1494	605	0.9
Deep Connected Riverine–Thaw Lake	1411	571	0.8
Shallow Tapped Riverine Lake, High-water Connection	5	2	0.0
Deep Tapped Riverine Lake, High-water Connection	15	6	0.0
Brackish Shallow Tapped Lake, Low-water Connection	9	4	0.0
Brackish Deep Tapped Lake, Low-water Connection	412	167	0.2
Tidal Lake	330	134	0.2
Tidal River	131	53	0.1
Nearshore Water	841	341	0.5
Lowland Headwater Stream	49	20	0.0
Lower Perennial River, non-glacial	1308	530	0.8
Total	171861	69579	100.0
Aggregated Subtotals			
Terrestrial Geomorphic Units	142313	57617	82.8
Coastal Water	1723	698	1.0
Fresh Water	27825	11265	16.2

	Area		
Surface Form	Acres	Ha	%
Small Dune	1008	408	0.6
Streaked Dune	966	391	0.6
Bluffs and Streambanks	717	290	0.4
Gelifluction Lobes	170	69	0.1
Nonpatterned	10879	4405	6.3
Disjunct Polygon Rims	5231	2118	3.0
Low-centered, Low-relief, Low-density Polygons	16822	6810	9.8
Low-centered, Low-relief, High-density Polygons	961	389	0.6
Low-centered, High-relief, Low-density Polygons	281	114	0.2
Low-centered, High-relief, High-density Polygons	290	117	0.2
High-centered, Low-relief Polygons	47869	19380	27.9
High-centered, High-relief Polygons	1051	426	0.6
Mixed High- and Low-centered Polygons	21271	8612	12.4
Mixed Thaw Pits and Polygons	14810	5996	8.6
Strang	948	384	0.6
Undifferentiated Mounds	134	54	0.1
Beads	541	219	0.3
Water Track	553	224	0.3
Polygonized Pond Margin	2905	1176	1.7
Lake with Islands	9640	3903	5.6
Basin Complex	15740	6373	9.2
Dune Complex	1875	759	1.1
Riverine Complex	197	80	0.1
Water	17001	6883	9.9
Total	171861	69579	100.0
Vegetation Class			
Open Tall Willow Shrub	656	265	0.4
Closed Tall Willow Shrub	2	1	0.0
Open Low Willow Shrub	2003	811	1.2
Closed Low Willow Shrub	345	140	0.2
Dryas Dwarf Shrub Tundra	1223	495	0.7
Cassiope Dwarf Shrub Tundra	993	402	0.6
Tussock Tundra	47102	19069	27.4
Moist Sedge–Shrub Tundra	39400	15951	22.9
Wet Sedge Meadow Tundra	24793	10038	14.4
Fresh Sedge Marsh	2854	1155	1.7
Fresh Grass Marsh	486	197	0.3
Halophytic Sedge Wet Meadow	793	321	0.5
Salt-killed Wet Meadow	34	14	0.0
Halophytic Willow Dwarf Shrub Tundra	109	44	0.1
Partially Vegetated	464	188	0.3
Barren	3277	1327	1.9
Dune Complex	1875	759	1.1
Riverine Complex	688	278	0.4
Deep Polygon Complex	74	30	0.0
Young Basin Wetland Complex	622	252	0.4
Old Basin Wetland Complex	15119	6121	8.8
Water	28950	11721	16.8
Total	171861	69579	100.0


Geomorphic Unit
Eolian Active Sand Deposit
Eolian Inactive Sand Deposit
Meander Fine Active Channel Deposit
Meander Fine Inactive Channel Deposit
Meander Active Overbank Deposit
Meander Inactive Overbank Deposit
Meander Abandoned Overbank Deposit
Lowland Headwater Floodplain
Delta Active Channel Deposit
Delta Inactive Channel Deposit
Delta Active Overbank Deposit
Delta Inactive Overbank Deposit
Delta Abandoned Overbank Deposit
Delta Thaw Basin, Ice-poor
Old Alluvial Terrace
Alluvial-Marine Deposit
Thaw Basin, Ice-poor Center
Thaw Basin, Ice-poor Margin
Thaw Basin, Ice-rich Center
Thaw Basin, Ice-rich Margin
Thaw Basin Pingo
Thaw Basin, Ice-rich Undifferentiated
Solifluction Deposit
Active Tidal Flat
Inactive Tidal Flat
Coastal Water
Fresh Water
Approximate Scale = 1 120,000
1 0 1 2 Miles
1 0 1 2 3 Kilometers
Photo-interpretation of geomorphic units based on color orthophoto mosaic by AeroMap U.S., Inc.
Pixel resolution: 2.0 ft, Dates of photography 30 June 1999, 14 & 15 July 2001.
Map projection, ASP Zone 4 NAD 83, expressed in feet
Map prepared by ABR, Inc.
File: NPRA_Geomorphology_02-166.mxd, 20 March 2003
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Geomorphology
Ecological Land Survey
Northeastern NPRA
Figure 5

fluvial, eolian, and lacustrine deposits. We used a map of terraces associated with past marine transgressions (Carter and Galloway 1982) as the main basis for differentiating between and Alluvial–Marine Deposits. For thaw basins, we initiated a new classification approach by differentiating silty centers from sandy margins, and ice-rich basins from ice-poor basins, based on the results of a companion study of geomorphology in the area (Jorgenson et al. 2003).

WATERBODIES

Nineteen classes of waterbody were identified within the delta and the adjacent coastal plain (Figure 6, Table 4). Waterbody types that were common on the coastal plain included Deep Isolated Thaw Lakes (9.1%), Shallow Isolated Thaw Lakes (2.5%), Deep Isolated Riverine Lakes (1.3%), and Lower Perennial Rivers, Non-glacial (0.8%). Salt-affected waterbody types that were common near the coast included Nearshore Water (0.5%) and Tidal Lakes (0.2%).

The waterbody classification differentiated numerous characteristics that affect habitat use by invertebrates, fish, and wildlife. In general, shallow water tends to melt earlier and become warmer than deep water, connected lakes allow better fish passage than isolated lakes, and tapped lakes and brackish lakes have widely varying salinity levels.

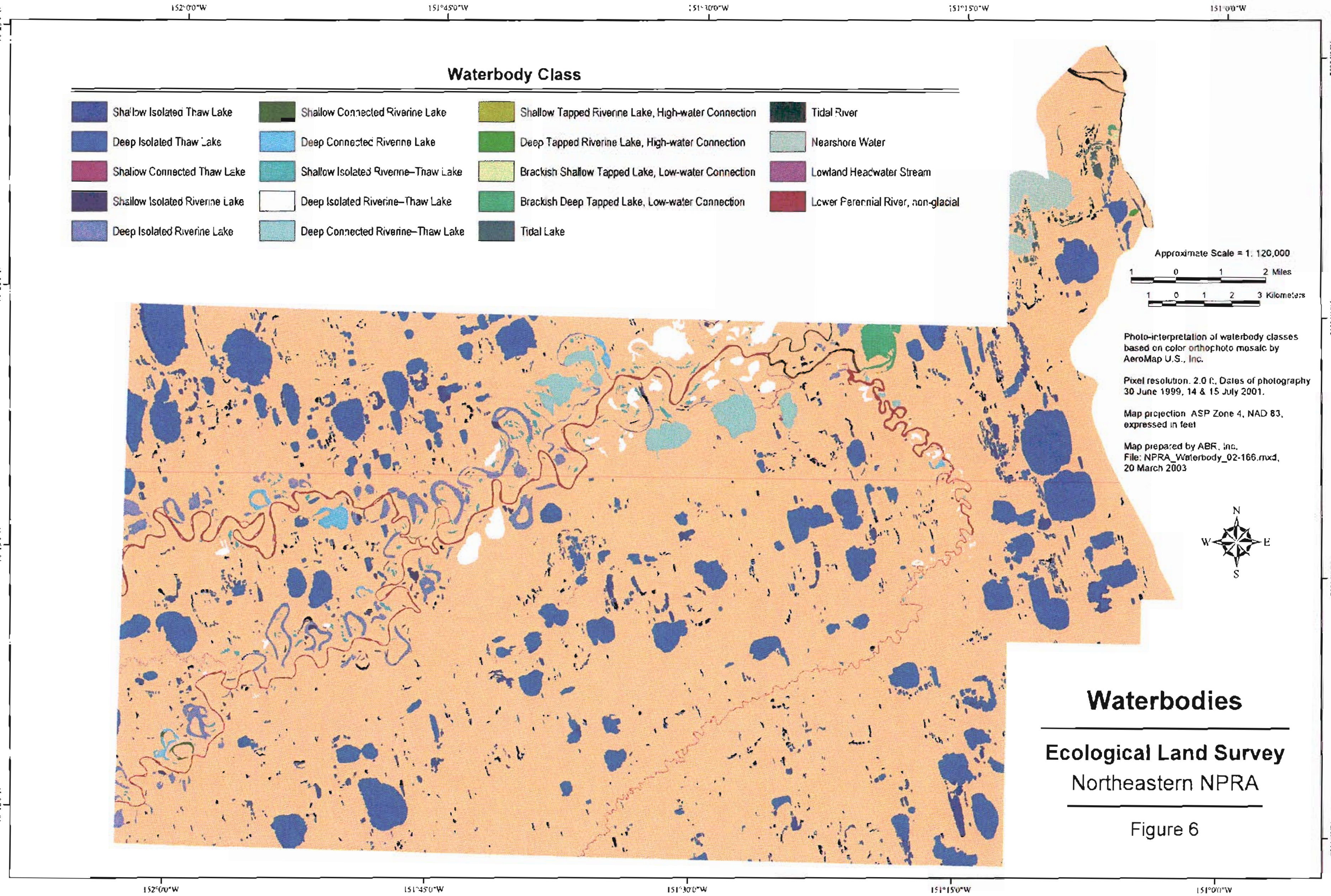
SURFACE FORMS

One of the most striking features of the study area is the seemingly endless variety of patterns on the ground surface. We emphasized surface forms in our mapping because they are related to the to freezing and thawing of surficial materials (Leffingwell 1919, Black 1952, Washburn 1956, Lachenbruch 1962, Hartwell 1973, NWWG 1988) and thus are good indicators of the extent of subsurface ice (Sellman et al. 1972, Billings and Peterson 1980, Walker et al. 1980, Jorgenson et al. 1997). The volume of ice contributed by wedge ice increases from 0% in Nonpatterned areas to 20% in Low-centered, High-density Polygons (Jorgenson et al. 1997). Surface forms also greatly influence drainage patterns and were used to help interpret soil moisture. Nonpatterned areas appear to be more productive, presumably because subsurface movement of water and nutrients is not impeded by the frozen soils underneath the polygon rims.

Twenty-seven surface forms were identified within the delta and the adjacent coastal plain, although three (Hummocks, Ice-cored Mounds, and Ripples) occurred only in areas that were too small or indistinct to map (Figure 7, Table 5). The most common surface forms were High-centered, Low-relief Polygons (27.9%); Mixed High- and Low-centered Polygons (12.4%); Low-centered, Low-relief, Low-density Polygons (9.8%); and Mixed Thaw Pits and Polygons (8.6%) (Table 3). Three surface forms related to water were differentiated because they are important for mapping waterbird habitat: Water (9.9%); Lakes with Islands (5.6%); and Polygonized Pond Margins (1.7%).

SOILS

Twenty-four soil classes (Table 6) were identified during field sampling, the most common types observed being Typic Aquorthel (11.5% of observations), Typic Historthel (8.6%), Typic Cryopsamment (8.0%), Typic Aquiturbel (7.5%), and Typic Histoturbel (6.9%). We did not produce a separate soils map because the landscape relationships were not sufficiently consistent to allow us to reliably predict individual soil types from ITUs or ecotypes. While some soil types were restricted to only a few terrain units, other soil types were found across a wide range of terrain units. For example, Typic Cryofluvents usually were found only on Meander Active Overbank Deposits, and Typic Cryopsamments were found on Eolian Active Sand Deposit and Eolian Inactive Sand Deposit. In contrast, the most common soil type Typic Aquothels was found on 10 different terrain units. The wide diversity of soil types and inconsistent associations with other ecological components were due to the sensitivity of the classification to small differences in organic depth, thaw depth, soil texture, moisture, and layering of horizons. While soils have been classified and mapped using the old Soil Conservation Service (SCS) classification taxonomy for limited areas near Meade River (Everett 1980), Fish Creek (Everett 1978), and Prudhoe Bay (Walker et al. 1980), classification and mapping of soils with the new Natural Resource Conservation Service Soil



Waterbodies

Ecological Land Survey

Northeastern NPRA

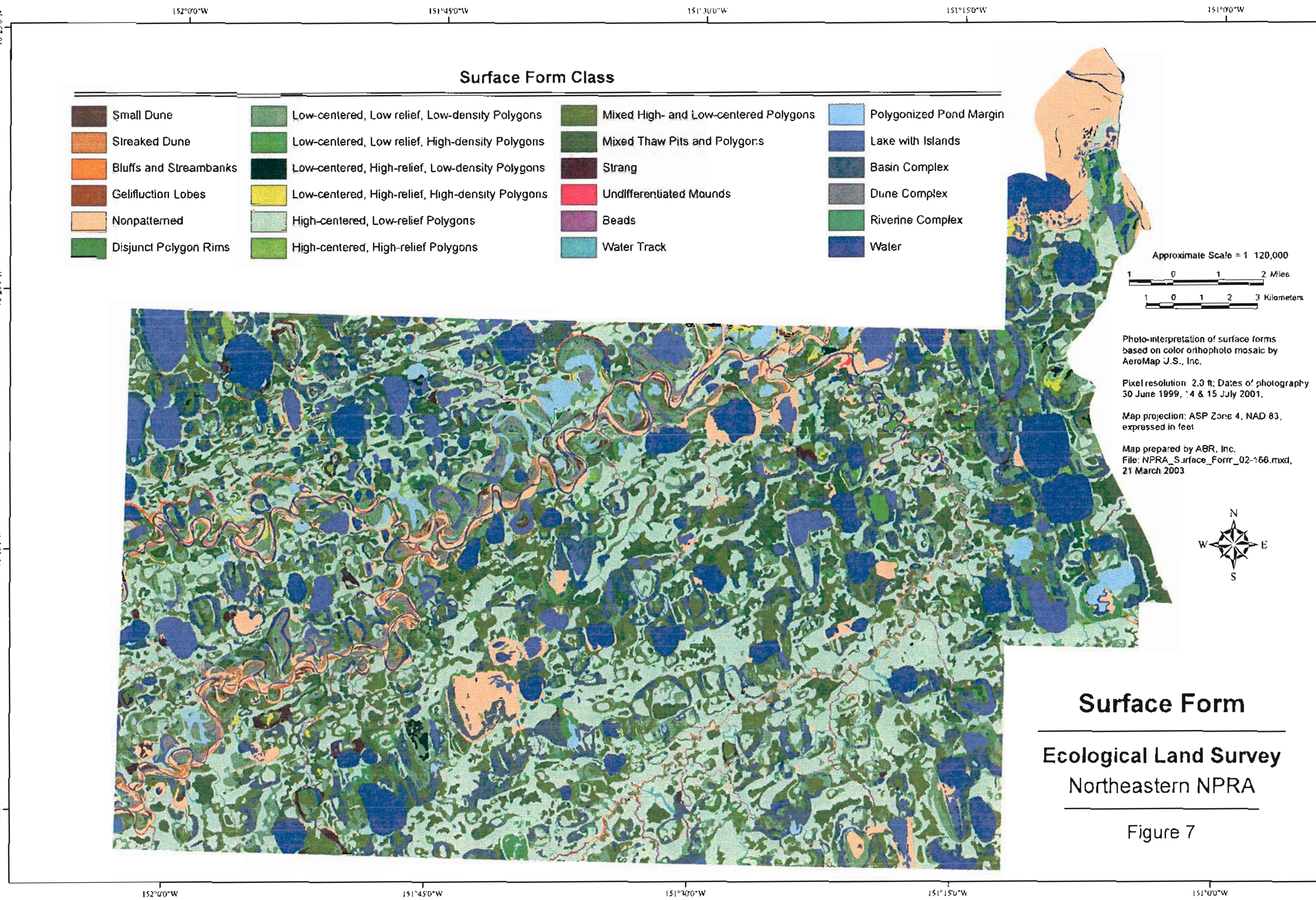
Figure 6

Table 4. Classification and description of waterbodies (aquatic geomorphic units) in the Northeastern Planning Area of the NPRA, 2002.

Unit	Description
Nearshore Water	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and sea ice create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2 m), but storm surges produced by winds may raise sea level as much as 2–3 m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. The ice-free period extends from July until October.
Tidal Lake	Coastal lakes and ponds that are flooded periodically with saltwater during high tides or storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate frequently is silt with some clay and fine sand and occasionally contains peat. Connected and isolated ponds were not differentiated from each other.
Tidal River	Permanently flooded channels of lower Fish Creek and the Colville River that are affected by daily tidal fluctuations and have correspondingly variable salinity. The channels generally experience peak flooding during spring breakup and lowest water levels during mid-summer. During winter unfrozen water in deeper channels can become hypersaline.
Lower Perennial River, Non-glacial	Permanently flooded channels of freshwater rivers where the gradient is low and water velocity is slow. There is no tidal influence and some water flows throughout the summer. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The rivers have well-developed floodplains.
Lowland Headwater Stream	Permanently flooded first order tributaries of Judy Creek, Fish Creek, and the Ublutuoch River.
Deep Connected Riverine Lake	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter and have low-water connections to the main river channel. The lakes develop in abandoned channels and old oxbows. They are subject to infrequent flooding, sedimentation, and fish migration during flooding. Sediments are sand and silt.
Deep Tapped Riverine Lake, High-water Connection	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter. These lakes are connected to rivers during flooding events. They occur on river floodplains above coastal deltas and thus not subject to flooding by brackish water. Sediments are fine-grained silt and clay
Deep Connected Riverine–Thaw Lake	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter and have low-water connections to the main river channel. The lakes develop from thawing of ice-rich permafrost on river floodplains and thus are subject to infrequent flooding, sedimentation, and fish migration during flooding. Sediments are sand and silt.
Deep Isolated Thaw Lake	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter. These lakes have no distinct outlets, and are not connected to rivers. The lakes develop from thawing of ice-rich permafrost. Sediments are fine-grained silt and clay.
Deep Isolated Riverine Lake	Deep (≥1.5 m) waterbodies formed in old river channels. They do not freeze to the bottom during winter. These lakes have no distinct outlets. They are connected to rivers only during flood events. Sediments are fine-grained silt and clay.
Deep Isolated Riverine–Thaw Lake	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter. These lakes have no distinct outlets, and are not connected to rivers. The lakes develop from thawing of ice-rich permafrost on river floodplains and thus are subject to infrequent flooding, sedimentation, and fish migration during flooding. Sediments are fine-grained silt and clay.

Table 4. (Continued).

Unit	Description
Shallow Connected Riverine Lake	Shallow (<1.5 m) ponds or small lakes with or without emergent vegetation that are connected to the river by low-water connections. Lakes form in abandoned channels and old oxbows. Water freezes to the bottom during winter, thaws by early to mid-June, and is warmer than water in deep lakes. Sediments are sand, silt, and clay.
Shallow Tapped Riverine Lake, High-water Connection	Shallow (<1 5 m) ponds or lakes that do not freeze to the bottom during winter. These lakes are connected to rivers during flooding events. They occur on river floodplains above coastal deltas and thus not subject to flooding by brackish water. Sediments are fine-grained silt and clay
Shallow Isolated Thaw Lake	Shallow (<1.5 m) ponds or small lakes with or without emergent vegetation. Water freezes to the bottom during winter, thaws by early to mid-June, and is warmer than water in deep lakes. Sediments are fine-grained silt and clay. These ponds most commonly are found within Ice-rich Thaw Basins
Shallow Connected Thaw Lake	Shallow (<1.5 m) ponds or small lakes with or without emergent vegetation. These lakes are connected to rivers by channels or outlets even during low-water connections. Water freezes to the bottom during winter, thaws by early to mid-June, and is warmer than water in deep lakes. Sediments are fine-grained silt and clay. These ponds most commonly are found within Ice-rich Thaw Basins.
Shallow Isolated Riverine Lake	Shallow (<1.5 m) ponds or small lakes with or without emergent vegetation. Lakes form in abandoned channels and old oxbows. Water freezes to the bottom during winter, thaws by early to mid-June, and is warmer than water in deep lakes. Sediments are sand, silt, and clay.
Shallow Isolated Riverine–Thaw Lake	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter. These lakes have no distinct outlets, and are not connected to rivers. The lakes develop from thawing of ice-rich permafrost on river floodplains and thus are subject to infrequent flooding, sedimentation, and fish migration during flooding. Sediments are fine-grained silt and clay.
Shallow Isolated Dune Lake	Shallow (<1.5 m) ponds or lakes without a distinct outlet that form in depressions among sand dunes. They freeze to the bottom during the winter. This class was mapped only on the Colville Delta.
Brackish Deep Tapped Lake, Low-water Connection	Deep (≥1.5 m) brackish (>800 µS/cm) waterbodies that have been partially drained through erosion of banks by adjacent river channels, and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish because the lakes are usually within the delta and subject to seawater flooding every year. Because water levels have dropped after tapping, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shores. Lakes do not freeze to the bottom during the winter.
Brackish Shallow Lake, Low-water Connection	Shallow (<1.5 m) brackish waterbodies that have been partially drained through erosion of banks by adjacent river channels, and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish because the lakes are usually within the delta and subject to flooding every year. Because water levels have dropped after tapping, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shores. Lakes freeze to the bottom during the winter.



Surface Form Class
Small Dune
Streaked Dune
Bluffs and Streambanks
Gelifluction Lobes
Nonpatterned
Disjunct Polygon Rims
Low-centered, Low relief, Low-density Polygons
Low-centered, Low relief, High-density Polygons
Low-centered, High-relief, Low-density Polygons
Low-centered, High-relief, High-density Polygons
High-centered, Low-relief Polygons
High-centered, High-relief Polygons
Mixed High- and Low-centered Polygons
Mixed Thaw Pits and Polygons
Strang
Undifferentiated Mounds
Beads
Water Track
Polygonized Pond Margin
Lake with Islands
Basin Complex
Dune Complex
Riverine Complex
Water
Approximate Scale = 1:120,000
Miles
Kilometers
Photo-interpretation of surface forms based on color orthophoto mosaic by AeroMap U.S., Inc.
Pixel resolution 2.0 ft; Dates of photography 30 June 1999, 14 & 15 July 2001.
Map projection: ASP Zone 4, NAD 83, expressed in feet
Map prepared by ABR, Inc.
File: NPRA_Surface_Form_02-166.mxd, 21 March 2003
N
S
E
W
152°0'0"W
151°45'0"W
151°30'0"W
151°15'0"W
151°0'0"W
70°25'0"N
70°20'0"N
70°15'0"N
70°10'0"N
Surface Form
Ecological Land Survey
Northeastern NPRA

Figure 7

Table 5. Classification and description of surface form classes in the Northeastern Planning Area of the NPRA, 2002.

Class	Description
Water Tracks	Found in areas where elevation and drainage are sufficient to cause small swales and ephemeral drainage ways but not an incised drainage. Most water tracks are connected polygon troughs in depressed areas of gentle slopes, but they also form short flooded connections between lakes. Water commonly is present throughout the summer months.
Small Dune	Elongated mounds or low ridges composed of wind-blown sand.
Streaked Dune	A form of dune on which wind scouring has caused stripes or undulations in the dune surface. Stripes are roughly parallel and form an acute angle to the long axis of the dune.
Hummocks (not mapped)	Small mounds composed of organic-rich, fine-grained mineral soil, usually < 50 cm high. Hummocks typically occur on gentle slopes and are thought to be caused by runoff from melting snow combined with thermal erosion.
Gelifluction Lobes	Imbricate lobes or sheets formed by slow, massive, downslope flow of saturated soils and vegetation. Gelifluction lobes frequently form on steep slopes where there is a ready source of meltwater and an impermeable frozen sub-layer.
Strang	Small hummocky ridges (< 50 cm high), or strings, formed by ice development and oriented perpendicular to the direction of slope. Areas between strings often have standing water.
Ice Cored Mounds (not mapped)	Small mounds (0.3–1 m high) formed from rapid ice aggradation at the top of the permafrost. The mounds usually are 5–15 m across. They often form in young drained basins.
Undifferentiated Mounds	Isolated but repeating low mounds that are not attributed to specific geomorphic or periglacial processes. In the study area, it was used for low mounds on point bars that are formed partly by eolian and fluvial processes.
Nonpatterned	These flat areas show no evidence of polygonal rims caused by the development of ice wedges. Ice wedges may be present but are not expressed in the surface form. Small, elevated microsites that may be present generally are < 30 cm high and compose less than 5% of the surface area. Nonpatterned ground includes some of the youngest portions of the tundra landscape, such as recently drained thaw lakes or young floodplains.
Ripples (not mapped)	Small scale features with small repeating, sinuous, linear features formed by wind or water movement. They typically occur on point bars and active dunes, but were not mapped. Ripples on active channels were mapped as Nonpatterned.
Disjunct Polygon Rims	Disjunct polygon rims are found where ice-wedge development is evident but not sufficient to create closed polygons. This surface form is common in relatively recently drained thaw basins and isolated depressions in older basins where ice wedges are actively developing.
High-centered, Low-relief Polygons	High-centered polygons are composed of a raised "center" and a relatively low "trough" between centers of adjacent polygons and no rim. Most high-centered polygons range between 5 and 10 m in diameter. Generally, high-centered polygons result from the melting of ice wedges in the troughs between polygons. The centers are only slightly raised (< 50 cm) with respect to the trough or crack areas. This class also includes "flat-centered" polygons where the relief between centers and troughs is barely noticeable. This surface form is common on old surfaces such as abandoned floodplains deposits, alluvial–marine terraces, or older ice-rich drained basins.
High-centered, High-relief Polygons	Areas of high-centered polygons (see above) in which progressive thawing of the ice wedge causes subsidence, resulting in the development of deep (> 50 cm) troughs. This process frequently is related to changes in drainage and can be found near lake outlets, adjacent to streambanks, or resulting from surface disturbance.
Low-centered, Low-relief, Low-density Polygons	Well-developed polygons with a central low "basin," a raised "rim," and (frequently) a "trough" between polygons. Typically, polygons range from 15 to 30 m across and rims are less than 50 cm tall. Larger polygons often are partially bisected by newly forming rims. The polygons are formed by the development of a polygonal network of ice wedges in the permafrost.

Table 5. (Continued).

Class	Description
Low-centered, Low-relief, High-density Polygons	Well-developed polygons with a central low "basin," a raised "rim," and (frequently) a "trough" between polygons. Typically, polygons range from 8 to 15 m across and rims are less than 50 cm tall. Larger polygons often are partially bisected by newly forming rims.
Mixed High- and Low-centered Polygons	This surface form generally is indicative of a transition from low to high centers. It is caused when ice wedges begin to melt between low center polygons and drainage is altered. Also the accumulation of ice and organic matter in the low centers can raise the surface to high-centers.
Mixed Thaw Pits and Polygons	This class contains elements of both high- and low- centered polygons and is characterized by deep thermokarst pits that commonly occur at the intersections of polygon troughs.
Beads	The Bead surface form is used in association with Lowland Headwater Streams that are formed through the connection of adjacent thermokarst pits. The stream channel consists of small linked ponds, resembling beads on a string.
Bluffs and Streambanks	Moderate to steep slopes of unconsolidated material. Banks form from undercutting by streams or thermal erosion due to transfer of heat by water and wind at lake margins.
Dune Complex	Dune Complexes are repeating patterns of ridge and swale formed by eolian deposition and erosion. Most dune complexes are found immediately behind active dunes and river point bars and may be further eroded by flooding during periods of especially high water.
Basin Complex	Complex microrelief within large basins formed by the thawing and draining of lakes in ice-rich permafrost. In young, Ice-poor Thaw Basins, the complex generally includes Ponds, Nonpatterned ground, and Disjunct Polygons. In older, Ice-rich Thaw Basins, the complex usually consists of Ponds, Low-centered Polygons, and High-Centered Polygons.
Riverine Complex	This class is used when surface components of a floodplain are too small to be mapped separately. Surface forms in this type include Water, Nonpatterned gravels, Beads, Disjunct and High-centered Low-relief Polygons, and Hummocks.
Polygonized Pond Margins	A distinctive feature of pond shorelines formed when polygon centers merge with the adjacent pond leaving the elevated rims as peninsulas extending into the waterbody. This class is appropriate when at least 10% of the shore is polygonized, islands may also be present.
Lake with Islands	Lakes with one or more islands present. Islands must be at least 1 m across and 3 m from the shore to be included in this class.
Water	Areas covered by permanent water.

Table 6. Classification and description of soil classes in the Northeastern Planning Area of the NPRA, 2002.

Soil Class	Description
Typic Cryaquent (Eact)	Poorly developed, wet soils with a thin organic surface layer (less than 8 cm) and deep season thaw (>1 m). This soil is unusual in the study area because most wet soils have shallow thaw depth and a substantial organic surface layer. The sole observation in the study area was in the shallow nearshore portions of a lake, in an *Arctophila fulva* grass marsh. Absorption of solar radiation by the shallow water on this site increases the thaw depth; and the lake bottom was probably colonized by vegetation rather recently, so that little surface organic layer has accumulated. This soil lacks other distinguishing features, and thus is a Typic Cryaquent. This soil may be fairly common in the study area in this highly specialized habitat.
Typic Cryofluvents (Efct)	Poorly developed, stratified, well-drained soils, with deep (>1 m) thaw depths. They have little or no organic surface layer but several to many dark, organic-rich subsurface layers separated by mineral soil with little organic matter. The mineral soil consists of alternating sandy and silty layers that have not been deformed by frost action. These soils occur on active floodplains or small dunes on river floodplains with sparse vegetation or low willows. Many Cryofluvents are covered by river floods nearly every year.
Aquic Cryofluvents (Efca)	Poorly developed, stratified, somewhat well-drained soils, with deep (>1 m) thaw depths. They have little or no organic surface layer but several to many dark, organic-rich subsurface layers separated by mineral soil with little organic matter. The mineral soil consists of alternating sandy and silty layers that have not been deformed by frost action. These soils occur on active floodplains or small dunes on river floodplains with sparse vegetation or low willows. Aquic Cryofluvents are moister and more mottled than Typic Cryofluvents.
Typic Cryorthents (Eoct)	Poorly developed, excessively or well-drained soils, with deep (>1 m) thaw depths. They have little or no organic surface layer or buried organic layers. They resemble the more widespread Typic Cryopsamment soils, but are composed of sand mixed with some very fine sand or silt rather than pure sand as in Typic Cryopsamments. They occur on gentle vegetated sand dunes near rivers. Vegetation is usually Dryas Dwarf Shrub Tundra or low willows. Typic Cryorthents lack any other features and are the only Cryorthents observed in the study area.
Typic Cryo-psamments (Espt)	Poorly developed, sandy, excessively or well-drained soils with deep (>1 m) thaw depths. They have little or no organic surface layer, and consist of homogenous sand with few or no dark layers. The soils occur on sand dunes or, less frequently, sandy river floodplains. Vegetation is usually Dryas Dwarf Shrub Tundra or low willows, sometimes with unvegetated "blowout" (wind-eroded) areas. Typic Cryopsamments lack any other features and are the most common Cryopsamments in the study area.
Fibristels, undiffer-entiated (Ghf)	Poorly drained soils with shallow thaw depths (<1 m) above permafrost, composed dominantly of organic matter that is only slightly decomposed. The water table is almost always near the ground surface, and the depth of thaw in late summer is 25 to 40 cm. These soils occur in areas of low-center polygons or disjunct polygon rims in drained lake basins, or on inactive or abandoned portions of floodplains. Vegetation is usually Wet Sedge Meadow Tundra.
Fluvaquentic Fibristels (Ghff)	Wet, slightly decomposed organic soils with shallow thaw depths (<1 m) to permafrost The soils have one or more layers of mineral material within the mostly organic soil mass, due to sediments deposited by flooding along rivers and lakes or by wind. Soils were primarily found on floodplains and lake basins and always associated with Wet Sedge Meadow Tundra.
Hemistels, Undifferentiated (Ghf)	Hemistels are wet soils with permafrost composed dominantly of organic matter that is moderately decomposed. The water table is almost always within 20 cm of the ground surface, and the depth of thaw in late summer is 20 to 40 cm. These soils occur in areas of low-center polygons, disjunct polygon rims, or tussocks, in drained lake basins or on terraces. Vegetation is usually Wet Sedge Meadow or Tussock Tundra.
Fluvaquentic Hemistels (Ghff)	Wet soils with a shallow active layer (<1 m) above permafrost, composed dominantly of organic matter that is moderately decomposed. The soils have one or more layers of mineral material within the mostly organic soil mass, due to sediments deposited by flooding along rivers and lakes or by wind Soils were primarily found in old lake basins and coastal plain deposits They usually are associated with Wet Sedge Meadow but occasionally Tussock Tundra.
Sapristels (Ghs)	Sapristels are wet soils with permafrost composed dominantly of organic matter that is highly decomposed. The depth of thaw is typically 25 to 40 cm in late summer. These soils are not widespread and appear to occur mostly on sites that were formerly saturated but currently better drained due to location near an escarpment or on a high-center polygon.
Fluvaquentic Sapristels (Ghsf)	Wet soils with a shallow active layer (<1 m) above permafrost, composed dominantly of organic matter that is highly decomposed. The soils have one or more layers of mineral material within the mostly organic soil mass, due to sediments deposited by flooding along rivers and lakes or by wind. This usual soil type was found on old Alluvial–Marine Deposits that supported acidic Tussock Tundra.
Typic Haplorthels (Goht)	Well-drained, fine-grained soils with a shallow active layer (<1 m) above permafrost and lacking evidence of frost churning or wetness. The organic surface layer is thin, usually 2 cm or less. Textures can be loamy or sandy, but not pure sand. A water table is absent or deep in the profile (more than 50 cm from the surface) and near the frost table. The depth of thaw is 50 to 100 cm. The common soils usually occur on well-drained surfaces such as floodplains, low dunes, or edges of terraces near an escarpment; patterned ground is absent. Vegetation is usually Dryas or Cassiope Dwarf Shrub Tundra, or sparse vegetation on the floodplains.

Table 6. (Continued).

Soil Class	Description
Aquic Haplorthels (Gohf)	Somewhat poorly drained soils with a shallow active layer (<1 m) above permafrost and lacking evidence of frost churning. The presence of mottling indicates occasional periods of saturation. Soils commonly occur on upper slopes of old coastal plain deposits and in ice-rich thaw basins. It is usually associated with Dryas or Cassiope Dwarf Shrub, and Tussock Tundra.
Typic Historthels (Goit)	Historthels are wet soils with permafrost that have a thick organic layer or layers in the upper one-half meter but are still composed dominantly of mineral soil. Soil layers are not deformed by frost action. The water table ranges from just above the surface to about 15 cm below the surface, and the depth of thaw in late summer is 35 to 50 cm. These soils occur in areas of low-center polygons or disjunct polygon rims in drained lake basins, or on inactive or abandoned portions of floodplains. Vegetation is usually Wet Sedge Meadow Tundra. Typic Historthels have no additional features and are the most common subgroup in the study area.
Typic Psammorthels (Gopt)	Well-drained, sandy soils that thaw to moderate depth (0.5 to 1 m) and lack evidence of frost churning. They have a relatively thin (several centimeters thick) surface organic layer. They occur on floodplains with low willows, and on gentle sand dunes with Dryas Dwarf Shrub Tundra. Typic Psammorthels have no additional features and are the only subgroup of this soil that was observed. Psammorthels are not widespread in the study area; their properties are intermediate between the more common Cryopsamments (drier and warmer soils) and various wetter and colder sandy soils (Aquorthels, Psammoturbels).
Psammentic Aquorthels (Goqp)	Wet, sandy soils with permafrost and a relatively thin (less than 20 cm) organic surface layer. The soil is grayish due to biochemical reduction under saturated conditions. Soil layers are not deformed by frost action. The water table ranges from near the surface to about 40 cm depth, and the depth of thaw in late summer is 30 to 70 cm. These soils occur in areas with weak or no ice-wedge polygons, in lake basins, on inactive or abandoned portions of floodplains, or in depressions between dunes on abandoned floodplains. Vegetation is Wet Sedge Meadow Tundra or low willow
Typic Aquothels (Goqt)	Wet, fine-grained soils with a relatively thin (less than 20 cm) organic surface layer and shallow active layer (<1 m) above permafrost. The soil is grayish due to biochemical reduction under saturated conditions. Soil layers are not deformed by frost action. The uncommon soils occur on inactive floodplains and usually are associated with Dryas Dwarf Shrub Tundra or Open Low Willow Shrub.
Aquic Haploturbels (Gthq)	Moist, moderately well-drained, mottled soils with a relatively thin (less than 20 cm) organic surface layer and shallow active layer (<1 m) above permafrost. The loamy to sandy soils have a relatively thin (less than 10 cm) surface organic layer, and horizons have been deformed by frost action. A water table is usually not present and the depth of thaw in late summer is 30 to 65 cm. Soils commonly occur on upper slopes of old coastal plain deposits and in ice-rich thaw basins. Vegetation is Dryas or Cassiope Dwarf Shrub Tundra.
Typic Haploturbels (Gtht	Moist, well-drained soils with a relatively thin (less than 20 cm) organic surface layer and shallow active layer (<1 m) above permafrost. Soil horizons horizons have been deformed by frost action and lack mottling. The uncommon soils usually occurs on steeper slopes along lakes and banks on older coastal plain surfaces. Soils are associated with Cassiope Dwarf Shrub Tundra.
Ruptic Histoturbels (Gtir)	Histoturbels are wet soils with permafrost that have a thick organic layer or layers in the upper one-half meter but are still composed dominantly of mineral soil. Soil layers have been deformed by frost action. The water table ranges from near the surface to about 30 cm below the surface, and the depth of thaw in late summer is 20 to 40 cm. Histoturbels occur among low- or high-center polygons in drained lake basins, and on terraces. Vegetation is Wet Sedge Meadow or Tussock Tundra. Typic Histoturbels have no additional features and are the most common subgroup. Ruptic Histoturbels have a surface organic layer with highly variable thickness.
Typic Psammo-turbels (Gtpt)	Psammoturbels are sandy soils with deformed horizons due to frost action. The surface organic layer is thin (0 to 5 cm thick). Psammoturbels occur in two different settings: on vegetated sand dunes or sand sheets, where a water table is absent or just above the frost table; and on sandy beach sediments in lake basins, where the water table is near or above the surface. In both cases the depth of thaw is 60 to 100 cm in late summer. The Psammoturbels on sand dune or sheets typically have Dryas or Cassiope Dwarf Shrub Tundra vegetation, while those in lake basins have sedges and willows. Typic Psammoturbels have no additional features and are the most common subgroup.
Typic Aquiturbels (Gtqt)	Wet, fine-grained soils with permafrost that have a relatively thin (5 to 20 cm) surface organic layer and subsurface layers that have been deformed by frost action. They occur on a variety of landforms (lake basins, terraces, abandoned floodplains) with weak polygon development. Vegetation is usually Moist Sedge–Shrub or Tussock Tundra.
Psammentic Aquiturbels (Gtqp)	Wet, sandy soils with permafrost that have a relatively thin (5 to 20 cm) surface organic layer and subsurface layers that have been deformed by frost action. The depth of thaw in late summer is 20 to 35 cm, and the water table is usually just 5 to 10 cm above the frost table, or not present

(NRSC) soil taxonomy (1998) is relatively new (Ping et al. 1998).

VEGETATION

Twenty-four vegetation types (Level IV, AVC) were recognized within the study area, although two types did not have distinct enough photo-characteristics to map (Figure 8, Table 7). Common vegetation types on the coastal plain included Tussock Tundra (27.4%), Moist Sedge–Shrub Tundra (Sedge–*Dryas* and Sedge–Willow combined, 22.9 %), Wet Sedge Meadow Tundra (14.4%), and Old Basin Wetland Complexes (8.8%) (Table 3). Common vegetation types along the coast included Barrens (1.9%), Halophytic Sedge Wet Meadow (0.5%), and Halophytic Willow Dwarf Shrub Tundra (0.1%).

We used the Level IV AVC classes for mapping because they are from a standardized classification system and are based on plant structures that can be recognized on aerial photography. There are, however, strong relationships between the AVC classes and the plant associations (Level V) derived from numerical analysis of the floristic data. Relationships among plant structure (Level IV), plant associations (Level V), and ecotypes are described in the section describing ecotypes.

The vegetation types in the Northeastern Planning Area are similar to the classes that have been recognized for the floodplain of the Meade River (Komarkova and Webber 1978, Peterson and Billings 1980), Fish Creek (Komarkova 1983), the floodplain of the Colville River near Umiat (Churchill 1955), and the Colville Delta (Jorgenson et al. 1997). Vegetation types also are generally consistent with the plant associations compiled for northern Alaska (Walker 1999), although the dominant and differential species used to define an association can vary among regions.

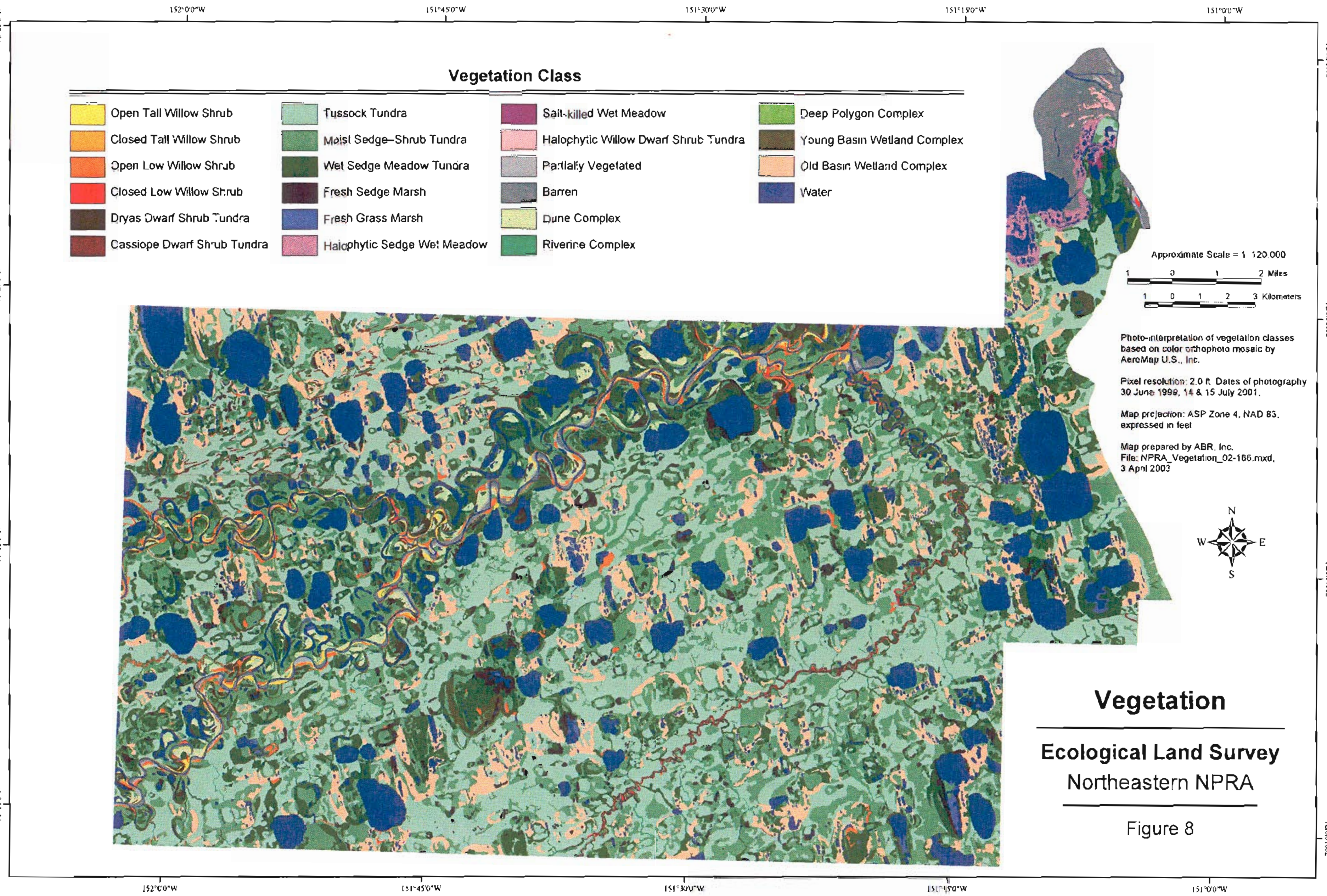
ECOTYPES AND ECODISTRICTS

HIERARCHICAL ORGANIZATION OF ECOLOGICAL COMPONENTS

Toposequences

The classification of ecotypes (local-scale ecosystems) was based on the survey of ecological components (topography, geomorphology, soil, hydrology, permafrost, and vegetation) along toposequences. Cross-sectional profiles were constructed to illustrate relationships among ecological components for five toposequences (Figures 9–13). Two of the toposequences (Transects 5 and 6) were on the floodplain of Fish Creek, extending from the river and across the floodplain to an upland terrace. The other three toposequences (Transects 1, 11, and 15) were on older coastal plain deposits that illustrated successional trends from Ice-rich and Ice-poor Thaw Basins to the older upland surfaces on Old Alluvial Terrace and Alluvial–Marine Deposits.

On the floodplain toposequences (Transects 5 and 6), geomorphology is dominated by changes from active, high-energy fluvial regimes associated with the Meander Active Channel Deposits` to lower energy regimes associated with Meander Inactive Overbank Deposits and Meander Abandoned Overbank Deposits. During this transition, the rate of sedimentation decreases while accumulation rates for organic matter and ice increase (Figures 9 and 10). At the early stages of ecological development, soils along the channels are well drained and sandy, whereas the soils on the oldest portions of the floodplain are poorly drained and have thick organic accumulations. Soil nutrients become less available, due to decreasing cation concentrations (indicated by lower electrical conductivity) and pH. Over this successional sequence, ice aggrades both as segregated ice and as wedge ice, transforming the surface patterns from Nonpatterned to Low-centered, High-relief, High-density Polygons. Eolian processes also are active on the floodplain, blowing sand off the barren point bars and forming dunes adjacent to the sandy barrens. The oldest, ice-rich portions of the floodplain accumulate sufficient ground ice that they become unstable and susceptible to thermokarst and formation of thaw lakes. Vegetation responds to these changing environmental conditions with changes in both structure and species composition. Open Tall Willow Shrub, dominated by *Salix alaxensis*, occurs on the well-drained, sandy soils. Behind this zone, Open Low Willow Shrub, dominated by *Salix lanata richardsonii*, is found on moderately well-drained soils with thin, interbedded organic layers. Farther from the channel, Moist Sedge–Shrub Tundra, dominated by *Dryas integrifolia* and *Carex bigelowii*, occurs on



Vegetation

Ecological Land Survey
Northeastern NPRA

Figure 8

Table 7. Classification and description of vegetation classes in the Northeastern Planning Area of the NPRA, 2002.

Class	Description
Barrens	Nonvegetated flats on river bars, sand dunes, tidal flats, and recently drained lake bottoms that are recently exposed or too unstable to support more than a few pioneering plants (<5% cover). Typical species include *Salix alaxensis, Festuca rubra, Deschampsia caespitosa, Juncus arcticus, Stellaria humifusa,* and *Equisetum arvense*. Riverine Barrens include river flats and bars, commonly along Fish and Judy Creeks. These areas are flooded seasonally and underlain by sand. Toward the coast, sediments are increasingly saline and tidally affected barrens are colonized by salt-tolerant species.
Partially Vegetated	Riverbanks, upland sand dunes, and shallow lake basins that have 5–30% vegetative cover. Colonizers include *Deschampsia caespitosa, Salix alaxensis, Juncus arcticus, Chrysanthemum bipinnatum, Stellaria humifusa, Elymus arenarius mollis, Equisetum arvense* and *Trisetum spicatum.*
Moist Sedge–Shrub Tundra	Lowland sites on moderately well-drained flats and gentle slopes within Thaw Basins, Alluvial–Marine, and Inactive Eolian Sand Deposits, and Riverine Inactive Overbank Deposits, frequently associated with high-centered, and mixed high- and low-centered polygons. Vegetation is co-dominated by sedges (e.g. *Carex bigelowii, C. aquatilis, Eriophorum angustifolium),* and dwarf or low shrubs including *Dryas integrifolia* and *Salix reticulata.* Other common vascular species include *Salix lanata richardsonii, S. planifolia pulchra, Equisetum variegatum, Arctagrostis latifolia,* and *Cassiope tetragona.* Important non-vascular species include *Tomentypnum nitens. Hylocomium splendens, Sanionia uncinata,* and *Dicranum* sp. This class can be confused with Dryas Tundra on drier sites where *Dryas integrifolia* is dominant and Tussock Tundra where *Eriophorum vaginatum* is dominant. Soils are saturated at intermediate depths (> 15 cm) but generally are free of surface water during summer; some sites may be inundated briefly during break-up.
Tussock Tundra	The tussock-forming sedge *Eriophorum vaginatum* dominates the vegetation. On somewhat acidic soils associated species include *Ledum decumbens, Vaccinium vitis-idaea, Salix planifolia pulchra, Betula nana, Salix phlebophylla, Dicranum* sp., and *Hylocomium splendens.* On circumneutral soils *Dryas integrifolia, Salix reticulata, Carex bigelowii,* and *Tomentypnum nitens* are more common though there are many species in common among the two tussock communities and Moist Sedge–Shrub Tundra. Found associated with high-centered, and mixed high- and low-centered polygons on broad slopes of Alluvial–Marine, Inactive Eolian Sand, and Old Alluvial Terrace Deposits and within Ice-rich Thaw Basins. Water generally is absent from the active layer during midsummer.
Common Marestail	In shallow coastal ponds, pond margins, and at the edges of slow moving streams. *Hippuris vulgaris* is the dominant species, *Arctophila fulva, Potamogeton* sp., *Carex subspathacea,* and *Calliergon* sp. are common associates. This class was not mapped.
Fresh Grass Marsh	Shallow lakes within Ice-Poor Thaw Basins and river ox-bows, shallow margins of large lakes, and shallow water of slow-moving headwater streams dominated by *Arctophila fulva.* Water depths generally are < 1.0m. *Hippuris vulgaris, Limprichtia revolvens,* and *Carex aquatilis* may be present in water < 0.5m .
Fresh Sedge Marsh	Permanently flooded shallow water within Thaw Basins, shallow margins of large lakes, and shallow water of slow-moving headwater streams dominated by *Carex aquatilis.* Often found as a fringe between deeper water with *Arctophila fulva* and the lake shore, *Carex aquatilis* also may form a monoculture within shallow (< 0.5m) waterbodies. Associated species include *Scorpidium scorpioides* and *Eriophorum angustifolium.* Polygon development is minimal though disjunct polygon rims may be present.
Wet Sedge Meadow Tundra	Low-lying, poorly drained areas with vegetation dominated by *Carex aquatilis, Eriophorum angustifolium,* and mosses. Associated with nonpatterned ground, low-centered, or disjunct polygons in Thaw Basins, Alluvial–Marine, Old Alluvial Terrace, and Inactive Overbank Deposits. This class is also found in water tracks and swales where willows may be co-dominant. Associated species include *E. russeolum, C. chordorrhiza, C. saxatilis, Salix lanata richardsonii, S. planifolia pulchra,* and *Pedicularis sudetica.* Frequently occurring mosses include *Scorpidium scorpioides, Limprichtia revolvens, Drepanocladus* spp., and *Campylium stellatum.* When polygons are present the rim vegetation is similar to Moist Sedge–Shrub Tundra. The tundra surface generally is flooded during early summer (depth < 0.3m) and water remains close to the surface throughout the growing season. Soils usually have a moderately thick organic layer over silt loam or sandy loam.

Table 7. (Continued).

Class	Description
Salt-killed Wet Meadow	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and where salt-tolerant plants are actively colonizing. Colonizing plants include *Puccinellia andersonii, Dupontia fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, Stellaria humifusa, Cerastium beeringianum,* and *Salix ovalifolia.* This class typically occurs either on low-lying areas that originally supported Wet Sedge Meadow Tundra and Basin Wetland Complexes, or less commonly, along drier coastal bluffs that originally supported Moist Sedge–Shrub Meadow Tundra. Salt-killed Wet Meadow differs from Halophytic Sedge Wet Meadow in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizers.
Halophytic Sedge Wet Meadow	Coastal areas with wet, saline soils typically dominated by the sedges *Carex subspathacea* and *C. ursina.* Primarily found on Inactive Tidal Flat Deposits and Delta Thaw Basins on nonpatterned ground or low-centered polygons, associated species often include *Puccinellia phryganodes, Salix ovalifolia, Calamagrostis deschampsioides, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.*
Dryas Dwarf Shrub Tundra	Dry, upland, sandy slopes, crests, and well-drained river terraces dominated by *Dryas integrifolia.* Most commonly associated with Inactive Eolian Sand Deposits and small dunes, Dryas Dwarf Shrub Tundra also is found on nonpatterned ground and high-centered polygons on Pingos, Inactive Overbank, and Alluvial–Marine Deposits. Inactive dune sites are strongly dominated by *Dryas* and occasionally co-dominated by lichens, associated species include *Salix glauca, S. reticulata, Arctostaphylos alpina, Arctagrostis latifolia, Thamnolia vermicularis,* and *Cetraria cuculata.* Riverine sites may have co-dominant species such as *Equisetum variegatum* and *Salix reticulata,* with *S. lanata richardsonii, Arctostaphylos rubra, Oxytropis deflexa, Tomentypnum nitens,* and *Thamnolia vermicularis* as associated species. Sedges (e.g. *Carex scirpoidea*) may be present on moist sites but are never co-dominant. Soils are sandy, well to somewhat excessively drained, and thaw depths often exceed 1.0m.
Cassiope Dwarf Shrub Tundra	Old dunes and banks on Inactive Eolian Sand, Alluvial–Marine Deposits, and Ice-rich Thaw Basins dominated by *Cassiope tetragona.* Compared with Dryas Dwarf Shrub Tundra, with which this class shares some species, Cassiope Dwarf Shrub Tundra is less well drained, has shallower thaw depths, and can occur on sandy or loamy soils. *Cassiope* dominated sites typically are very species rich, common associated species include *Dryas integrifolia, S. phlebophylla, Salix reticulata, Vaccinium vitis-idaea, Carex bigelowii, Hierochloe alpina,* and *Arctagrostis latifolia.* Cryptogams present include crustose lichens, *Hylocomium splendens, Dicranum* sp., *Tomentypnum nitens,* and *Rhytidium rugosum.* All sites have a wide variety of forbs.
Halophytic Willow Dwarf Shrub Tundra	Coastal areas with moist to wet, saline or slightly saline soils typically dominated by *Salix ovalifolia* or co-dominated by *S. ovalifolia* and halophytic graminoids. Primarily found on Inactive Tidal Flats, Delta Overbank Deposits, and Delta Thaw Basins on nonpatterned ground or low-centered polygons. Associated species often include *Carex subspathacea, C. aquatilis, C. glareosa, Calamagrostis deschampsioides, Dupontia fisheri, Drepanocladus* sp., and *Thamnolia vermicularis.*
Open and Closed Low Willow Shrub	Riverine, lowland or upland communities dominated by low willows (0.2– 1.5m) with an open (25–75% cover) or closed (>75%) canopy. Riverine deposits typically are dominated by *Salix lanata richardsonii* (sometimes co-dominant with *S. planifolia pulchra*), with *Carex aquatilis, Equisetum arvense, E. variegatum, Arctagrostis latifolia,* and *Tomentypnum nitens.* Lowland willow shrub is found primarily on high-centered polygons or nonpatterned ground on Abandoned Floodplains, within Thaw Basins, and on banks or water tracks of Alluvial–Marine Deposits. Lowland communities are dominated by *S. planifolia pulchra,* with *C. aquatilis, S. reticulata, C. bigelowii, Pyrola grandiflora, Dicranum* sp., *Aulacomnium turgidum, A. palustre,* and *Hylocomium splendens.* Upland communities, dominated by *Salix glauca,* are found on small dunes of Eolian Inactive Sand Deposits. Associated species include *S. alaxensis, Arctostaphylos rubra, Dryas integrifolia,* and *Oxytropis nigrescens.*
Open Low Mesic Shrub Birch–Ericaceous Shrub	More typical of areas in the southern NPRA, this class infrequently is found on banks, or high-centered polygons on Alluvial–Marine Deposits. *Betula nana* is dominant with *Salix planifolia pulchra, S. glauca, S. reticulata, Arctostaphylos rubra, Dryas integrifolia, Vaccinium vitis-idaea, Pyrola grandiflora, Hylocomium splendens, Aulacomnium palustre, Dicranum* sp., and *Pleurozium schreberi* as associates. This class was not mapped.

Table 7. (Continued).

Class	Description
Open and Closed Tall Willow Shrub	Active Eolian Sand and Riverine Deposits dominated by *Salix alaxensis*. Willows often are > 1.5m tall with an open (25–75% cover) or closed (>75%) canopy. Soils are very well-drained, sandy, and frequently disturbed by flooding or strong winds. Understory species on riverine deposits include *Equisetum arvense, Chrysanthemum bipinnatum, Festuca rubra, Aster sibiricus,* and *Gentiana propinqua*. Upland dune associates include S. *glauca, Arctostaphylos rubra, Astragalus alpinus, Castilleja caudata, Festuca rubra*, and *Chrysanthemum bipinnatum*.
Water	Permanently flooded, non-vegetated waterbodies. Included in this class are non-vegetated Thaw Lakes, Headwater Streams, Lower Perennial Rivers, Riverine Lakes, and Beaded Streams. Areas mapped as water may include some partially vegetated waterbodies where vegetation was submerged and therefore not discernable on the aerial photography.
Young Basin Wetland Complex (ice-poor)	Young Basin Wetland Complexes occur in portions of recently drained lake basins and are characterized by a complex mosaic of open water, Fresh Sedge and Grass Marshes, Wet Sedge Meadow, and Moist Sedge–Shrub Tundra in patches too small (< 0.5 ha) to map individually. Young basins are distinguished from older basins because they have little ground ice development and typically are dominated by more productive vegetation than older basins. Surface forms are nonpatterned ground or disjunct polygons. To be mapped as a complex an area must be at least 2 ha and have at least three vegetation types, with no single type dominant.
Old Basin Wetland Complex (ice-rich)	Similar to Young Basin Wetland Complexes but occurring in portions of less recently drained basins. This type is characterized by vegetation found in association with ice wedge development and aggradation of segregated ice including Wet Sedge Meadow Tundra with low-centered polygons, Moist Sedge–Shrub, and Tussock Tundra. Fresh Grass Marshes are absent and Sedge Marsh occurs only in flooded portions of margins. Centers of old basins are uplifted sands and loams with shallow to moderate organic horizons. Complexes mapped in centers typically are Tussock, Moist Sedge–Shrub, and Wet Sedge Meadow Tundra. Margins of old basins are wetter with many small, discrete ponds. Soils generally have a moderately thick organic layer overlying sand or sandy loam, vegetation in margins typically is Moist Sedge–Shrub Tundra, Wet Sedge Meadow, Fresh Sedge Marsh, and Water. Complexes are comprised of at least three vegetation types, with no single type dominant. Minimum size for complexes is 2 ha.
Riverine Complex	Permanently flooded channels and narrow bands or patches of vegetation too small to be mapped separately. The variety of vegetation reflects the degree and regularity of flooding. Vegetation classes include Water, Barren or Partially Vegetated gravel bars, Fresh Sedge or Grass Marsh, Wet Sedge Meadow, Moist Sedge–Shrub Tundra, or Low Willow Shrub. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer.
Deep Polygon Complex	Mosaic of vegetation on inactive and abandoned floodplains where low-centered polygons have particularly deep (>0.5 m) centers formed by thaw settlement of ice-rich soils. Permanently flooded nonvegetated polygon centers are fringed by Fresh Grass or Sedge Marsh. Broad, low, rims of Wet Sedge Meadow or Moist Sedge–Shrub Tundra separate the centers. While water forms a substantial portion of this class, no single vegetation type or water is dominant.
Dune Complex	Complex formed on inactive sand dunes on meander floodplains. A series of narrow swale and ridge features develop in parallel with river flow that are too small to map separately. Vegetation in moist to wet swales typically is Low Willow Shrub, Wet Sedge Meadow Tundra, or Fresh Sedge Marsh, while dry to moist sandy, dune ridges commonly are Dryas Dwarf Shrub Tundra or Low Willow Shrub.

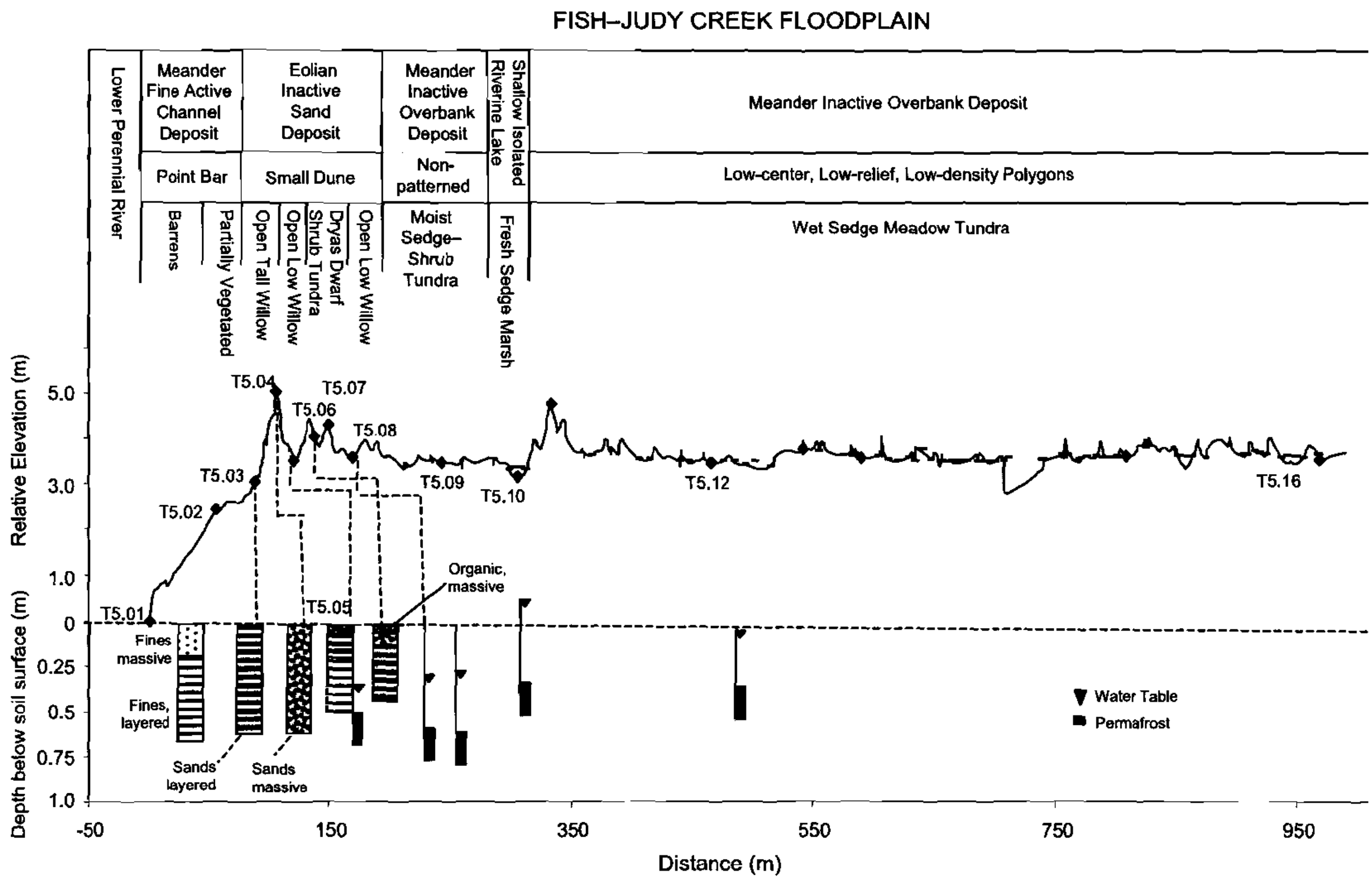


Figure 9. A representative terrain sequence (Transect 5) illustrating changes in terrain units, soils, hydrology, surface form, vegetation, and permafrost on the Fish-Judy Creek Floodplain in the Northeastern Planning Area, NPRA, 2002.

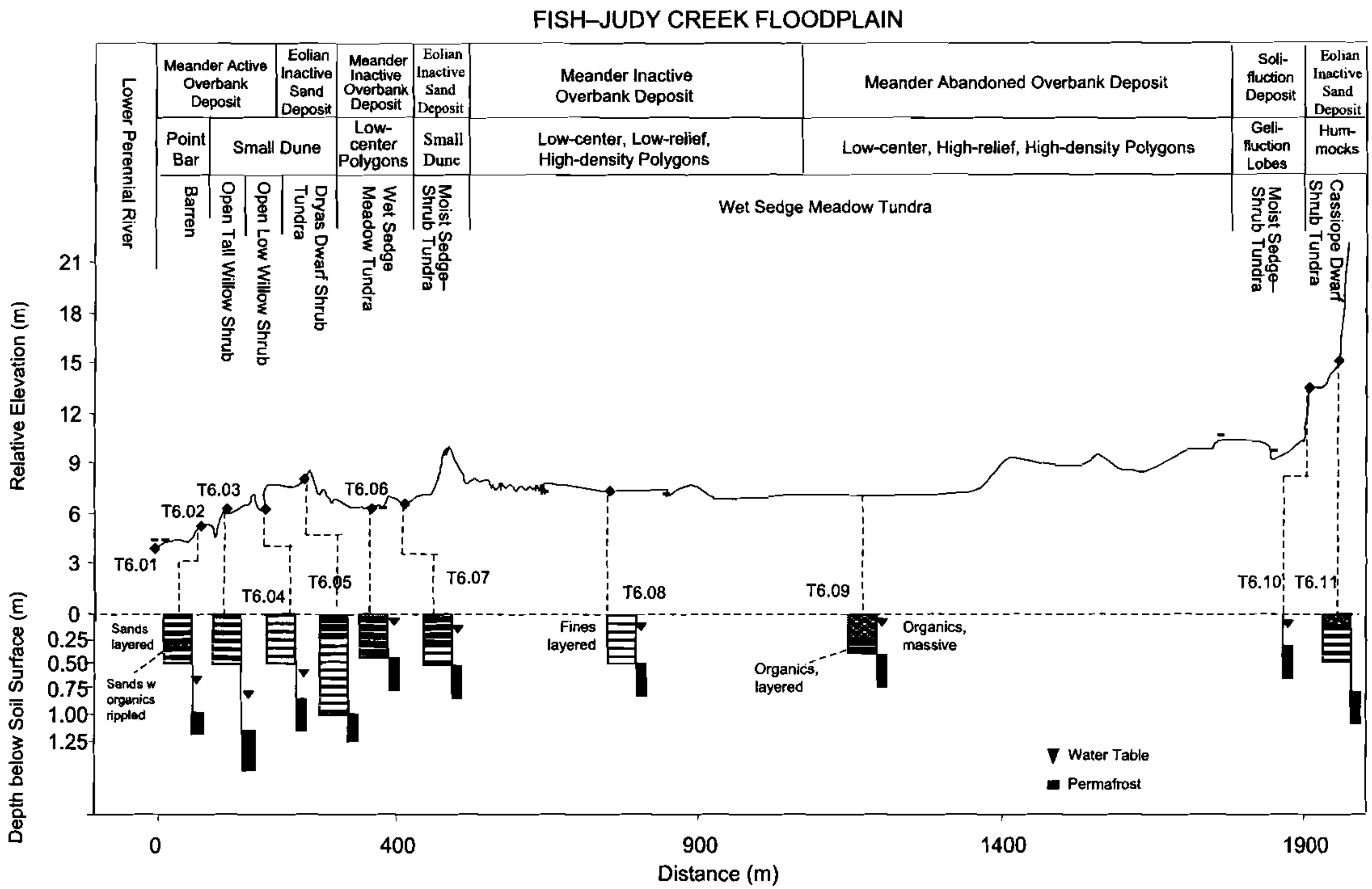


Figure 10. A representative terrain sequence (Transect 6) illustrating changes in terrain units, soils, hydrology, surface form, vegetation, and permafrost on the Fish-Judy Creek Floodplain in the Northeastern Planning Area, NPRA, 2002.

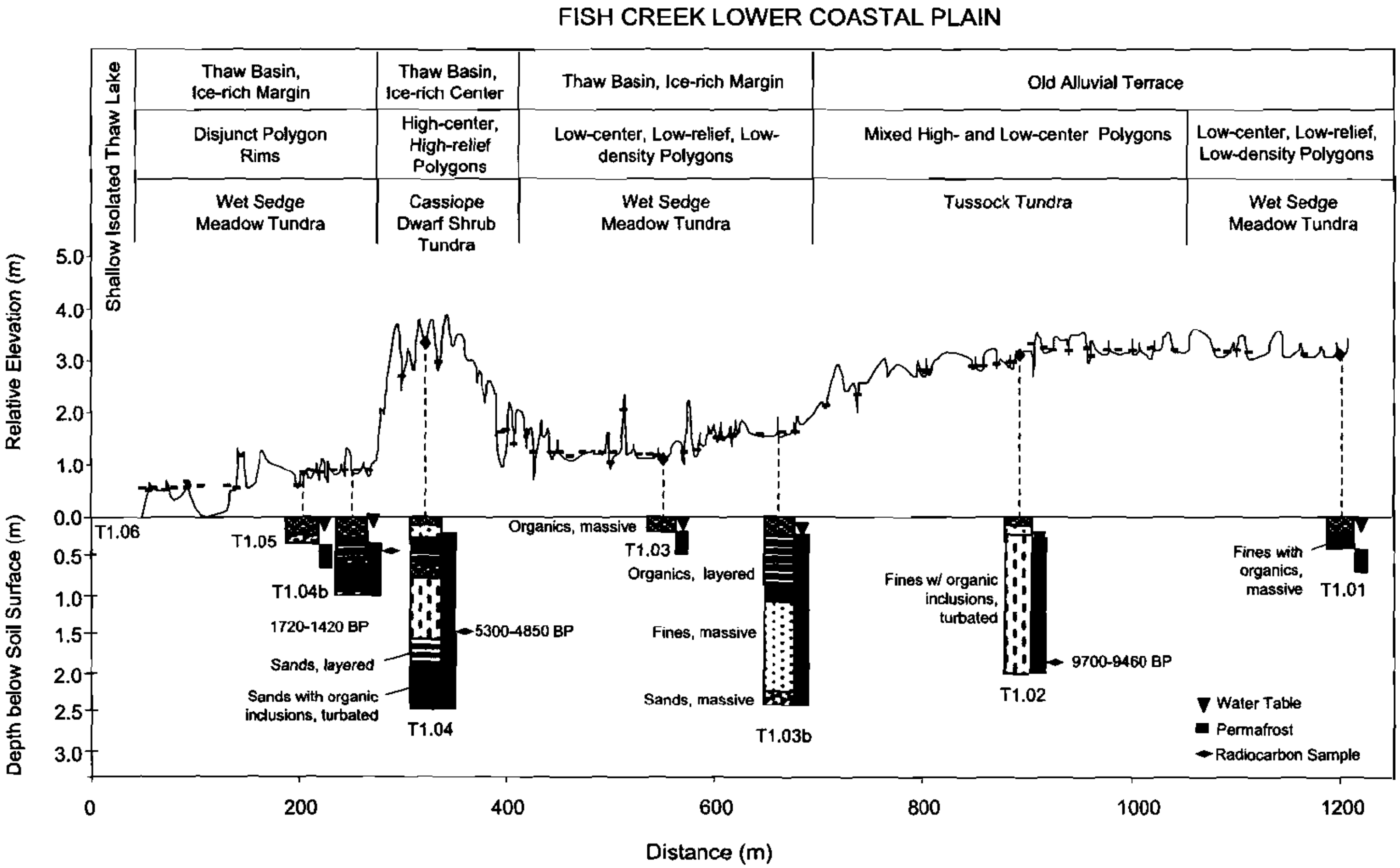


Figure 11. A representative toposequence (Transect 1) illustrating changes in terrain units, soils, hydrology, surface form, vegetation, and permafrost on the Fish Creek Lower Coastal Plain in the Northeastern Planning Area, NPRA, 2002.

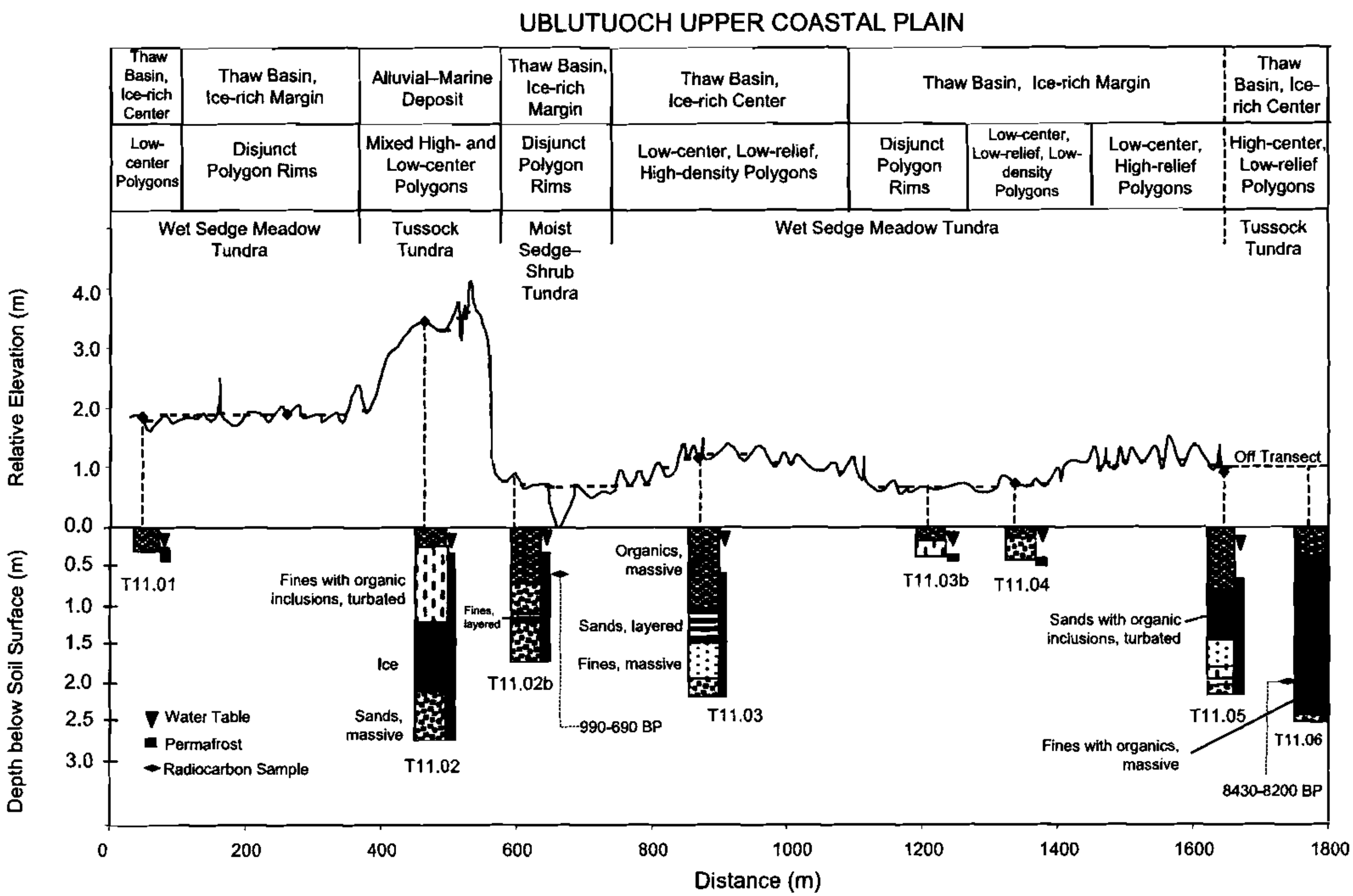


Figure 12. A representative toposequence (Transect 11) illustrating changes in terrain units, soils, hydrology, surface form, vegetation, and permafrost on the Ublutuoch Upper Coastal Plain in the Northeastern Planning Area, NPRA, 2002.

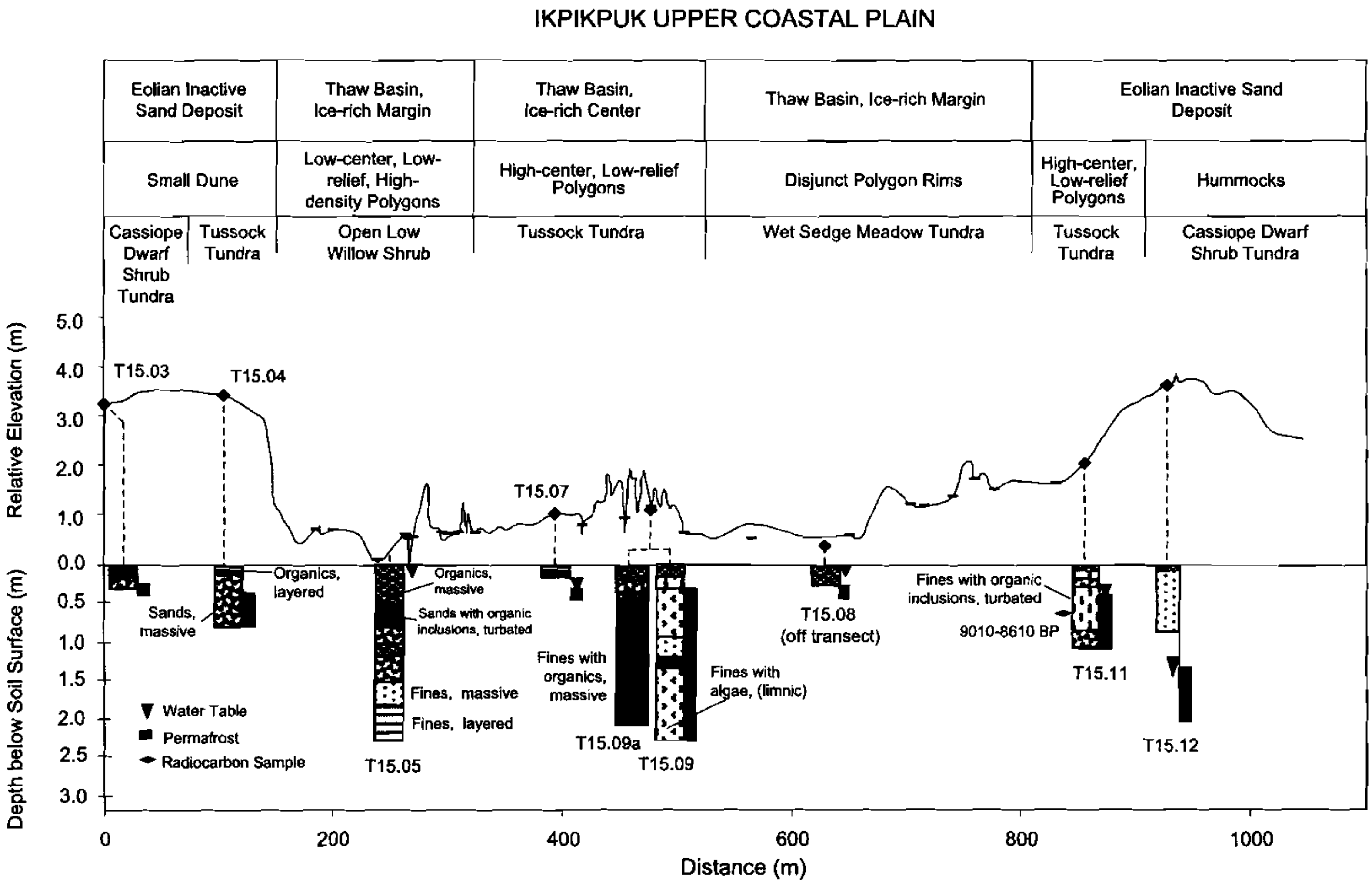


Figure 13. A representative toposequence (Transect 15) illustrating changes in terrain units, soils, hydrology, surface form, vegetation, and permafrost on the Ikpikpuk Upper Coastal Plain in the Northeastern Planning Area, NPRA, 2002.

somewhat poorly drained soils, while Wet Sedge Meadow Tundra, dominated by *Carex aquatilis* and *Eriophorum angustifolium*, is found on very poorly drained soils.

Toposequences on the older, slightly higher coastal plain, cross Old Alluvial Terrace Deposits (Transects 1, Figure 11), Alluvial–Marine Deposits (Transect 11, Figure 12), and Eolian Inactive Sand Deposits (Transect 15, Figure 13). While the oldest and highest deposits vary across the landscape, geomorphic units follow a common evolutionary sequence from Ice-poor Thaw Basins, to Ice-rich Thaw Basins, to the oldest stabilized surface. Macro-topographic variation is 3–4 m across the landscape, while micro-topographic relief generally is <0.5 m (occasionally up to 1 m in troughs). Along this gradient, surface forms change from Nonpatterned to Low-centered, Low-relief Polygons to High-centered, Low-relief Polygons indicating increasing development of ice wedges. Soils in the lower, wetter portions of the basins have thick organic accumulations caused by slow decomposition under anaerobic conditions. On the older, upland surfaces, soils tend to be better drained and highly turbated by cryogenic processes. Over this sequence vegetation changes from Fresh Sedge Marsh and Wet Sedge Meadow Tundra in basins, to Moist Sedge–Shrub Tundra on lower slopes, Tussock Tundra on upper slopes, and Dryas Dwarf Shrub Tundra on well-drained ridges.

Relationships Among Ecological Components

We developed hierarchical relationships among ecological components by successively grouping data from the 285 survey plots by physiography, soil texture, geomorphology, slope position, surface form, drainage, soil chemistry, vegetation structure, and floristic class. Frequently, geomorphic units with similar texture or genesis were grouped (e.g., loamy and organic were grouped for some lowlands) to reduce the number of classes. Ecotypes then were derived from these tabular associations to differentiate different sets of associated characteristics (see the Ecotype section for more detailed descriptions and analysis).

Examination of the toposequences and cross-tabulation of the plot data revealed consistent associations among soil texture, geomorphic units that denote depositional environments, slope position, surface forms related to ice aggradation and active-layer processes, hydrology, and vegetation structure (Table 8). The hierarchical organization of the ecological components reveals how tightly or loosely the components are linked. For example, some physiographic settings included several geomorphic units with similar soil textures. Similarly, a given vegetation type could occur on several geomorphic units, depending on surface form characteristics and hydrology. In contrast, some geomorphic units (e.g., Tidal Flats) were associated only with a few distinctive vegetation types.

Results from this analysis of relationships were used in several ways. First, they were used to develop conceptual models of landscape evolution on floodplains and the adjacent coastal plain. Identification of the changing patterns in geomorphic units and vegetation, along with analysis of changes in soil properties, helps identify processes (e.g., acidification, sedimentation) that affect the changing patterns. Second, the hierarchical relationships developed "from the ground up" were used to determine the rules for aggregating the ITUs (based on only three parameters) used for mapping "from the top down." This simpler set of characteristics (geomorphic unit, surface form, and vegetation structure) was used to assign the mapped ITUs to ecotypes with a well-defined suite of ecological characteristics. Third, knowledge of ecological relationships helps constrain the choices faced during photo-interpretation, improving classification within a physiographic district. For example, the hierarchical organization of landscape relationships reveals that only a few vegetation types (e.g., Wet Sedge Meadow Tundra, Moist Sedge–Shrub Tundra, and Dryas Dwarf Shrub Tundra) are found on Alluvial–Marine Deposits; this knowledge can be used during mapping to improve accuracy and consistency.

The contingency table analysis also can be used to evaluate how well these general relationships conform to the data set, and how reliably they can be used to extrapolate trends across the landscape. During development of the relationships, 14% of the observations were excluded from the table because of inconsistencies among physiography, texture, geomorphology, drainage, soil chemistry, and vegetation. We

Table 8. Relationships among ecological components of ecosystems in the Northeastern Planning Area of the NPRA, 2002.

Physiography	Soil Texture	Geomorphic Unit	Slope Position	Surface Form	Drainage	Soil Chemistry	Vegetation Structure	Plant Association	Ecosystem Class (Ecotype Level)
Upland	Sand	Eolian Active Sand Deposit	Upper slopes,	Streaked Dunes	Exces-sive,	Alkaline, Circum-	Barren	*Salix alaxensis–Chrysanthemum*	Upland Dry Barrens
			ridges		Well-drained	Neutral (CN)	Tall Shrub	*bipinnatum*	Upland Dry Tall Willow Shrub
	Sand, Loam	Eolian Inactive Sand Deposit, Old Alluvial	Upper slopes	Streaked Dunes,	Well-drained	Alkaline, CN	Low Shrub	*Salix glauca–Arctostaphylos rubra*	Upland Moist Low Willow Shrub
		Terrace, Alluvial–Marine Deposit,	ridges	Banks, Bluffs Pingos			Dwarf Shrub	*Dryas integrifolia– A. alpina–S. glauca*	Upland Dry Dryas Dwarf Shrub
		Ice-rich Thaw Basin Centers,	Shoulders, Banks	Hummocky		CN, Acidic	Dwarf Shrub	*Cassioppe tetragona–Hierochloe alpine*	Upland Moist Cassiope Dwarf Scrub
		Thaw Basin Pingo	Upper slopes,	High-centered, Low	Mod. Well,	Alkaline, CN	Graminoid Tussocks	*Eriophorum vaginatum–Dryas integrifolia*	Upland Moist Tussock Meadow
			Ridges	-relief Poly (HCP)	Somewh at poorly	CN, Acidic		*Eriophorum vaginatum–Ledum decumbens*	
Lowland	Water	Deep Isolated Lake, Deep Connected Lake, Shallow Connected Lake, Shallow Isolated Lake	Water	Water	Flooded	Alkaline, Circum-neutral	Water	Water	Lowland Lake
	Peat, Loam,	Old Alluvial Terrace, Alluvial– Marine Deposit,	Flat	Nonpatterned, Low-centered,	Flooded	Alkaline, CN	Graminoid	*Carex aquatilis*	Lowland Sedge Marsh
	Sand	Eolian Inactive Sand Deposit		Low-relief Polygons	Very Poor,	Circum-neutral,		*Carex aquatilis–Carex saxatilis*	Lowland Wet Sedge Meadow
				(LCP)	Poor	Acidic		*Eriophorum angustifolium–S. pulchra–Sphagnum* sp.	
	Loam, Sand	Ice-rich Thaw Basin Margins, Ice-rich Thaw	Flat, Gently	LCP, Mixed High- and	Some-what	Circum-neutral	Graminoid	*Dryas integrifolia–Carex bigelowii–S. richardsonii*	Lowland Moist Sedge–Shrub Meadow
		Basin Centers, Meander Abandoned-floodplain	Sloping	Low-centered Polygons	Poor	Acidic	Low Shrub	*Salix planifolia pulchra–Carex aquatilis*	Lowland Moist Low Willow Shrub
		Cover Deposit, Eolian Inactive Sand Deposit	Basin	Basin Complex	Complex	Complex	Complex	Marsh, Wet Meadow, Moist Meadow, Tussock Meadow, Water	Lowland Basin Complex

Table 8. (Continued).

Physiography	Soil Texture	Geomorphic Unit	Macro-topography	Micro-topography	Drainage	Soil Chemistry	Vegetation Structure	Floristic Class	Ecotype
Lacustrine	Water	Shallow Isolated or Connected Pond	Water	Water	Flooded	Alkaline, Circum-neutral	Graminoid	*Arctophila fulva*	Lacustrine Grass Marsh
								Carex aquatilis	Lacustrine Sedge Marsh
	Sand, Peat	Ice-poor Thaw Basin	Flat	Nonpatterned, Disjunct	Very Poor	Circum-neutral	Graminoid	*Carex aquatilis–Carex saxatilis*	Lacustrine Wet Sedge Meadow
	Sand			Polygon Rims	Somewh at Poor		Graminoid	*Dryas integrifolia–C. bigelowi–S. richardsonii*	Lacustrine Moist Sedge–Shrub Meadow
							Low Shrub	*Salix planifolia pulchra–Carex aquatilis*	Lacustrine Moist Low Willow Shrub
							Barren	Barren, Partially Vegetated	Lacustrine Moist Barrens
					Complex	Complex	Complex	Marsh, Wet Meadow, Moist Meadow, Water	Lacustrine Basin Complex
Riverine	Water	Lower Perennial River	Water	Water	Flooded	Alkaline, Circum-Neutral	Water	Water	Lower Perennial River
		Headwater Stream							Headwater Stream
		Deep Isolated Lake, Shallow Isolated Lake							Riverine Lake
		Meander Fine Inactive Channel Deposit,	Water	Water	Flooded	Circum-Neutral,	Graminoid	*Carex aquatilis*	Riverine Sedge Marsh
		Shallow Isolated Lake				Alkaline		*Arctophila fulva*	Riverine Grass Marsh
	Sand	Meander Fine Active Channel Deposit	Point Bar	Nonpatterned	Well to Poor	Alkaline, CN	Barren	*Deschampsia caespitosa–Salix alaxensis*	Riverine Moist Barrens
	Loam, Sand	Meander and Delta Inactive Overbank Deposit	Flat, Point Bar	Nonpatterned, HCP	Well	Alkaline	Dwarf Shrub	*Dryas integrifolia–Oxytropis deflexa*	Riverine Dry Dryas Dwarf Shrub

Table 8. (Continued).

Physiography	Soil Texture	Geomorphic Unit	Macro-topography	Micro-topography	Drainage	Soil Chemistry	Vegetation Structure	Floristic Class	Ecosystem Class (Ecotype Level)
Riverine	Sand, Loam	Meander and Delta Active Overbank Deposit	Flat, Point Bar	Nonpatterned, Mounds	Well	Alkaline, CN	Tall Shrub	*Salix alaxensis–Chrysanthemum bipinnatum*	Riverine Moist Tall Willow Shrub
		Meander and Delta Active and Inactive Overbank	Flat	Nonpatterned, Mixed High-	Mod. Well	neutral	Low Shrub	*Salix richardsonii–Equisetum variegatum*	Riverine Moist Low Willow Shrub
		Deposit, Headwater Floodplain		and Low-centered				*S. pulchra–S. richardsonii –Arctagrostis latifolia*	
				Polygons	Somewh at Poor		Graminoid	*Dryas integrifolia–Carex bigelowii–S. richardsonii*	Riverine Moist Sedge –Shrub Meadow
				(LCP)	Very Poor			*C. aquatilis–Salix richardsonii– E.variegatum*	Riverine Wet Sedge Meadow
	Vari-able	Floodplain variable	Flat	Variable	Variable	Variable	Variable	Barrens, Shrub, Wet Meadow, Moist Meadow	Riverine Complex
	Loam	Delta Inactive Overbank Deposit		LCP; High-relief	Variable	Variable	Variable	Fresh Marsh, Wet Meadow, Moist Meadow, Water	Riverine Deep-polygon Complex
	Sand, Loam	Meander Inactive Overbank Deposit, Eolian Inactive Sand Deposit	Flat, Small Dunes	Dune Complex	Variable	Variable	Variable	Dwarf Scrub, Low Scrub, Moist Meadow, Wet Meadow, Marsh	Riverine Dune Complex
Coastal	Water	Nearshore Water	Water	Water	Flooded	Saline	Water	Water	Nearshore Water
		Tidal River	Water	Water	Flooded	Slightly	Water	Water	Tidal River
		Shallow Tapped Lake w/				Brackish	Water	Water	Coastal Lake
		Low-water Connection				Brackish	Herb	*Hippurus vulgaris*	Coastal Herb Marsh
	Sand, Loam	Active and Inactive Tidal Flat	Flat	Nonpatterned, Low-centered	Poor	Brackish	Graminoid	*Carex subspathaceae–Puccinellia phryganodes*	Coastal Wet Sedge Meadow
				Polygons	Well to Poor	Slightly Brackish	Dwarf Shrub	*Salix ovalifolia–Carex subspathaceae*	Coastal Moist Dwarf Willow Shrub
						Circum-neutral	Barren	*Stellaria humifusa–Puccinellia phryganodes*	Coastal Salt-killed Wet Meadow
		Delta Active Channel Deposits, Active Tidal Flat	Flat	Nonpatterned	Well	Slightly Brackish	Barren	*Elymus mollis–Stellaria humifusa*	Coastal Moist Barrens
						Fresh, CN		*Deschampsia caespitosa–Stellaria humifusa*	

excluded these outliers because our primary goal was to identify the most distinct and consistent trends, not necessarily to include every plot. We believe that there is an upper limit to our ability to describe landscape patterns; there will always be a proportion (in this case 14%) of sites that do not conform to the overall relationships among factors. These sites may be transitional (ecotones) or sites where vegetation and soils have been affected by historical factors (e.g., changes in water levels, disturbances) in ways that are not readily explainable based on current environmental conditions.

The advantage of this hierarchical approach is that the combination of physiography (strongly associated with geomorphic units), moisture (related to surface form), and vegetation structure yields classes that effectively differentiate both soil characteristics and vegetation composition. This "bottom up" approach is particularly useful for mapping, where the interpreter can easily distinguish physiography (e.g. floodplains versus hilly uplands), surface form (e.g., low-centered polygons versus bank), and vegetation structure (e.g., low shrubs versus graminoids), but not individual plant species. In addition, this approach links vegetation with soil characteristics. This linkage is particularly important for differentiating ecotypes that may have different sensitivities to disturbance. For example, Lacustrine Wet Sedge Meadows in Ice-poor Thaw Basin Margins with Nonpatterned surface form will be less susceptible to thermokarst than will Lowland Wet Sedge Meadows in with Ice-rich Thaw Basins Margins with Low-centered Polygons, where ice wedges are abundant.

ECOTYPES

Classification and Mapping

Forty-two ecotypes were developed for the Northeastern Planning Area (Table 9, Figures 14 and 15). Of these ecotypes, 41 were mapped and 1 type (Coastal Herb Marsh) was not mapped because it lacked distinctive photo characteristics. For map presentation, the 41 ecotypes were derived from 325 code combinations created by the integrated-terrain-unit mapping. The most common ecotypes in the area included Upland Moist Tussock Meadow (27.4%), Lowland Moist Sedge–Shrub Meadow (19.5%), Lowland Lake (11.4%), Lowland Wet Sedge Meadow (9.4%), and Lowland Basin Complex (8.8%) (Table 10). Twenty-nine ecotypes each had areal coverage of <1% of the study area.

The linking of geomorphic units with surface form and vegetation structure helped distinguish areas with important ecological differences that would otherwise be difficult to detect. For example, we differentiated seven waterbody classes (e.g., Nearshore Water, Headwater Stream), based on large differences in salinity, sediment load, and water velocity. We did not differentiate water depth (deep vs. shallow water), however, because it would have added several more classes. Water depth, however, is still a component of the waterbody and avian habitat classifications and preserved in the ITU mapping. In most vegetation or land-cover maps for northern Alaska, water is treated as only one or two classes. In some cases, different ecotypes (e.g., types of wet sedge meadow) differed only slightly in vegetation composition, but the geomorphic data revealed differences in soil and hydrologic characteristics that lead to differing ecological functions and successional pathways (see *Ecological Development During Landscape Evolution*).

Accuracy Assessment

The overall accuracy of the ecotype map was 79%, based on a comparison of field and map determinations at 118 locations (Table 11). While the sample size was insufficient for rigorous analysis of omission and commission errors by ecotypes some general patterns were evident. Substantial confusion occurred between Upland Moist Tussock Meadow and Lowland Moist Sedge–Shrub Meadow types because they often are highly interspersed and they are differentiated primarily by the abundance of tussocks, which has an arbitrary cutpoint of 15% cover. Lowland Moist Sedge–Shrub Meadow also was frequently confused with Lowland Wet Sedge Meadow because they also are highly interspersed types. The most poorly mapped class in this analysis was Lacustrine Grass Marsh, which had a high omission error. While easily recognized on the ground, aquatic grass often does not occur in sufficiently dense stands to be recognizable on aerial photography. Factors that contributed to the

Table 9. Classification and descriptions of ecotypes (local-scale ecosystems) in the Northeastern Planning Area of the NPRA, 2002. Species in bold type indicate floristic associations.

Class	Description
Upland Dry Tall Willow Shrub	Crests of Eolian Active Sand Deposits (dunes) with vegetation dominated by the tall willow ***Salix alaxensis***. Soils are sandy, excessively drained, alkaline to circumneutral, with deep active layers (> 1m) and no surface organic horizons. The shrub canopy usually is open with dominant shrubs > 1m tall. Other common species include ***Chrysanthemum bipinnatum***, *Festuca rubra*, and *Equisetum arvense*.
Upland Moist Low Willow Shrub	Upper, well-drained, protected slopes of Alluvial Terrace, Alluvial–Marine and Inactive Eolian Sand Deposits. Soils are sandy, alkaline to circumneutral with deep active layers, and have little organic accumulation. Low shrubs (0.2–1.5m tall) are dominant, typically ***Salix glauca***, with *Dryas integrifolia, Salix lanata richardsonii*, ***Arctostaphylos rubra***, and mosses. Included in this class are sites dominated by low shrub birch, *Betula nana*.
Upland Dry Dryas Dwarf Shrub	Windswept, upper slopes and ridges of Alluvial Terrace, Alluvial–Marine and Inactive Eolian Sand Deposits. Vegetation is dominated by the dwarf (< 0.2m tall) evergreen shrub ***Dryas integrifolia***. Soils are sandy to loamy, excessively to well drained, alkaline to circumneutral, and lack surface organic accumulation. Associated species include *Salix reticulata*, ***Salix glauca***, ***Arctostaphylos alpina***, *Arctagrostis latifolia*, and lichens.
Upland Moist Cassiope Dwarf Shrub	Slopes and banks of Old Alluvial Terrace, Alluvial–Marine Deposits, Inactive Eolian Sand Deposits, Pingos, and banks of drained lake basins. Soils are well-drained, loamy to sandy, and circumneutral to acidic. Vegetation is species rich, dominated by the dwarf shrub ***Cassiope tetragona***, with *Dryas integrifolia, Salix phlebophylla, Vaccinium vitis-idaea, Carex bigelowii, Arctagrostis latifolia*, ***Hierochloe alpina***, *Pyrola grandiflora*, and *Saussurea angustifolia*. Lichens and mosses also are common.
Upland Moist Tussock Meadow	Gentle slopes and ridges of Eolian Inactive Sand Deposits, Old Alluvial Terrace, Alluvial–Marine Deposits and Ice-rich Thaw Basin Centers. Vegetation is dominated by tussock-forming plants, most commonly ***Eriophorum vaginatum***. High-centered polygons of low or high relief are associated with this ecotype. Soils are loamy to sandy, somewhat well-drained, acidic to circumneutral, with moderately thick (10–30cm) organic horizons and shallow (< 40cm) active layer depths. On acidic sites, associated species include ***Ledum decumbens***, *Betula nana, Salix planifolia pulchra, Cassiope tetragona* and *Vaccinium vitis-idaea*. On circumneutral sites common species include ***Dryas integrifolia***, *S. reticulata, Carex bigelowii*, and lichens. Mosses are common at most sites.
Upland Dry Barrens	Eolian Active Sand and Landslide Deposits with partial vegetative cover (< 30%). These deposits are well drained, alkaline, have deep active layers, and little to no organic accumulation. Early colonizing species adapted to disturbance are found on these sites, including *Salix alaxensis, Festuca rubra*, and *Chrysanthemum bipinnatum*. These sites become fully vegetated when surface soils stabilize.
Lowland Moist Low Willow Shrub	Flats and gentle slopes with high-centered polygons or drainage tracks on Abandoned Floodplains, Old Alluvial Terrace, Alluvial-Marine Deposits, Eolian Inactive Sand Deposits, and Ice-rich Thaw Basins. Soils typically are somewhat poorly drained, and acidic with moderate to thick organic horizons. Vegetation is dominated by low willows (0.2–1.5m tall), most commonly ***Salix planifolia pulchra***. Common associated species include *S. reticulata, Carex bigelowii*, ***C. aquatilis***, *Eriophorum angustifolium, Pyrola grandiflora*, and mosses (*Dicranum* spp., *Polytricum* spp., *Aulacomnium* spp.).
Lowland Moist Sedge–Shrub Meadow	Typically high-centered, low-relief polygons on Abandoned Floodplain, Ice-rich Thaw Basin, Old Alluvial Terrace, Alluvial–Marine, Eolian Inactive Sand, and Solifluction Deposits. Soils are saturated at intermediate depths (> 15cm) but generally are free of surface water during summer. The active layer is relatively shallow and the organic horizon is moderate (10–15cm). Vegetation is dominated by ***Dryas integrifolia*** and ***Carex bigelowii***. Other common species include *C. aquatilis, Eriophorum angustifolium, Salix reticulata*, ***S. lanata richardsonii***, and the moss *Tomentypnum nitens*.
Lowland Wet Sedge Meadow	Low-centered, low-relief polygons, with water near the surface on Abandoned Floodplain, Ice-rich Thaw Basin, Old Alluvial Terrace, Alluvial–Marine, and Eolian Inactive Sand Deposits. The surface generally is flooded during early summer (depth < 30cm) and drains later, soils are saturated throughout the growing season, and are circumneutral to acidic, with moderate to thick (20–40 cm) organic layers and moderately deep active layer depths (> 40cm). Vegetation is dominated by sedges, usually ***Carex aquatilis*** and ***Eriophorum angustifolium***, with ***C. saxatilis***, *E. russeolum* and ***Salix planifolia pulchra***. Mosses typical of wet conditions are common, including *Limprichtia revolvens, Aulacomnium turgidum, Scorpidium scorpioides*, and *Sphagnum* spp. Drier polygon rims are populated by species typical of moist meadows including *Dryas integrifolia, S. reticulata, C. bigelowii* and *Cassiope tetragona*.

Table 9. (Continued).

Class	Description
Lowland Sedge Marsh	Vegetated, permanently flooded, shallow (< 50cm) basins, most commonly in Ice-rich Thaw Basin Margins, but also on Alluvial–Marine and other lowland deposits. Surface waters are alkaline to circumneutral, sediments commonly are organic. Vegetation is dominated by ***Carex aquatilis.***
Lowland Lake	Deep (> 1.5m) and shallow (< 1.5m) lakes and ponds that form in low-lying basins and from thawing of ice-rich permafrost. These lakes lack riverine or coastal influences and emergent vegetation. In deep lakes, a substantial volume of deep water remains unfrozen through the winter. In shallow lakes, water freezes to the bottom during winter, thaws by early to mid-June, and is warmer than water in deep lakes. Sediments are sandy to loamy. Lowland lakes may or may not have distinct outlets or connections to rivers.
Lowland Basin Complex	Basin complexes occur in drained lake basins and are characterized by a mosaic of vegetation types. Complexes are mapped when at least three ecotypes occur together and no single class is dominant. Lowland Basin Complex occurs in older basins (see Lacustrine Basin Complex) and is characterized by well-developed low- and high-centered polygons or strang resulting from ice-wedge development and aggradation of segregated ice. Polygon development may be more distinct in the raised basin centers than the frequently flooded margins. Basins often have distinct rims marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of multiple basins. Ecotype classes commonly found in this complex include Lowland Sedge Marsh, Lowland Wet Sedge Meadow, Lowland Lake, Lowland Moist Sedge–Shrub Meadow in basin margins, and Lowland Moist Sedge–Shrub Meadow, Upland Moist Tussock Meadow, and Lowland Wet Sedge Meadow in basin centers.
Lacustrine Moist Low Willow Shrub	Nonpatterned, flat areas of recently drained Ice-poor Basins dominated by low shrubs (< 1.5m tall). Soils are circumneutral, sandy, and somewhat poorly drained, with shallow to moderate (10–20cm) organic horizons and variable active layer depths. Vegetation is dominated by *Salix lanata richardsonii* and/or ***Salix planifolia pulchra*** with an understory of *Eriophorum angustifolium*, ***Carex aquatilis***, and the mosses *Tomentypnum nitens* and *Aulacomnium turgidum*.
Lacustrine Moist Sedge–Shrub Meadow	Ice-poor Basins with nonpatterned ground or isolated mounds. Soils are somewhat poorly drained, circumneutral, and sandy with little organic accumulation, and a moderately deep active layer. Ground water is present at > 15cm depth. Vegetation is co-dominated by ***Dryas integrifolia, Carex bigelowii***, *Salix reticulata*, and *C. aquatilis*. Common associates include ***S. lanata richardsonii***, *S. planifolia pulchra*, *Eriophorum angustifolium*, and the mosses *Tomentypnum nitens* and *Hylocomium splendens*.
Lacustrine Wet Sedge Meadow	Areas of nonpatterned ground and disjunct polygons on flats within Ice-poor Basins. Drainage is very poor and water is near the surface throughout the growing season. The surface generally is flooded during early summer (depth < 30cm) and drains later, soils are circumneutral with moderately thick (10–25cm) organic layers over sand or loamy sand. Active layer depths are moderately deep (40–60 cm). Vegetation is strongly dominated by the sedges ***Carex aquatilis*** and *Eriophorum angustifolium*, occasional associates include ***C. saxatilis***, *Pedicularis sudetica*, and *Salix planifolia pulchra*.
Lacustrine Sedge Marsh	Vegetated, permanently flooded, shallow (< 50cm) depressions in Ice-poor Basins and along the margins of Lowland Lakes. Water is alkaline to circumneutral and soils have thick (40cm) organic horizons over sands. ***Carex aquatilis*** and *Eriophorum angustifolium* are dominant, *C. chordorrhiza* and *Scorpidium scorpioides* are common.
Lacustrine Grass Marsh	Vegetated, depressions and lakes (depth < 1m), in Ice-poor Basins and shallow margins of deeper Lowland Lakes defined by the presence of ***Arctophila fulva***. Water is alkaline to circumneutral and sediments have a variable peat layer (10–40cm deep) overlying sands. *Hippuris vulgaris* and *Carex aquatilis* may be present in shallow water.
Lacustrine Moist Barrens	Barren or partially vegetated (< 30% cover) areas on newly exposed sediments on Ice-poor Thaw Basin Deposits. The surface generally is nonpatterned, although occasionally mounds are present reflecting the degradation of ice-wedge polygons along shorelines. Soils are sandy and may be saturated or well-drained, with little to no organic accumulation. Typical colonizers are forbs, graminoids, and mosses including *Carex aquatilis, Dupontia fisheri, Scorpidium scorpioides*, and *Calliergon* spp. on wet sites and *Poa* spp., *Festuca rubra, Deschampsia caespitosa, Stellaria humifusa, Senecio congestus*, and *Salix ovalifolia* on drier sites.

Table 9. (Continued).

Class	Description
Lacustrine Basin Complex	Basin complexes occur in drained lake basins and are characterized by a mosaic of vegetation types. Complexes are mapped when at least three ecotypes occur together and no single class is dominant. Lacustrine Basin Complex is found in recently drained (young) basins characterized by nonpatterned ground and disjunct polygon rims that indicate a lack of ice-wedge development or aggradation of segregated ice (see Lowland Basin Complex). Basins often have distinct rims marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of multiple basins. Young basins typically are flooded during early spring and water remains close to the soil surface throughout the growing season. Soils generally are circumneutral and sandy with variable organic horizons. The distinction between basin centers and margins is less clear than in Lowland Thaw Basins. Ecotype classes commonly found in this complex include Lacustrine Grass Marsh, Lacustrine Sedge Marsh, Lacustrine Wet Sedge Meadow, Lacustrine Moist Sedge–Shrub Meadow, Lacustrine Moist Low Willow Shrub, and Lowland Lake.
Riverine Moist Tall Willow Shrub	Active Overbank Deposits of meander and tidal rivers dominated by tall (> 1.5m) shrubs. Sites are nonpatterned and subject to variable flooding frequency, soils are well-drained, alkaline to circumneutral, and lack organic accumulation. Vegetation is defined by an open canopy of ***Salix alaxensis***. Understory species include *Equisetum arvense*, *Gentiana propinqua*, ***Chrysanthemum bipinnatum***, *Festuca rubra*, and *Aster sibiricus*.
Riverine Moist Low Willow Shrub	Active and Inactive Overbank Deposits of meander and tidal rivers with nonpatterned ground or high-centered polygons dominated by low (< 1.5m) shrubs. Frequently flooded sites are well drained with little organic accumulation whereas infrequently flooded areas are moderately well drained with interbedded layers of fine mineral soil and organic material. Soils are circumneutral with deep (> 60cm) active layer depths. ***Salix lanata richardsonii*** is dominant on sites where both riverine and eolian processes (dunes) are present. Common understory species include ***Equisetum arvense***, *Astragalus alpinus*, *Drepanocladus* sp., and *Tomentypnum nitens*. On smaller floodplains without extensive dune development, ***S. lanata richardsonii*** and ***S. planifolia pulchra*** co-dominate with ***Arctagrostis latifolia*** and *Petasites frigidus* in the understory.
Riverine Dry Dryas Dwarf Shrub	Active and Inactive Overbank Deposits of meander and tidal rivers with nonpatterned ground or high-centered polygons dominated by dwarf (< 0.2m) shrubs. The loamy to sandy soils are well-drained and alkaline with shallow (< 15cm) organic horizons and deep (> 80cm) active layer depths. The dwarf shrub ***Dryas integrifolia*** is dominant with *Salix reticulata*, *Equisetum variegatum*, ***Oxytropis deflexa***, *Arctostaphylos rubra*, and lichens as common associates.
Riverine Moist Sedge–Shrub Meadow	This class occurs on gently sloping Meander Fine Inactive Channel and Overbank Deposits. The surface usually is nonpatterned, high-centered or mixed high- and low-centered polygons. Soils are somewhat poorly drained, alkaline to circumneutral, with shallow organic horizons and moderately deep (40–80cm) active layer depths. Vegetation is dominated by ***Dryas integrifolia, Carex bigelowii, Salix lanata richardsonii***, and *S. reticulata*, with *Carex aquatilis*, *Eriophorum angustifolium*, and *Equisetum variegatum*. Common mosses include *Tomentypnum nitens* and *Dicranum* sp.
Riverine Wet Sedge Meadow	Flat, Active and Inactive Overbank Deposits of meander and tidal rivers and along the margins of Headwater Streams. Surface forms vary from nonpatterned to low-relief, low-centered polygons, the latter are indicative of progressive ice-wedge development and are common on Inactive Overbank Deposits. Sites in this class are flooded in early spring and soils remain saturated with ground water close to the surface throughout the growing season. Soils usually have a moderately thick organic layer (10–40cm) over sand or loam, and are alkaline to circumneutral. Thaw depths are approximately 40–60cm. Vegetation is dominated by the sedges ***Carex aquatilis*** and *Eriophorum angustifolium*, occasionally the willow ***Salix lanata richardsonii*** is a co-dominant. Common associated species include ***Equisetum variegatum***, *Pedicularis sudetica*, and the mosses *Scorpidium scorpioides* and *Limprichtia revolvens*.
Riverine Sedge Marsh	Vegetated, permanently flooded, shallow (< 50cm) depressions in Meander Fine Active Channel Deposits, and along the margins of Riverine Lakes and Headwater Streams. Water is circumneutral to alkaline and sediments have moderate organic horizons. Thaw depths typically exceed 60cm. Vegetation is dominated by ***Carex aquatilis***, *Eriophorum angustifolium*, and *Scorpidium scorpioides*.
Riverine Grass Marsh	Vegetated depressions and lakes (depth < 1m), in channel and overbank deposits and shallow margins of deeper Riverine Lakes defined by the presence of ***Arctophila fulva***. Water freezes to the bottom in the winter and the ice melts by early June. Water is alkaline to circumneutral, organic horizons vary, underlying mineral material is loam or sand. *Hippuris vulgaris* and *Carex aquatilis* may be present in shallow water.

Table 9. (Continued).

Class	Description
Riverine Lake	Shallow (< 1.5m) and deep (> 1.5m) ponds or lakes associated with old river channels, point bars and meander scrolls and that lack emergent vegetation. Some may have connecting channels that flood during high water. Water freezes to the bottom during winter in shallow, but not in deep lakes. Water is alkaline to circumneutral and sediments are fine-grained.
Riverine Moist Barrens	Barren or partially vegetated (< 30% cover) areas most commonly on river bars of Meander Fine Active Channel Deposits. Frequent sedimentation and scouring restricts establishment and growth of vegetation. There is no organic accumulation on these sandy sediments. Typical pioneer plants include ***Deschampsia caespitosa***, *Poa hartzii, Festuca rubra,* ***Salix alaxensis***, and *Equisetum arvense.*
Riverine Deep-polygon Complex	This class is associated with permafrost degradation on Delta Inactive Overbank Deposits. A substantial component of this complex is permanent water due to flooded low-centered, high-relief polygons. Most polygon centers are deep (up to 2m) and rims are broad and flat. Deep polygons support a fringe of marsh species such as *Arctophila fulva, Caltha palustris, Hippuris vulgaris,* and *Carex aquatilis.* Rims are dominated by *Eriophorum angustifolium, Carex aquatilis, Dryas integrifolia,* and *Salix reticulata.* Occasional, shallower (< 0.5m) polygons support wet meadow vegetation dominated by *Carex aquatilis* and *Eriophorum angustifolium.* Vegetated ecotypes in this complex include Riverine Sedge and Grass Marshes, Riverine Wet Sedge, and Riverine Moist Sedge–Shrub Meadows.
Riverine Complex	Permanently flooded channels and small floodplains that have a complex of vegetation types in narrow bands or patches too small to be mapped separately. The variety of vegetation reflects the degree and regularity of flooding. Soils vary from sands or gravels in channels to thick organic deposits in infrequently flooded meadows and marshes. Ecotypes in this complex include Headwater Stream, Riverine Moist Barrens, Riverine Sedge or Grass Marsh, Riverine Wet Sedge Meadow, Riverine Moist Sedge–Shrub Meadow, and Riverine Moist Low Willow Shrub. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer.
Riverine Dune Complex	Complex formed from the action of irregular flooding on inactive sand dunes, most commonly on riverine point bars. A series of narrow swale and ridge features develop in parallel with river flow that are too small to map separately. Swales are moist or saturated with moderate active layer depths and organic accumulation while ridges are moist to dry with little organic material and deep thaw depths. Ecotypes in swales typically are Riverine Moist Low Willow Shrub, Riverine Wet Sedge Meadow, or Riverine Sedge Marsh, while ridges commonly are Upland Dry Dryas Dwarf Shrub or Upland Moist Low Willow Shrub.
Coastal Herb Marsh (not mapped)	Vegetated, permanently flooded, shallow (< 50cm) depressions in Inactive Tidal Flats or on the margins of Coastal Lakes. Water is brackish (~ 13 ppt) and affected by extreme tides and storm surges. The dominant plant species is *Hippuris vulgaris.*
Coastal Wet Sedge Meadow	Active and Inactive Tidal Flats with vegetation dominated by sedges. Soils are saturated, saline, loams with shallow to moderate (< 20cm) organic horizons. Active layer depths range from 35–55cm. Vegetation is dominated by ***Carex subspathacea, Puccinellia phryganodes***, with *C. ursina, Salix ovalifolia,* and *Dupontia fisheri.*
Coastal Moist Willow Dwarf Shrub	Active and Inactive Tidal Flats with vegetation dominated by ***Salix ovalifolia*** and graminoids. Soils are loamy (with variable organic horizons), variably saline, and saturated, with ground water depths ~ 25cm. Active layer depth is ~ 40cm. Commonly occurring graminoids are ***Carex subspathacea*** and *Calamagrostis deschampsioides.*
Coastal Salt-Killed Meadow	Barren or partially vegetated (< 30% cover) delta deposits, where saltwater intrusions from storm surges have killed much of the original vegetation and salt-tolerant plants are actively colonizing. Newly deposited sediments typically are found on top of a thick organic horizon. These areas have low pH, high salinity, and shallow thaw depths. Groundwater levels are variable. Common colonizing plants include ***Puccinellia phryganodes, Stellaria humifusa***, *Cochlearia officinalis*, and *Salix ovalifolia.* Litter from dead vegetation is abundant and non-vascular plants are absent. Remnant patches of Riverine or Lowland Wet Sedge Meadow are common.
Coastal Lake	Coastal waterbodies that are flooded periodically with saltwater during high tides or storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate is loamy and occasionally contains peat. Shorelines usually have halophytic vegetation. Some Coastal Lakes have distinct outlets or have been partially drained (tapped) through erosion of river banks. Shallow lakes (< 1.5m) freeze to the bottom during winter.

Table 9. (Continued).

Class	Description
Coastal Moist Barrens	Barren or partially vegetated (< 30% cover) Active Tidal Flats and Delta Active Channel Deposits where frequent sedimentation restricts vegetation establishment. Sediments usually are variably saline, have deep thaw depths and little organic accumulation. Slightly brackish sites are colonized by ***Deschampsia caespitosa***, *Equisetum arvense*, *Salix alaxensis* and ***Stellaria humifusa***, while more saline sites are dominated by ***Elymus arenarius mollis***, ***Stellaria humifusa***, and *Salix ovalifolia*.
Tidal River	Unvegetated, permanently flooded channels of lower Fish Creek and the Colville River that are affected by daily tidal fluctuations and have correspondingly variable salinity. The channels generally experience peak flooding during spring breakup and lowest water levels during mid-summer. During winter unfrozen water in deeper channels can become hypersaline.
Nearshore Water	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and sea ice create dynamic changes in physical and chemical characteristics. Tidal range normally is small (<0.2m), but storm surges produced by winds may raise sea level as much as 2–3m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. The ice-free period extends from July until October.
Lower Perennial River	Permanently flooded channels of freshwater rivers where the gradient is low and water velocity is slow. There is no tidal influence and some water flows throughout the summer. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The rivers have well-developed floodplains.
Headwater Stream	Permanently flooded first order tributaries of Judy Creek, Fish Creek, and the Ublutuoch River.

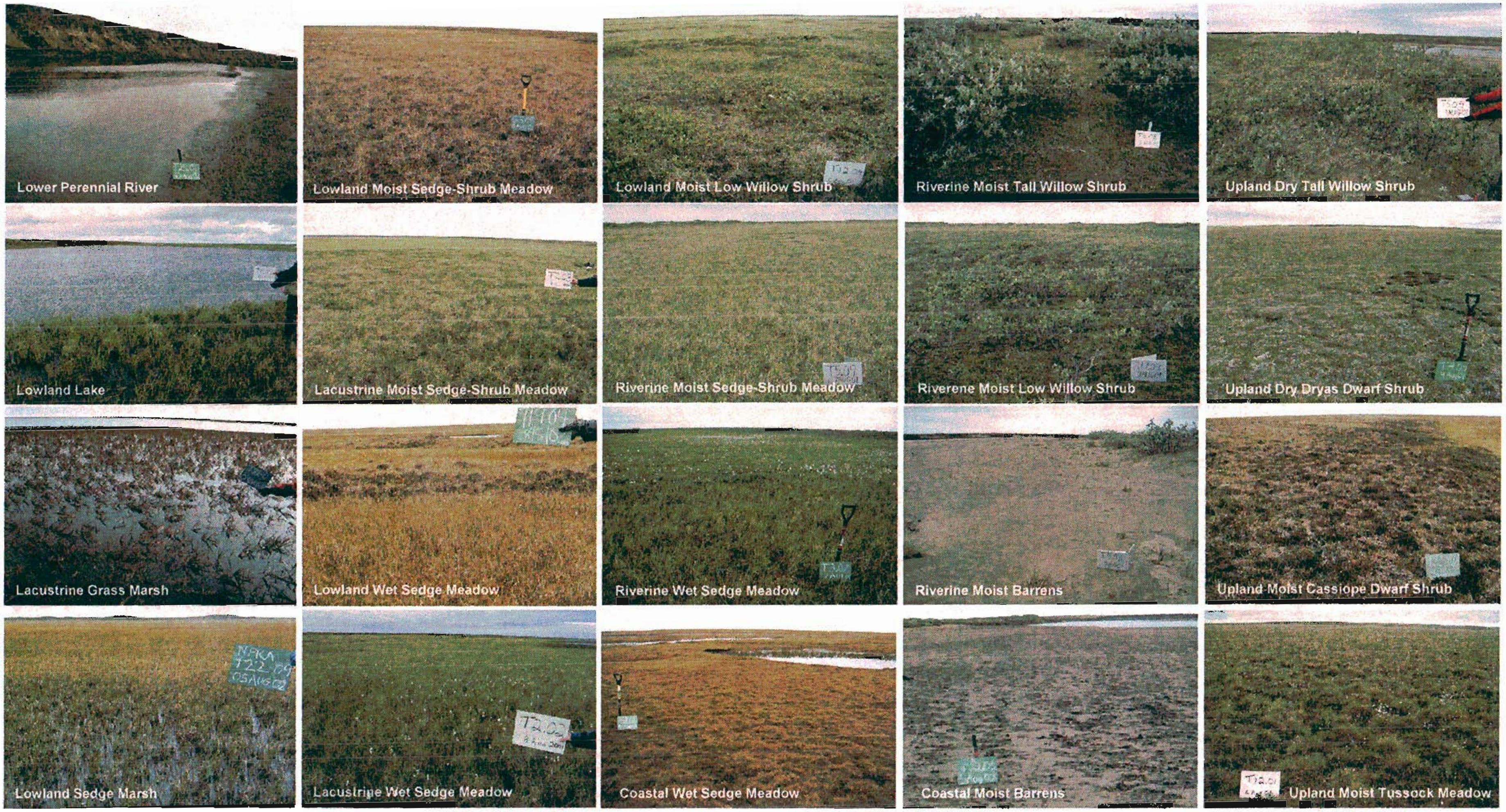
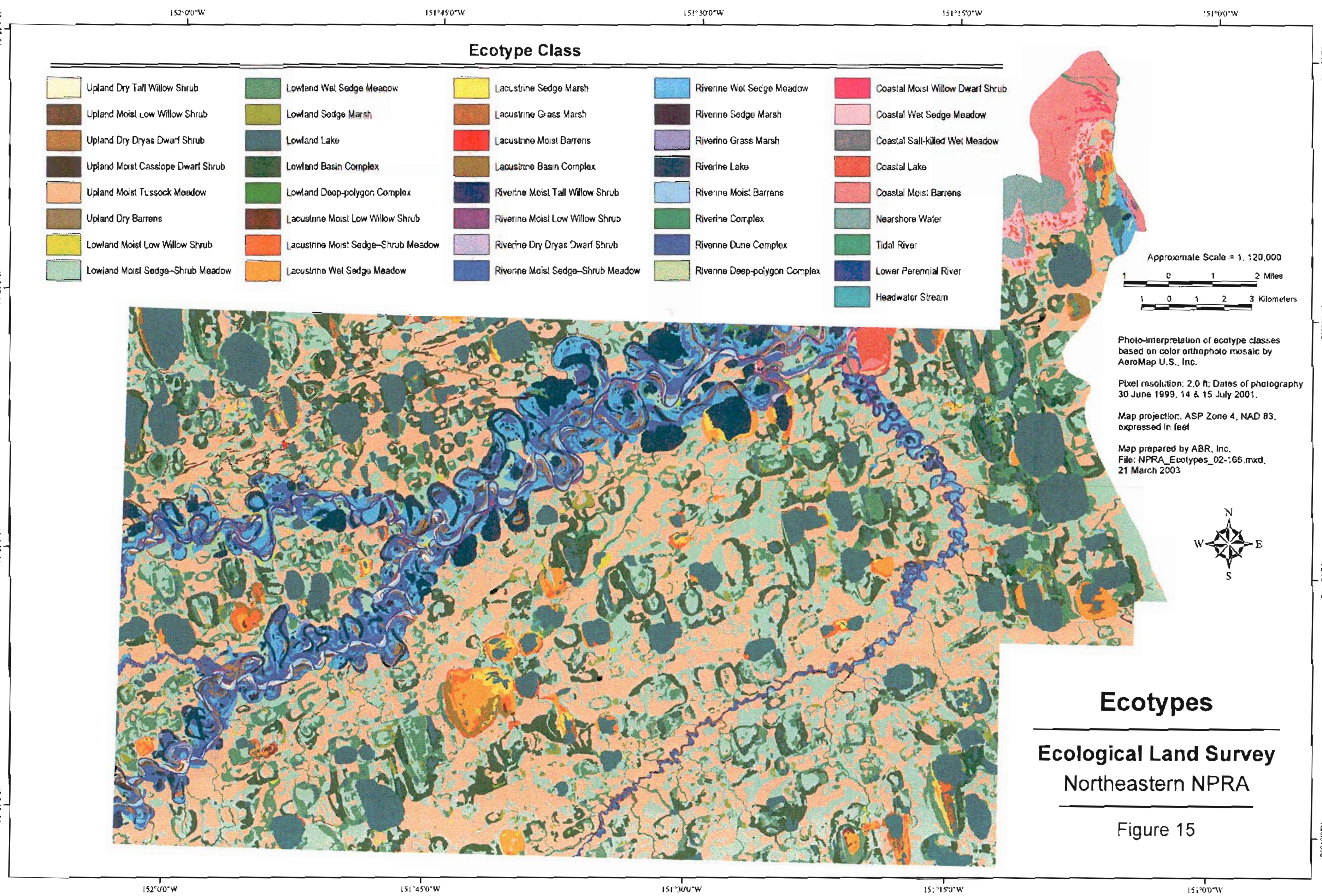


Figure 14. Photographs of common ecotypes in the Northeastern Planning Area of the NPRA, 2002.



Ecotypes

Ecological Land Survey
Northeastern NPRA

Figure 15

Table 10. Areal extent of ecotypes (local-scale ecosystems) and habitat classes in the 2001 study area within the Northeastern Planning Area of the NPRA, 2002.

	Area		
Ecotype	Acres	Hectares	%
Upland Dry Tall Willow Shrub	413	167	0.2
Upland Moist Low Willow Shrub	280	113	0.2
Upland Dry Dryas Dwarf Shrub	1154	467	0.7
Upland Moist Cassiope Dwarf Shrub	993	402	0.6
Upland Moist Tussock Meadow	47102	19069	27.4
Upland Dry Barrens	300	121	0.2
Lowland Moist Low Willow Shrub	451	183	0.3
Lowland Moist Sedge–Shrub Meadow	33540	13579	19.5
Lowland Wet Sedge Meadow	16155	6541	9.4
Lowland Sedge Marsh	1747	707	1.0
Lowland Lake	19576	7926	11.4
Lowland Basin Complex	15119	6121	8.8
Lowland Deep-polygon Complex	62	25	0.0
Lacustrine Moist Low Willow Shrub	69	28	0.0
Lacustrine Moist Sedge–Shrub Meadow	1085	439	0.6
Lacustrine Wet Sedge Meadow	2455	994	1.4
Lacustrine Sedge Marsh	755	306	0.4
Lacustrine Grass Marsh	379	154	0.2
Lacustrine Moist Barrens	14	6	0.0
Lacustrine Basin Complex	622	252	0.4
Riverine Moist Tall Willow Shrub	245	99	0.1
Riverine Moist Low Willow Shrub	1548	627	0.9
Riverine Dry Dryas Dwarf Shrub	68	28	0.0
Riverine Moist Sedge–Shrub Meadow	4775	1933	2.8
Riverine Wet Sedge Meadow	6183	2503	3.6
Riverine Sedge Marsh	351	142	0.2
Riverine Grass Marsh	107	43	0.1
Riverine Lake	6294	2548	3.7
Riverine Moist Barrens	950	385	0.6
Riverine Complex	688	278	0.4
Riverine Dune Complex	1875	759	1.1
Riverine Deep-polygon Complex	11	5	0.0
Coastal Moist Willow Dwarf Shrub	109	44	0.1
Coastal Wet Sedge Meadow	793	321	0.5
Coastal Salt-killed Wet Meadow	34	14	0.0
Coastal Lake	751	304	0.4
Coastal Moist Barrens	2449	991	1.4
Nearshore Water	841	341	0.5
Tidal River	168	68	0.1
Lower Perennial River	1308	530	0.8
Headwater Stream	49	20	0.0
Total	171861	69579	100

	Area		
Habitat Class	Acres	Hectares	%
Upland and Riverine Dwarf Shrub	2216	897	1.3
Upland Low and Tall Shrub	693	280	0.4
Moist Sedge–Shrub Meadow	39920	16162	23.2
Moist Tussock Tundra	47102	19069	27.4
Riverine Low and Tall Shrub	1793	726	1.0
Nonpatterned Wet Meadow	5307	2148	3.1
Patterned Wet Meadow	19487	7889	11.3
Old Basin Wetland Complex (Ice-rich)	15119	6121	8.8
Young Basin Wetland Complex (Ice-poor)	622	252	0.4
Riverine Complex	688	278	0.4
Salt Marsh	902	365	0.5
Salt-killed Tundra	34	14	0.0
Aquatic Grass Marsh	486	197	0.3
Aquatic Sedge Marsh	2854	1155	1.7
Aquatic Sedge with Deep Polygons	74	30	0.0
Shallow Open Water without Islands	1737	703	1.0
Shallow Open Water with Islands or Polygonized Margins	2823	1143	1.6
Deep Open Water without Islands	12342	4997	7.2
Deep Open Water with Islands or Polygonized Margins	8950	3624	5.2
Tapped Lake with High-water Connection	18	7	0.0
Tapped Lake with Low-water Connection	421	170	0.2
River or Stream	1488	602	0.9
Barrens (Riverine, Eolian, or Lacustrine)	1698	688	1.0
Brackish Water (tidal ponds)	330	134	0.2
Nearshore Water	841	341	0.5
Tidal Flat	2043	827	1.2
Dune Complex	1875	759	1.1
Total	171861	69579	100

Table 11. Omission and commission errors used to assess the accuracy associated with mapping of ecotypes in the 2001 study area within the Northeastern Planning Area of the NPRA, 2002.

	Ecotype Ground Determination																				
Ecotype Map Call	Upland Dry Dryas Dwarf Shrub	Upland Moist Cassione Dwarf	Upland Moist Tussock Meadow	Lowland Moist Sedge–Shrub	Lowland Wet Sedge Meadow	Lowland Sedge Marsh	Lowland Lake	Lacustrine Wet Sedge Meadow	Lacustrine Grass Marsh	Riverine Moist Tall Willow Shrub	Riverine Moist Low Willow Shrub	Riverine Moist Sedge–Shrub Meadow	Riverine Wet Sedge	Riverine Sedge Marsh	Riverine Lake	Riverine Moist Barrens	Coastal Lake	Lower Perennial River	Headwater Stream	Total	Percent correct
Upland Dry Dryas Dwarf Shrub	**1**																			1	100
Upland Moist Cassiope Dwarf Shrub																				0	
Upland Moist Tussock Meadow		1	**28**	7	1															37	76
Lowland Moist Sedge–Shrub Mead.			9	**9**	7															25	36
Lowland Wet Sedge Meadow			1		**9**															10	90
Lowland Sedge Marsh					1	**1**														2	50
Lowland Lake							**4**		3											7	57
Lowland Basin Complex				**2**	**9**															11	82
Lacustrine Wet Sedge Meadow								**1**												1	100
Lacustrine Grass Marsh																				0	
Riverine Moist Tall Willow Shrub										**1**										1	100
Riverine Moist Low Willow Shrub											**3**									3	100
Riverine Moist Sedge–Shrub Meadow												**2**								2	100
Riverine Wet Sedge Meadow			1									2	**3**						1	7	43
Riverine Sedge Marsh																				0	
Riverine Lake															**1**					1	100
Riverine Moist Barrens																**2**				2	100
Riverine Complex											**1**			**1**					**1**	3	100
Coastal Lake																	**1**			1	100
Lower Perennial River																		**2**		2	100
Headwater Stream																				0	
Riverine Dune Complex	**2**																			2	100
Total	3	1	39	18	27	1	4	1	3	1	4	4	3	1	1	2	1	2	2	118	79
Percent correct	100	0	72	61	67	100	100	100	0	100	100	50	100	100	100	100	100	100	50	79	

error included: (1) cutpoint errors between similar classes, (2) sampling of inclusions on the ground within larger map units, and (3) positional accuracy when field verification plots were near map boundaries.

Vegetation Characteristics

To facilitate comparison of floristic composition, riverine and upland ecotypes (Table 12) were analyzed separately from the wetter (lowland, lacustrine, and coastal) ecotypes (Table 13). Within each table the species were ordered to emphasize the gradient in species distribution across ecotypes. The tables include only species with high cover and/or high frequency within an ecotype. Overall, we identified 17 species or subspecies of deciduous shrubs, 7 evergreen shrubs, 105 forbs, 29 grasses, 49 sedges and rushes, 32 lichens, and 72 mosses, for a total of 207 vascular plants and 104 nonvascular plants (Appendix Tables 5 and 6). In addition, 50 taxa were identified only to the genus level.

Analysis of the tables revealed strong gradients in species composition among ecotypes. Little or no overlap in species occurred between the extreme ends of the gradient from dry upland sites to wet lowland sites or from non-saline to salt-affected ecotypes. For example, almost no species were in common between Riverine Moist Tall Willow Shrub and Riverine Sedge Marsh or between Lowland Wet Sedge Meadow and Coastal Wet Sedge Meadow. In the central portions of the gradients, however, different ecotypes often had similar species composition and were distinguished mainly by differences in relative abundance of the dominant species. For example, species composition was highly similar between Upland Moist Tussock Meadow and Upland Moist Cassiope Dwarf Shrub, but cover values for a few species (e.g., *Dryas integrifolia, Cassiope tetragona*, and *Eriophorum vaginatum*) were strongly different.

The relative abundance of various plant growth forms varied widely among ecotypes (Figure 16). For example, evergreen shrubs were most abundant on drier soils associated with Riverine Dry Dryas Dwarf Shrub, Upland Dry Dryas Dwarf Shrub, and Upland Moist Cassiope Dwarf Shrub. Deciduous shrubs were most abundant on moist soils associated with Upland Moist Low Willow Shrub, Riverine Moist Low Willow Shrub, and Lowland Moist Low Willow Shrub, and Lacustrine Moist Low Willow Shrub. Sedges were most abundant on wet soils associated with Lowland Wet Sedge Meadow, Lacustrine Wet Sedge Meadow, Riverine Wet Sedge Meadow, and Riverine Sedge Marsh.

Rare Plants

Three rare species of vascular plants were found in the study area during our survey. *Poa hartzii* ssp. *alaskana* is listed by the Alaska Natural Heritage Program (ANHP 2002) as being rare statewide (S1), and rare or uncommon globally or of long-term concern (G3G4T1). We located five new populations of this species on river sands and active dunes along Fish and Judy Creeks, where it was common to abundant in Barren (<5% total vegetation cover) to Partially Vegetated (5% to 30% cover) areas. This species was generally found in the coarser sediments on the upstream side of point bars. In some of these areas *P. hartzii* ssp. *alaskana* was the dominant species; in others, generally in the finer sediments on the downstream side of point bars, it was co-dominant with *Deschampsia caespitosa* and *Festuca rubra*. *Poa hartzii* ssp. *alaskana* is also known from populations in sandy areas along the Meade River and from the Peters Lake in the Arctic National Wildlife Refuge (ANWR). *Carex holostoma*, which is considered rare or uncommon globally (G3G4) and imperiled in the state (S2), was found in 11 Wet Sedge Meadow Tundra locations generally in old basin margins. *Koeleria asiatica*, which is considered apparent secure globally but of long-term concern (G4) and imperiled to rare in the state (S2S3); was found on one inactive sand dune. These latter two species were not previously known to occur in the area.

Several other species on the ANHP tracking list are known to occur in or near the study area, but were not found in our survey. *Thlaspi arcticum*, a species of global concern, is known from populations along stream banks in ANWR. Three additional species are globally common to uncommon but are at the edge of their ranges in Northern Alaska and, therefore, are considered species of concern for the state. *Potentilla stipularis* has been found on sandy substrates near Umiat, to the south of the study area; *Pleuropogon*

Table 12. Mean cover (%) of the most abundant species in upland and riverine ecotypes in the Northeastern Planning Area of the NPRA, 2002. Bolded number represent frequencies >60% within ecotype, blank when absent, and 0 = <0.5%. Italicized numbers identify floristic associations.

Taxon	Riverine Moist Barrens	Riverine Moist Tall Willow Shrub	Upland Dry Tall Willow Shrub	Upland Moist Low Willow Shrub	Riverine Moist Low Willow Shrub	Riverine Dry Dryas Dwarf Shrub	Riverine Moist Sedge–Shrub Meadow	Upland Dry Dryas Dwarf Shrub	Upland Moist Cassiope Dwarf Shrub	Upland Moist Tussock Meadow	Riverine Wet Sedge Meadow	Riverine Sedge Marsh	Riverine Grass Marsh
Poa hartzii	1	0											
Deschampsia caespitosa	2	0				0							
Chrysanthemum bipinnatum	1	2	2	1	0								
Aster sibiricus	0	1	0		0								
Gentiana propinqua	0	1	0		0	0		0					
Parnassia palustris	0	0			0	0					0		
Oxytropis viscida		0	1		0	1		1					
Castilleja caudata	0	1	1	1	0	0							
Juncus arcticus	1	1			0	1					0		
Salix alaxensis	2	31	34	3	2	1							
Trisetum spicatum	0	0	0	0	0	0	0	0	0				
Equisetum arvense	1	5	1	0	3	1		1			0		
Festuca rubra	2	1	2	0	0	1		0	0	0			
Salix polaris	0					13							
Oxytropis deflexa	0	0	0		0	2	0	0					
Astragalus alpinus	0	0	2	1	1	0	0	1					
Arctostaphylos rubra		0	3	13	3	5	2	3	0	0			
Equisetum variegatum		0	0	1	2	25	6	0			2		
Salix lanata richardsonii	0	0	2	1	28	2	8	1		0	5		
Salix glauca		0	1	13	6	1	2	3	1	0			
Dryas integrifolia		0	0	9	1	43	6	39	14	5	1		
Salix reticulata	0			8	2	15	8	4	4	2	1		
Thamnolia vermicularis			0	1		3	0	4	1	1			
Polygonum viviparum		0			0	0	0	0	0	0	0		
Arctostaphylos alpina		0	1		4	3	1	3	0	0			
Carex scirpoidea				1		1	0	1	1				
Pedicularis capitata				1	0	0	0	0	0	0			
Arctagrostis latifolia		0		1	2		4	1	3	1	0		
Cetraria cucullata			0	1		1	1	3	3	2	0		
Poa arctica SL	0	0	0	0			0	0	1	0	0		
Polygonum bistorta	0			1	1		0	0	2	1			
Dicranum sp.			0	5	1	3	6	2	5	12	1		
Salix arctica					0	1	1	0	0	0	1		
Tomenthypnum nitens					17	5	16	1	4	3	2		
Carex bigelowii				1	0		5	0	4	5	1		
Salix planifolia pulchra				5	13		2	0	2	7	1		
Cetraria nivalis				1		3		1	1	0			
Tofieldia pusilla					0	0	0	0	0	0			
Rhytidium rugosum				5	0		3	0	3	2			
Saxifraga punctata				0	0		0	0	1	0			
Aulacomnium palustre				5	1		10	0	0	2	1		
Hylocomium splendens				8	1		7	0	10	5			
Betula nana				22					2	5			
Pyrola grandiflora				3	0		0	0	2	2			
Saussurea angustifolia				1				0	2	1			
Hierochloe alpina				1			0	0	2	0			
Vaccinium vitis-idaea				8				0	4	11			
Oxytropis nigrescens				3				0					
Cladonia sp.				1		0	0	1	1	1			
Eriophorum vaginatum				2			1		1	19			
Aulacomnium turgidum				1	0		0	0	1	5	1		
Cassiope tetragona					0	1	2	6	20	5			
Senecio atropurpureus							0	0	1	1	0		
Salix phlebophylla								0	7	3	0		
Ledum palustre decumbens									2	7			
Campylium stellatum					4		0				2		
Pedicularis sudetica					0		0			0	1		
Carex aquatilis					8	3	15		0	0	17	34	
Eriophorum angustifolium					1		6		0	1	8	5	
Limprichtia revolvens					4					0	15	0	0
Scorpidium scorpioides										0	5	20	1
Arctophila fulva													11
Sample size	8	6	6	2	13	4	6	16	12	35	12	5	5

Table 13. Mean cover (%) of the most abundant species in coastal, lacustrine, and lowland ecotypes in the Northeastern Planning Area of the NPRA, 2002. Bolded number represent frequencies >60% within ecotype, blank when absent, and 0 = <0.5%. Italicized numbers identify floristic associations.

Taxon	Lowland Moist Sedge–Shrub Meadow	Lacustrine Moist Sedge–Shrub Meadow	Lowland Moist Low Willow Shrub	Lacustrine Moist Low Willow Shrub	Lowland Wet Sedge Meadow	Lacustrine Wet Sedge Meadow	Lacustrine Sedge Marsh	Lowland Sedge Marsh	Lacustrine Grass Marsh	Coastal Moist Barrens	Coastal Moist Dwarf Willow Shrub	Coastal Wet Sedge Meadow	Coastal Herb Marsh
Arctostaphylos rubra	1	1		1									
Equisetum variegatum	2	1		0	0								
Salix arctica	**1**	0	0		0	0							
Eriophorum vaginatum	**1**	**3**		0	1								
Cassiope tetragona	**1**	**1**	0		1								
Cetraria cucullata	**1**	**0**	0	0	0								
Dryas integrifolia	***17***	***9***	**1**	0	**1**								
Salix reticulata	**8**	**7**	**4**	**3**	1	0							
Carex bigelowii	***11***	***4***	**2**		1								
Tomenthypnum nitens	**24**	**31**	1	**18**	0	**1**							
Salix lanata richardsonii	***4***	***6***		**15**	0	2		0					
Dactylina arctica	0	**0**	0	1	**0**								
Ptilidium ciliare	1	**3**	**2**	1	0								
Pyrola grandiflora	1	**1**	**2**	0	0								
Dicranum sp.	6	**5**	**12**	**1**	**1**							0	
Polygonum viviparum	0	**0**	**0**	0	0	0							
Hylocomium splendens	5	**6**	**4**	**3**	1								
Thamnolia vermicularis	**1**	**0**	**0**	0	0						2		
Peltigera aphthosa	0	0	**0**		0								
Polytrichum strictum		3	12		0								
Stellaria sp.			**0**		0	0							
Petasites frigidus	**1**	0	**0**		0								
Sphagnum sp.	0	1		0	**1**								
Aulacomnium palustre	1	3	**5**	**1**	1	0							
Aulacomnium turgidum	2	**1**	**6**	**8**	**2**	**1**							
Salix planifolia pulchra	2	**6**	***40***	***20***	***2***	**3**							
Campylium stellatum	1	0	3		**2**	2	0						
Eriophorum angustifolium	**5**	**6**	**2**	**5**	***16***	**15**	**7**	**1**			**1**		
Carex aquatilis	**6**	**12**	*7*	***11***	***10***	***20***	***13***	***15***			8		
Poa arctica SL			**1**	0	0					0			
Limprichtia revolvens	**1**	0	1	5	5	3	0		23				
Carex saxatilis	0		2		***4***	*2*		0					
Pedicularis sudetica	0		0	0	**1**	**1**	0	0			0		
Carex chordorrhiza					**2**	0	**2**	3					
Eriophorum russeolum	0				**4**	1	**1**		1				
Scorpidium scorpioides					**7**	5	**6**	5					
Arctophila fulva									***14***				
Equisetum arvense	0		1	0						**2**			
Arctagrostis latifolia	2		0		0					**0**			
Salix alaxensis										***1***			
Deschampsia caespitosa										***3***			
Dupontia fischeri	0	0		0	0	0					0	**1**	
Stellaria humifusa										***2***		3	
Elymus arenarius molis										***2***		4	
Salix ovalifolia					0	0				0	***35***	**4**	
Calamagrostis deschampsioides											3	3	
Carex subspathacea											*10*	***24***	0
Puccinellia phryganodes											0	***13***	0
Carex ursina												3	0
Hippuris vulgaris									1				***15***
Sample size	16	6	3	4	43	8	5	2	4	3	2	4	1

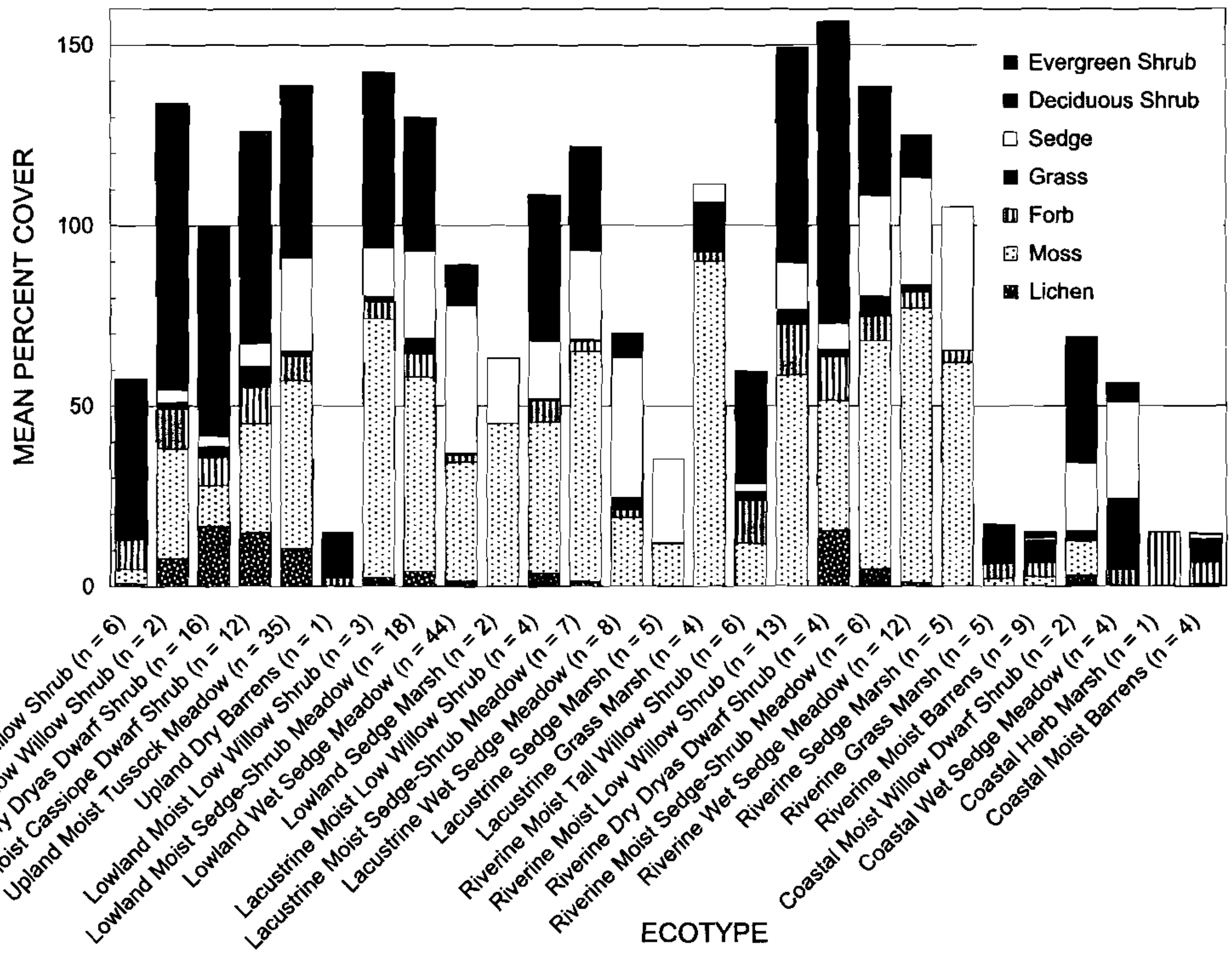


Figure 16. Percent cover of plant growth forms by ecotype within the Northeastern Planning Area of the NPRA, 2002.

sabinei occurs in permanently flooded grass and sedge marshes near Teshekpuk Lake; and *Draba pauciflora* has been found on eroding polygons near Barrow.

Two additional rare vascular plant species are known to occur in the general vicinity, but also were not found in the study area. *Erigeron muirii* occurs on calcareous outcrops in foothills to the south, but no such outcrops are in the study area. *Mertensia drummondii* is known from active sand dunes and blowouts near rivers along the Meade and Kogosukruk rivers to the west but was not found in the study area, despite extensive searches of suitable habitats. Both species are listed by ANHP as being imperiled both globally and within the state.

Environmental Characteristics

Single-factor Comparisons by Ecotype

Six environmental parameters (surface organic-horizon thickness, cumulative organic-horizon thickness, thaw depth, depth to groundwater, pH, and electrical conductivity) were compared among ecotypes. Not all ecotypes, however, were included in the charts because data were insufficient in some cases.

The thickness of the surface organic-horizon (an indicator of frequency of sedimentation) showed large differences among sites (Figure 17). Ecotypes where surface organic accumulations were absent (indicating frequent sediment deposition) included Riverine Moist Barrens, Riverine Moist Tall Willow Shrub, and Upland Dry Tall Willow Shrub. The thickest surface organic accumulations were found in Lacustrine Sedge Marsh, Riverine Sedge Marsh, and Lowland Wet Sedge Meadow, indicating that sedimentation events occurred rarely or never in these ecotypes. Total (cumulative) thickness of organic-matter followed a similar pattern, with a few notable differences. In both riverine and coastal ecotypes, total organic thickness tended to be substantially greater than surface organic thickness, due to repeated sedimentation. Particularly in Riverine Wet Sedge Meadows, total organic thickness was much thicker than surface organic thickness, indicating frequent sediment deposition alternating with periods of rapid organic accumulation in the saturated soils.

Mean thaw depth varied up to five-fold among ecotypes (Figure 17). The greatest mean thaw depths were measured in river sediments and in well-drained ecosystems (Upland Dry Tall Willow Shrub, Riverine Moist Tall Willow Shrub, Riverine Moist Barrens, and Upland Dry Dryas Dwarf Shrub). The shallowest thaw depths occurred in Upland Moist Tussock Meadow, Lowland Moist Low Willow Shrub, Lowland Wet Sedge Meadow, and Lowland Sedge Marsh. These are predominantly late-successional ecotypes with thick organic layers and/or ice-rich permafrost.

Water depth also varied widely among ecotypes, but relatively little within ecotypes (Figure 18). Mean water depths were above the soil surface for 11 ecotypes, and were greatest for Tidal River, Lower Perennial River, Headwater Stream, Riverine Lake, and Lowland Lake. Ecotypes with the deepest water tables included Upland Dry Tall Willow Shrub, Upland Moist Low Willow Shrub, Upland Dry Dryas Dwarf Shrub, Riverine Moist Tall Willow Shrub, and Riverine Moist Barrens.

Mean pH values varied from 5.4 to 7.9 among ecotypes (Figure 18). Ecotypes that occurred on sites with the lowest (most acidic) pH values were Lowland Moist Low Willow Shrub, Upland Moist Tussock Meadow, Lowland Wet Sedge Meadow, and Upland Moist Cassiope Dwarf Shrub. These ecotypes are late successional, where carbonates have been leached from soils over long periods. Aquatic ecotypes with high pH values were Tidal River and Riverine Lake. The high pH values in these ecotypes are due to the presence of carbonates derived from gas exchange with the atmosphere. Among terrestrial ecotypes, the highest mean pH values occurred in early successional ecotypes (e.g., Riverine Grass Marsh, Riverine Moist Tall Willow Shrub) and in dry upland areas (e.g., Riverine Dry Dryas Dwarf Shrub and Upland Dry Dryas Dwarf Shrub), where evaporation causes carbonates to accumulate near the surface.

conductivity (EC) measurements indicated that most ecotypes were nonsaline (Figure 18). Higher mean EC values (>2,000 μS/cm), indicating brackish or slightly brackish conditions, occurred in Coastal Wet Sedge Meadow, Coastal Herb Marsh (not mapped), Coastal Moist Barrens, and Coastal Moist Willow Dwarf Shrub. EC

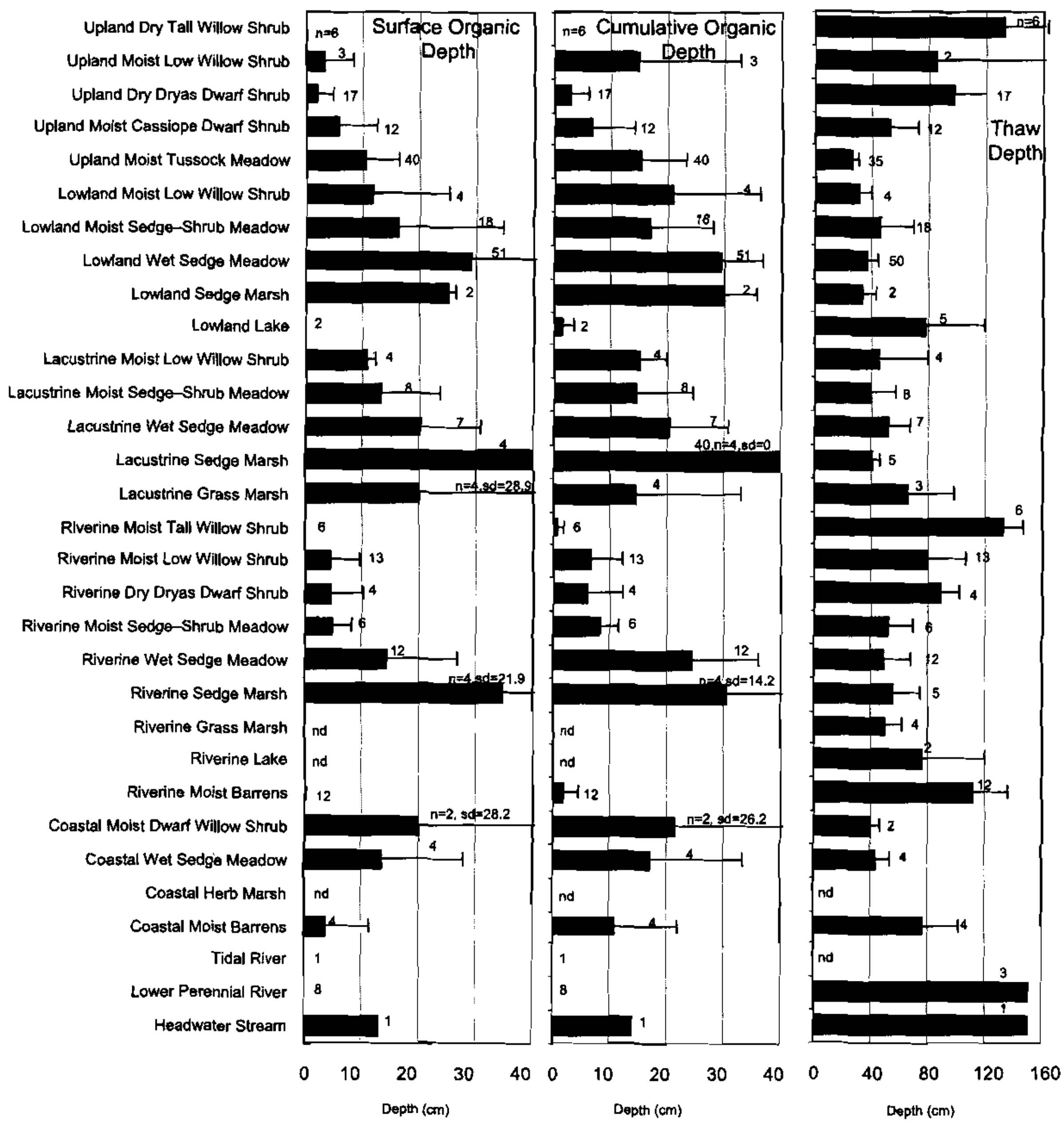


Figure 17. Mean (± SD) surface organic layer thickness, cumulative organic thickness in the top 40 cm, and thaw depths of ecotypes in the Northeastern Planning Area of the NPRA, 2002.

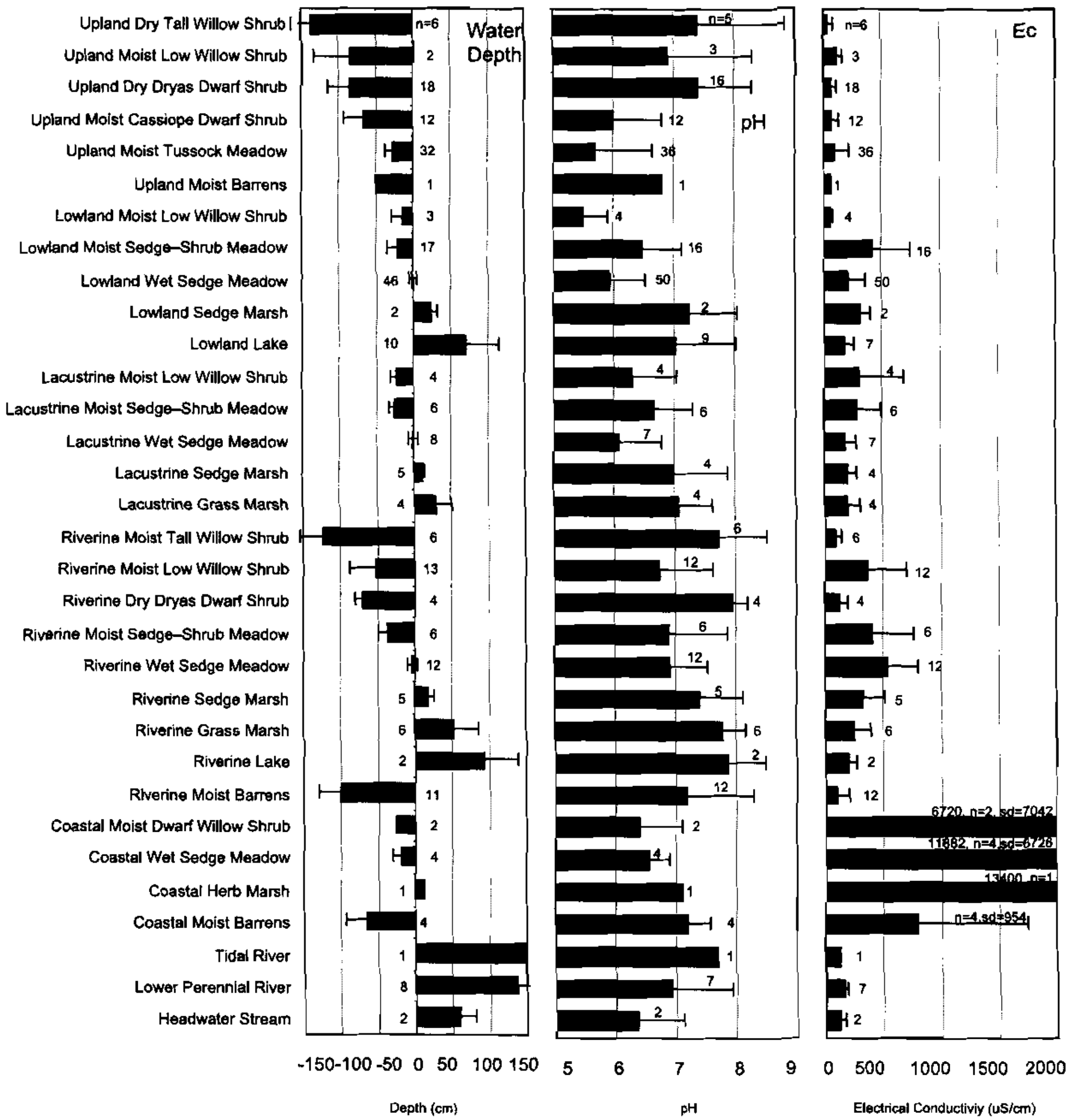


Figure 18. Mean (± SD) water depths, pH, and electrical conductivity (EC) of ecotypes in the Northeastern Planning Area of the NPRA, 2002.

values tended to be lowest in sandy upland and riverine soils (e.g., Upland Dry Tall Willow Shrub, Riverine Moist Tall Willow Shrub, Upland Dry Dryas Dwarf Shrub, and Lowland Moist Low Willow Shrub) where cation exchange capacity presumably was low. Variability was low within nonsaline ecotypes and high within saline ecotypes.

Single-factor Comparisons by Plant Species

To determine how the environmental parameters influenced the distribution of individual plant species, we calculated the mean value of each parameter for locations where each of the 53 most common species occurred. Only sites where a species had >1% cover were included, to exclude locations with atypical conditions for that species.

Mean depth of the surface organic horizon (an indication of frequency of sedimentation) was highly variable both among and within species (Figure 19). Species typically found on sites with thin organic horizons at the surface (indicating frequent sedimentation), included *Deschampsia caespitosa, Chrysanthemum bipinnatum, Festuca rubra, Juncus arcticus,* and *Salix alaxensis.* These species typically occur mainly in early successional ecotypes subject to frequent fluvial or eolian deposition. Species characteristic of sites with thick surface organic accumulations included *Carex chordorrhiza, Scorpidium scorpioides, Hippuris vulgaris, Carex saxatilis, Eriophorum russeolum,* and *Pedicularis sudetica.* These species typically occurred on wet soils with little or no disturbance. Patterns of species distribution relative to mean total thickness of the organic horizons were similar.

Mean thaw depth varied up to four-fold among species (Figure 19). Species associated with the greatest thaw depths included *Salix alaxensis, Chrysanthemum bipinnatum, Deschampsia caespitosa, Festuca rubra,* and *Oxytropis viscida.* These species typically occur on well-drained sandy soils in early successional ecotypes. Species generally found on sites with shallow thaw depths included *Sphagnum* spp., *Betula nana, Eriophorum vaginatum, Vaccinium vitis-idaea, Ledum palustre decumbens,* and *Pyrola grandiflora.* These species are characteristic of late successional sites where soils are acidic, ice-rich, and highly organic.

Depth to water above (+) or below (-) the surface varied widely both among and within species (Figure 20). Species associated with the greatest water depths above the surface were *Hippuris vulgaris* and *Arctophila fulva,* both species that typically grow in standing water. Species that occurred mostly on sites where water was near the surface included *Carex chordorrhiza, C. aquatilis, C. saxatilis, Pedicularis sudetica, Eriophorum russeolum, Scorpidium scorpioides,* and *Limprichtia revolvens.* Species associated with the greatest depths to groundwater included *Salix alaxensis, Deschampsia caespitosa, Festuca rubra, Chrysanthemum bipinnatum, Oxytropis viscida, O. deflexa,* and *Equisetum arvense.* Many species occurred on sites with a wide range of water depths, indicating that most tundra plants can tolerate a wide range of moisture conditions. Depth to groundwater was highly variable both spatially and temporally, contributing to high standard deviations both within and among species.

The mean pH of groundwater or soil (when groundwater was not present) was circumneutral (5.6–7.4) for most species and highly variable within species (Figure 20). Species associated with strongly acidic sites included *Ledum palustre decumbens, Vaccinium vitis-idaea, Betula nana, Eriophorum vaginatum,* and *Salix planifolia pulchra.* Species associated with slightly alkaline (7.4–7.8) soils included *Oxytropis deflexa, Salix alaxensis, Deschampsia caespitosa, Festuca rubra,* and *Chrysanthemum bipinnatum.* The latter group typically occur in early successional ecotypes. However, most species occurred on sites with a wide range of pH values, indicating broad ecological tolerances to pH conditions.

Most plant species were restricted to sites with relatively low mean EC values, indicating nonsaline conditions (Figure 20). Species that occurred mainly where EC was high, indicating saline conditions, included *Carex subspathacea* and *Puccinellia phryganodes.* Several species, including *Stellaria humifusa, Deschampsia caespitosa, Salix ovalifolia, Dupontia fisheri, Elymus arenarius mollis,* and *Hippuris vulgaris* had intermediate mean EC values and high standard deviations, indicating tolerance to a broad range of salinity conditions.

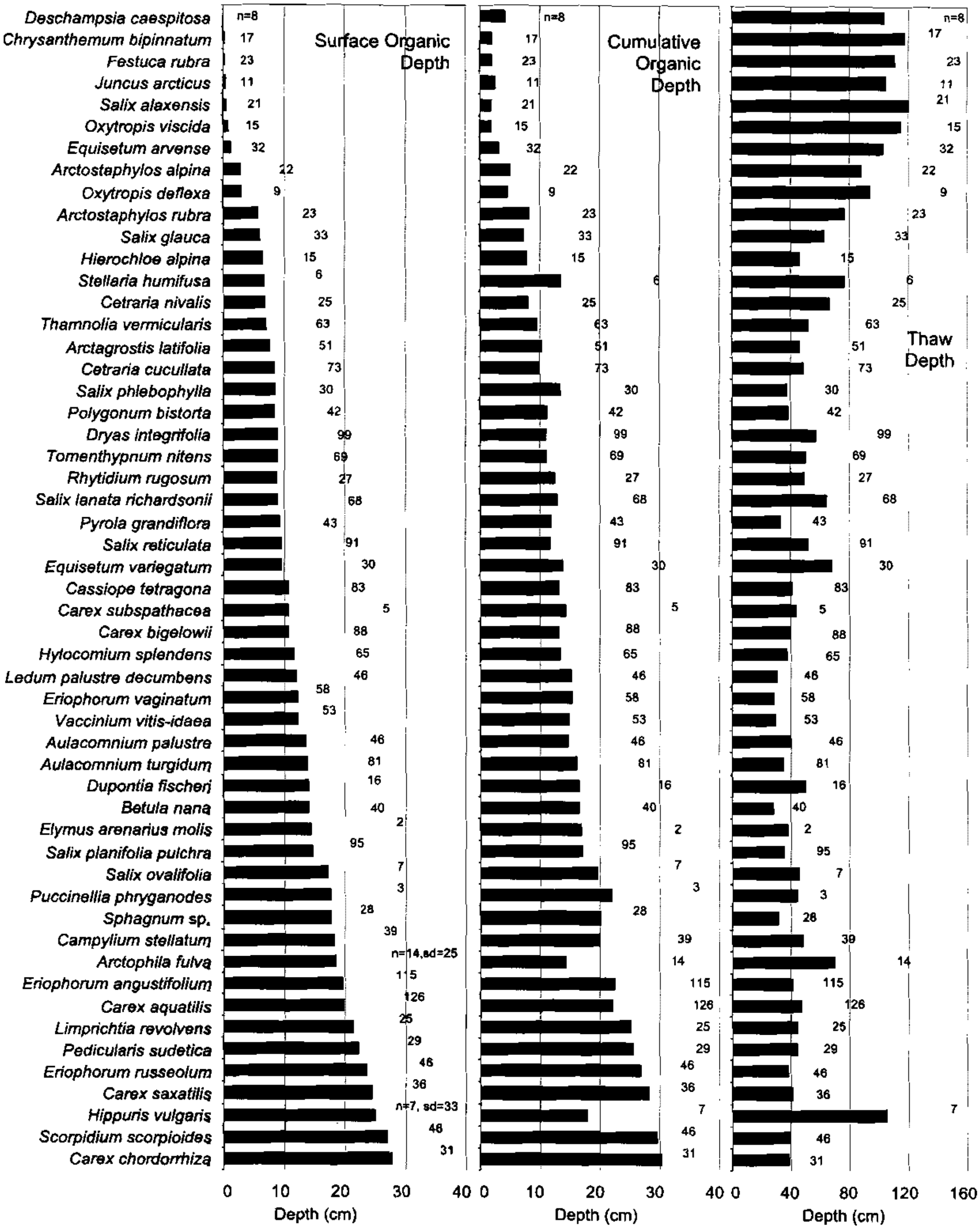


Figure 19. Mean (± SD) surface organic layer thickness, cumulative organic thickness in the top 40 cm, and thaw depths for abundant species in the Northeastern Planning Area of the NPRA, 2002.

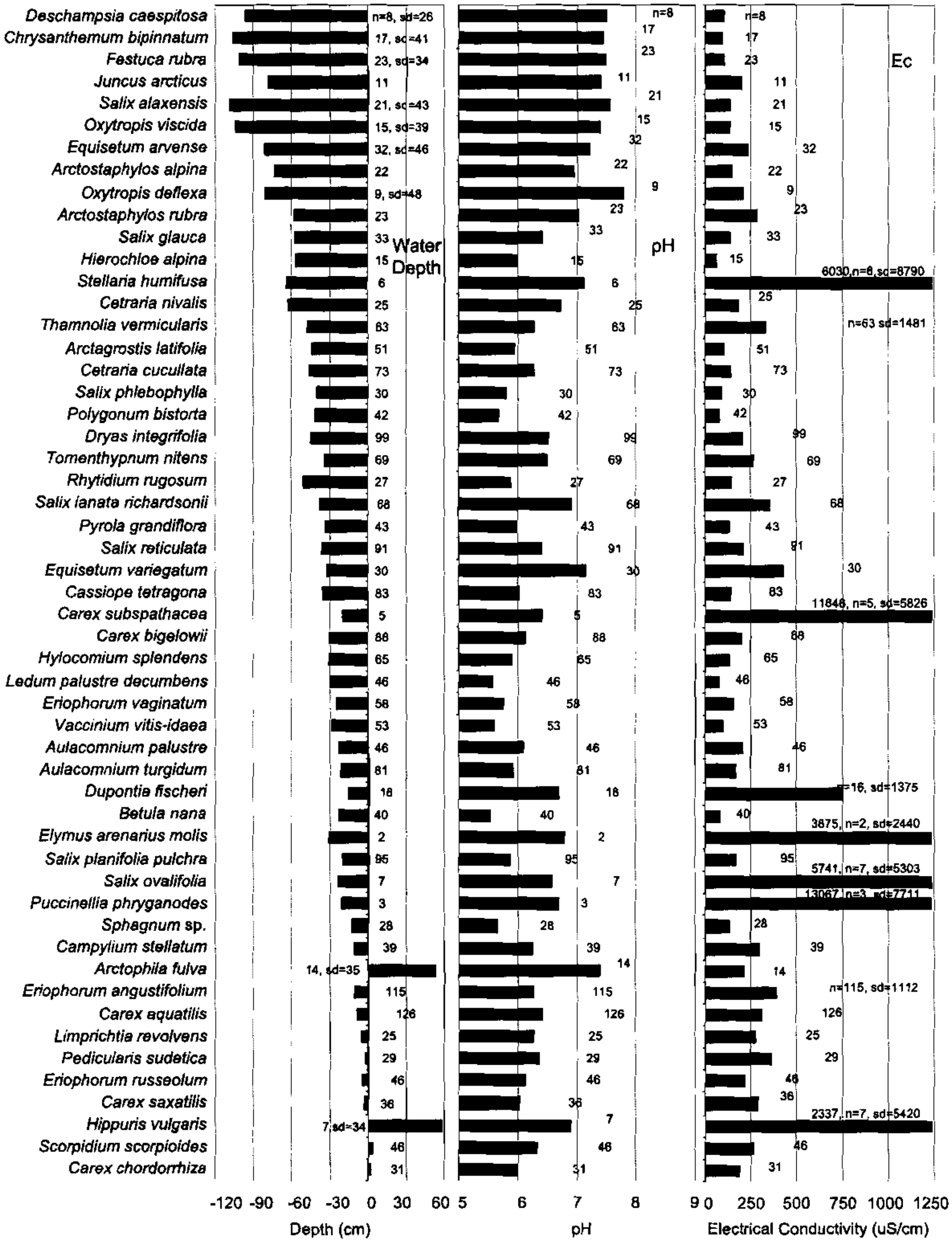


Figure 20. Mean (± SD) water depths, pH, and electrical conductivity (EC) for abundant species in the Northeastern Planning Area of the NPRA, 2002.

Ordination of Vegetation

In addition to the single-factor comparisons, detrended correspondence analysis (DCA) was used to demonstrate the separation of plots by species composition. By superimposing the ecotype class for each plot on the ordination, the combined effect of physiography and environmental variables may be described (Figure 21). Only non-saline plots were analyzed because preliminary analysis showed the species composition of salt-affected plots to be so different as to force the nonsaline plots into a tight, irresolvable cluster in ordination space.

The DCA revealed strong separation on the vertical axis due to physiography, with riverine and upland classes particularly distinct. Riverine ecotypes are some of the youngest and most frequently disturbed classes and most are early or mid-successional, while Upland Moist Tussock Meadow and Upland Moist Cassiope Dwarf Shrub represent some of the oldest classes on the landscape. The only substantial overlap between riverine and upland occurred with Riverine Moist Tall Willow Shrub and Upland Dry Tall Willow Shrub which both occur on floodplains and share a dominant, pioneering species, *Salix alaxensis*. The ordination placed lowland and lacustrine ecotypes between riverine and upland in vertical ordination space, and showed considerable overlap between lowland and lacustrine classes. There was good separation between Riverine and Lowland Moist Low Willow Shrub, Riverine and Upland Dry Dryas Dwarf Shrub, and Riverine Wet Sedge Meadow and other wet sedge classes. Some other physiographic distinctions were not as pronounced, sedge marsh and moist sedge–shrub classes showed considerable overlap among all physiographic units. Sedge marshes are dominated by *Carex aquatilis* with few distinguishing species, and the species composition of moist sedge–shrub probably is driven more by soil moisture and thaw depth than specific physiography.

The horizontal axis of the ordination represents a gradient of moisture and drainage. Ecotypes with dry or moist conditions and good drainage were positioned in the right ordination space and ecotypes with wet or flooded conditions on the left. Ecotypes with sandy soils and little organic accumulation such as Riverine Moist Barrens and tall shrub classes were substantially separated from all other classes in ordination space, while there was some degree of overlap between moist and wet meadow classes and complete overlap between wet meadows and sedge marshes. This agrees well with observations in the field where cutpoints between moist and wet, and wet and flooded often were encountered. It also emphasizes the value of a physiographic term in partitioning and describing differences in vegetation composition that can not be distinguished from vegetation class alone.

Ecological Development During Landscape Evolution

We developed conceptual models that relate changes in vegetation structure and composition to geomorphic processes such as sedimentation, organic-matter accumulation, ice aggradation and degradation, soil aeration/drainage, and acidification. These models, which synthesize the interaction between abiotic and biotic processes over time and space, are useful in the extrapolation of ecological characteristics across the landscape. They also improve our ability to map ecotypes and their associated characteristics, and allow us to predict ecological responses to natural and human disturbance. Generalized models for the floodplains along Fish and Judy creeks and the coastal plain west of the Colville River are presented below. These models are based on a combination of empirical and inferential data, and are intended to present a theoretical overview of the patterns and processes associated with landscape evolution. More detailed information on geomorphic processes is provided in related reports on the geomorphology and hydrology of the study area (Jorgenson et al. 2003).

Ecological Development on Floodplains

On the floodplains of Fish and Judy creeks, ecological development is affected by numerous geomorphic factors, including permafrost aggradation and marine, fluvial, eolian, and thaw-lake processes (Figures 22 and 23). Analysis of soil stratigraphy revealed that the meander floodplain deposits had been formed by four processes: (1) fluvial deposition of mineral material; (2) eolian deposition of mineral material from the barren channels; (3) accumulation of organic material derived from partially

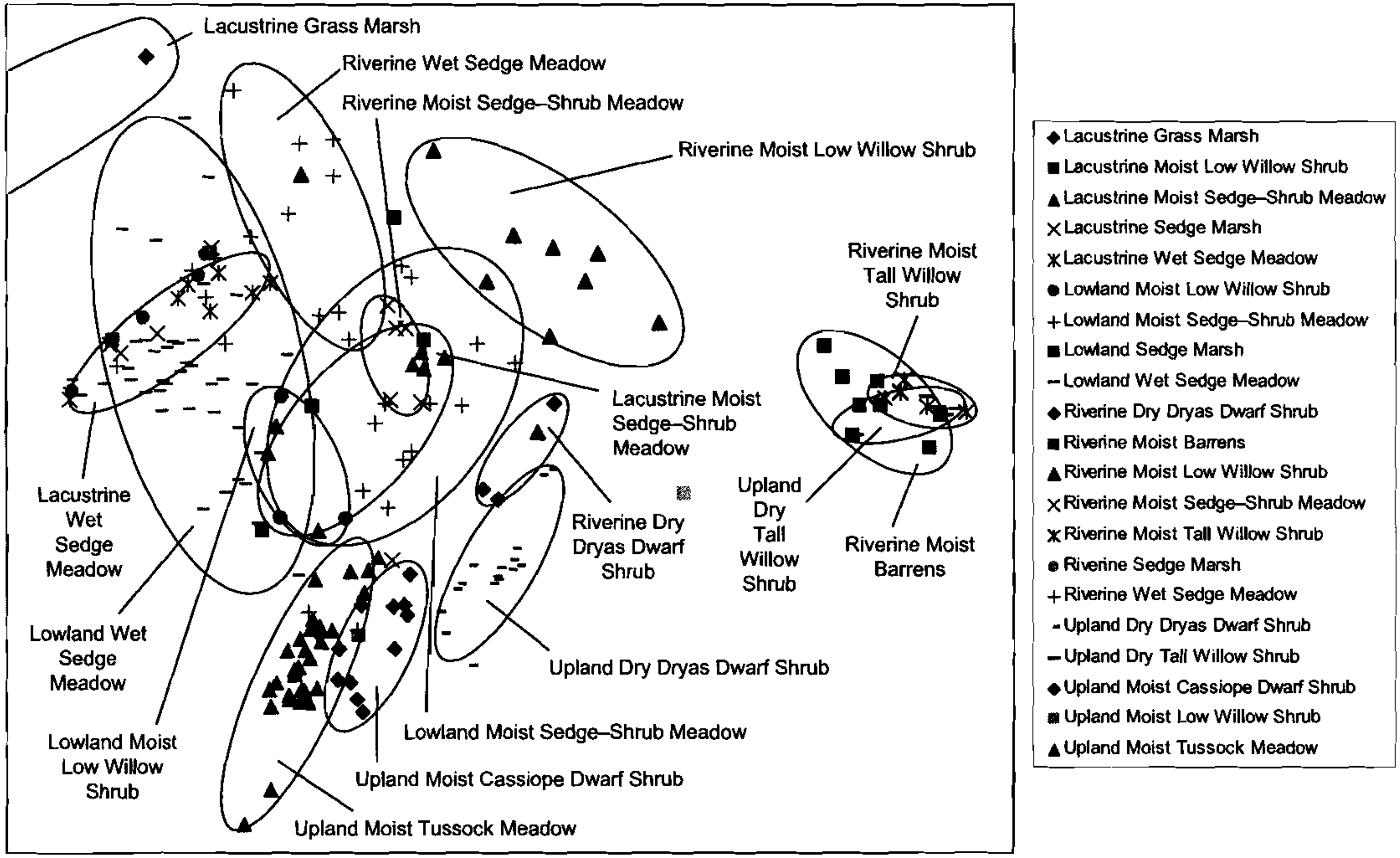


Figure 21. Detrended correspondence analysis of species composition of plots sampled within 21 nonsaline, vegetated ecotypes in the Northeastern Planning Area of the NPRA, 2002. Ellipses depict central groupings of 16 ecotypes.

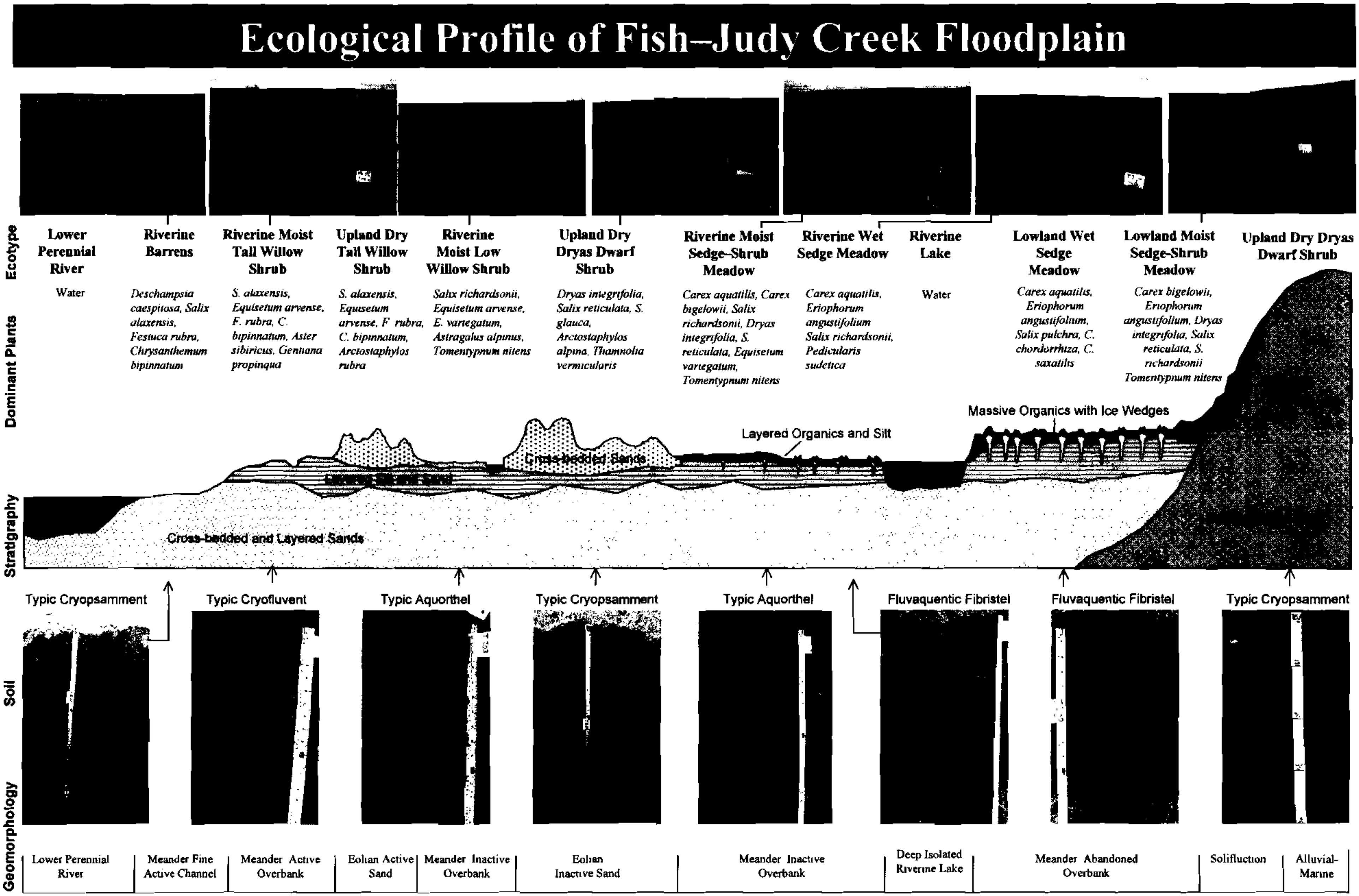

Ecological Profile of Fish–Judy Creek Floodplain
Ecotype
Dominant Plants
Stratigraphy
Soil
Geomorphology
Lower Perennial River
Water
Riverine Barrens
Deschampsia caespitosa, Salix alaxensis, Festuca rubra, Chrysanthemum bipinnatum
Riverine Moist Tall Willow Shrub
S. alaxensis, Equisetum arvense, F. rubra, C. bipinnatum, Aster sibiricus, Gentiana propinqua
Upland Dry Tall Willow Shrub
S. alaxensis, Equisetum arvense, F rubra, C. bipinnatum, Arctostaphylos rubra
Riverine Moist Low Willow Shrub
Salix richardsonii, Equisetum arvense, E. variegatum, Astragalus alpinus, Tomentypnum nitens
Upland Dry Dryas Dwarf Shrub
Dryas integrifolia, Salix reticulata, S. glauca, Arctostaphylos alpina, Thamnolia vermicularis
Riverine Moist Sedge–Shrub Meadow
Carex aquatilis, Carex bigelowii, Salix richardsonii, Dryas integrifolia, S. reticulata, Equisetum variegatum, Tomentypnum nitens
Riverine Wet Sedge Meadow
Carex aquatilis, Eriophorum angustifolium Salix richardsonii, Pedicularis sudetica
Riverine Lake
Water
Lowland Wet Sedge Meadow
Carex aquatilis, Eriophorum angustifolium, Salix pulchra, C. chordorrhiza, C. saxatilis
Lowland Moist Sedge-Shrub Meadow
Carex bigelowii, Eriophorum angustifolium, Dryas integrifolia, Salix reticulata, S. richardsonii Tomentypnum nitens
Upland Dry Dryas Dwarf Shrub
Massive Organics with Ice Wedges
Layered Organics and Silt
Cross-bedded Sands
Cross-bedded and Layered Sands
Typic Cryopsamment
Typic Cryofluvent
Typic Aquorthel
Typic Cryopsamment
Typic Aquorthel
Fluvaquentic Fibristel
Fluvaquentic Fibristel
Typic Cryopsamment
Lower Perennial River
Meander Fine Active Channel
Meander Active Overbank
Eolian Active Sand
Meander Inactive Overbank
Eolian Inactive Sand
Meander Inactive Overbank
Deep Isolated Riverine Lake
Meander Abandoned Overbank
Solifluction
Alluvial-Marine

Figure 22.

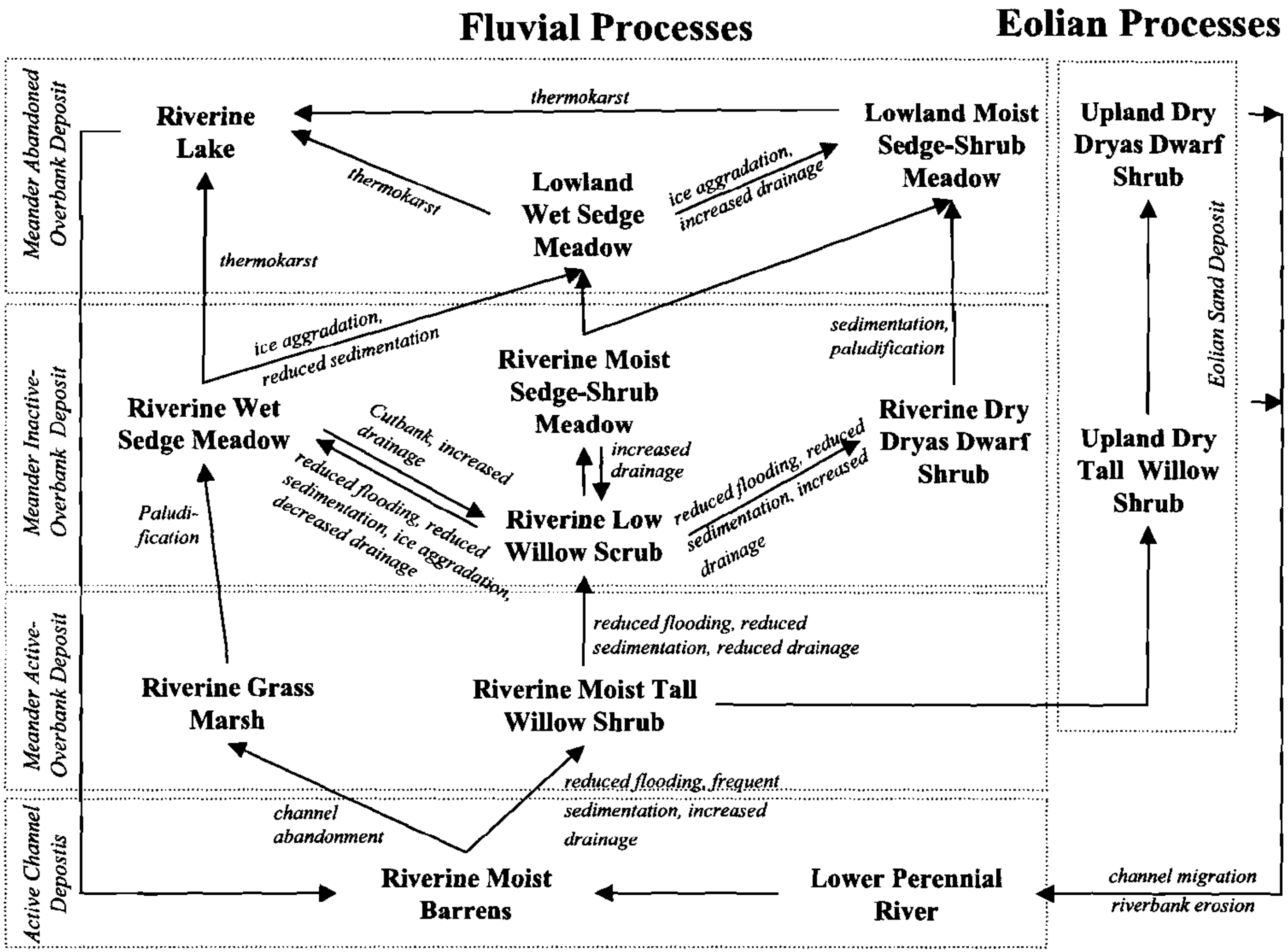


Figure 23. Conceptual model of the evolutionary pathways of ecosystem development on the Fish and Judy creeks floodplains in the Northeastern Planning Area of the NPRA.

decomposed plants; and (4) accumulation of ice. The importance of each process varies during ecological development from Channel Deposits (riverbars) to Meander Abandoned Overbank Deposits. Eolian Sand Deposits are included in the conceptual model of floodplain development because they are prominent features on point bars, although they are not usually part of the evolutionary sequence of fluvial deposits.

The formation of syngenetic permafrost is an important developmental process in arctic floodplains. Over the course of floodplain evolution, new material is added to the top of the active layer through fluvial deposition of sediment and accumulation of organic matter. The accumulation of organic material, increased saturation of the active layer, and changes in vegetation structure alter the thermal regime of the soils, causing the thickness of the active layer to decrease. The addition of new material, and the decrease in active-layer thickness, results in the incorporation of new mineral and organic material into the top of the permafrost. At the same time, ice is formed at the bottom of the active layer, because water freezes to the top of the permafrost during refreezing of the active layer in the fall. Over time, this accumulation of ice raises the ground surface and makes the surface more susceptible to thermokarst. Raising of the surface also reduces flooding and sedimentation. Ecological development on meander floodplains in response to these geomorphic processes is described below.

Riverine Moist Barrens, which occur on Meander Fine Active Channel Deposits along point and lateral bars, are flooded frequently (every 1–2 yr), based on analysis of flood frequency for similar deposits on the Colville Delta (Jorgenson et al. 1998). The sediments usually are composed of rippled sands or fines, which are typical of lateral accretion deposits, and overlying massive or inclined (including cross-bedded) sands, which are typical of sandy bedforms. The inclusion of thin detrital peat layers, which become stranded on the surface by receding floodwaters, is a unique characteristic of these sediments. The coarse texture of the sediments and lack of vegetative cover result in deep thaw layers (mean depth = 112 cm). The water table is highly variable but averages 101 cm below the surface during mid-summer. Mean soil pH is 7.2. The surface is barren at lower elevations due to the frequent scouring and sediment deposition, but pioneering herbaceous vegetation may be present along the upper margins. Plant species adapted to the frequent disturbance include *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum*, and *Equisetum arvense.*

Riverine Grass Marsh and Riverine Sedge Marsh typically form in high-water channels or in small ponds created by channel meandering. The sites can be rapidly colonized by *Arctophila fulva* and *Carex aquatilis*. The vegetation may be productive, as the habitat is newly available, and frequent sediment deposition contributes abundant nutrients. Water depths average 53 cm and 17 cm above the surface, and pH averages 7.8 and 7.4, for Riverine Grass Marsh and Riverine Sedge Marsh, respectively. As sediments and organic matter accumulate over time, Riverine Grass Marshes develop into Riverine Sedge Marshes and, eventually, into Riverine Wet Sedge Meadows. During the transition, the waterbodies are transformed into Meander Inactive Overbank Deposits.

Riverine Moist Tall Willow Shrub occurs in narrow strips on point bars immediately adjacent to channels, and is associated with Meander Active Overbank Deposits. Flooding is relatively frequent (every 3–5 yr), but material (mostly sediment) accumulates at a lower rate than in Active Channel Deposits. The surface sediments generally include layered (horizontally stratified silts and fine sands) or massive fines, and the active layer is deep (133 cm) and well drained. In addition, wind-blown sands from nearby barren areas usually form small mounds on the surface. Groundwater is usually absent in the well-drained soils near the channels and soil pH averages 7.7. In areas closest to barren river bars, tall shrubs dominate. Willow, *Salix alaxensis,* growth is vigorous with *Bromus pumpellianus*, *Equisetum arvense*, *Hedysarum alpinum*, and *Astragalus alpinus* common below the shrub canopy. With increasing distance from channels, flood deposition becomes less frequent, and thin (<1 cm) layers of moss occasionally form at the surface of the Meander Active Overbank Deposits.

During this active-floodplain phase, approximately 0.5–1.0 m of loamy sediment can accumulate on top of the riverbed deposits. This accumulation of fine-grained sediments provides the primary material for ice aggradation during the next evolutionary phase. Eventually, due to sediment accumulation and channel migration, flooding frequency is reduced to the point where peat starts to accumulate. Based on sedimentation rates and the lack of change between 1955 and 1992 on similar deposits on the Colville Delta (Jorgenson et al. 1996), we estimate that the active-floodplain phase may persist for 100–300 yr. After this early stage in floodplain evolution, a large transition in permafrost development occurs on Meander Inactive Overbank Deposits.

Ecotypes found on Meander Inactive Overbank Deposits include Riverine Wet Sedge Meadows; Riverine Moist Sedge–Shrub Meadows; Riverine Moist Low Willow Shrub; and Riverine Dry Dryas Dwarf Shrub, depending on soil moisture status. Flood frequency (approximately every 5–25 yr) and sedimentation rates are substantially lower, leading to build-up of organic material and the formation of distinctive interbedded layers of silt and peat. Layered organics generally are contained within the active layer but sometimes extend into the permafrost. Thaw depths are substantially less than in the previous stage due to changes in vegetation composition and in thermal properties of the soil. The sediments in the active layer, which were deposited during the previous phase, slowly join the permafrost. Ice wedges become well developed, leading to the formation of low-centered polygons on the surface. Over most of the inactive floodplain, the active layer remains saturated throughout the summer, resulting in anaerobic conditions and gleyed soils. The permanently saturated soils (mean water depth below surface = 4 cm) typically have neutral soil pH (mean = 6.9) and usually support Wet Sedge Meadow Tundra dominated by *Carex aquatilis*, *Eriophorum angustifolium*, and *Salix lanata richardsonii*. In areas with slightly better drainage, such as gently sloping point bars (mean water depth below the surface = 37 cm), Riverine Moist Sedge–Shrub Meadows with *C. aquatilis*, *E. angustifolium*, and *Dryas integrifolia* are prevalent. On somewhat well-drained (mean water depth = 52 cm), mottled soils, the typical ecotype is Riverine Moist Low Willow Shrub, dominated by *S. lanata richardsonii*, *Equisetum scirpoides*, *E. variegatum*, *Carex aquatilis*, *Lupinus arcticus*, and *Tomentypnum nitens*. The Riverine Moist Low Willow Shrub can occur either in a successional sequence after the Riverine Moist Tall Willow Shrub stage or at locations where channel migration has undercut the bank, leading to increased soil drainage, and sedimentation. On well-drained areas (mean water depth below surface = 70 cm, when present), such as old point bar ridges, Riverine Dry Dryas Dwarf Shrub, dominated by *Dryas integrifolia*, commonly is found. Soil conditions are aerobic, with little organic matter accumulation, and soil pH remains strongly alkaline, presumably due to capillary movement of cation-rich groundwater to the surface where it evaporates and deposits carbonates.

The decrease in thaw depth, increase in soil saturation, and reduced sedimentation that occur during this phase all contribute to the accumulation of organic material and ice at the top of the permafrost. Eventually, the surface becomes raised enough that flooding is rare (every 25–200 yr), at which point the deposit can be considered a Meander Abandoned Overbank Deposit. The time required to reach this transition is approximately 1500–2500 yr, based on similar processes in the Colville Delta (Jorgenson et al. 1998).

Meander Abandoned Overbank Deposits are the oldest portions of the floodplain (with the exception of a few isolated Alluvial Terraces). These areas typically support Lowland Wet Sedge Meadows and Lowland Moist Sedge–Shrub Meadows. Flooding and sedimentation are sufficiently rare (every 25–150 yr) that these ecotypes are not considered to be riverine. Surficial deposits typically have deep (1–3 m) accumulations of massive and layered organics that have been deformed or turbated by formation of large ice-wedges. Eolian material also is present occasionally. Due to the accumulation of organic material and moderate thaw depths (mean = 48 cm) on the abandoned floodplain, the active layer becomes dominated by organic material. The continued development of massive ice wedges creates a network of Low-centered, High-relief, High-density, Polygons, in which the ice wedges occupy approximately 20% of the volume of the top 2 m of permafrost. Because of the irregular topography resulting from polygon development, the surface typically supports a complex mosaic of lowland meadow ecotypes. In Lowland Wet Sedge Meadows, water depths average 3 cm below the soil surface and pH averages 6.6. The vegetation is dominated by *Carex aquatilis* and *Eriophorum angustifolium*. The common associates *C. chordorrhiza* and *C. rariflora* are indicative of slightly acidic, nutrient-poor conditions. At the latest stage of development, the centers of the polygons are raised sufficiently, by accumulation of organic matter and ice, to become high-centered polygons supporting Lowland Moist Sedge–Shrub Meadows. Water depths average 28 cm below the soil surface and mean soil pH is 7.0. The vegetation is dominated by *C. aquatilis, C. bigelowii, Dryas integrifolia* and *Salix planifolia pulchra*. We estimate that this phase occurs 2000–3000 yr after the active-floodplain phase.

By the time the abandoned-floodplain stage is reached, so much ice has accumulated in the sediments that the deposits become susceptible to thermal degradation and collapse. The centers and troughs of low-centered polygons can degrade enough to form permanent waterbodies (0.3–3 m deep). As thermokarst proceeds, small ponds coalesce into larger Riverine Lakes. The thermokarst lakes tend to have rounded shorelines, in contrast to the long, sinuous lakes that form in abandoned channels. Some of these thaw lakes become tapped and drained by river channels. Because of the low elevation of the exposed lake bottom, sediment deposition from floodwater again becomes frequent and, at this point the whole evolutionary process begins again, starting with Riverine Barrens.

This conceptual model of floodplain evolution is similar to those developed for the Meade River by Peterson and Billings (1978, 1980); for the upper Colville River by Bliss and Cantlon (1957); and for the Colville Delta by Jorgenson et al. (1997). Ecological development in the northeastern NPRA is most similar to that described for Meade River, which is also characterized by sandy channel deposits. The upper Colville River differs in that the channel deposits are gravelly and alder is the dominant shrub on the floodplain. The Colville Delta differs slightly because of the effects of salinity at lower floodplain stages.

Ecological Development on the Coastal Plain

One on the most striking features of the Arctic Coastal Plain is the great abundance of lakes and drained lake basins. The presence of the lakes and basins has been attributed to a thaw-lake cycle where (1) thermokarst lakes develop in ice-rich sediments; (2) the lakes are tapped and drained to form drained-lake basins; and (3) the basins eventually accumulate sufficient ice to start a new cycle (Black and Barksdale 1949, Hopkins 1949, Britton 1957, Carson and Hussey 1962, Tedrow 1969, Webber 1978, Walker et al. 1980). These concepts of the development of thermokarst lakes and subsequent drainage are applicable to areas with ice-rich sediments, such as near Barrow and on the Colville Delta, but a substantially different process occurs in the sandy, ice-poor sediments that cover most of the coastal plain.

Recent studies have indicated that most of the lakes and basins on this portion of the coastal plain were not formed by thermokarst (Jorgenson et al. 2003). Instead, the lakes resulted from flooding of low-lying terrain during the beginning of the Holocene, when the surface stabilized and the climate became warmer and wetter than in the late Pleistocene. Erosion of lake shorelines, by wave action and differential transport of fine-grained sediments, has lead to the sorting of sands along the margins and accumulation of disseminated peat and algae in the deep central portions of the lake basins. Concurrently, development of drainage networks through the poorly integrated landscape during the early Holocene lead to widespread drainage of lakes.

Complete or partial drainage of the basins then created the conditions for ice aggradation in the newly exposed sediments. The nature and volume of the ground ice that develops in the newly exposed sediments are highly variable within a basin depending on soil texture. A common pattern, however, is for organic-rich silts in the centers to accumulate high volumes of segregated and wedge ice and become raised, while the sandy margins remain ice-poor with minor amounts of wedge ice. As the centers become raised, the margins become the lowest portions of the basins and, therefore, accumulate water in small, shallow ponds. These ponds eventually become subdivided and shrink as organic matter and small amounts of segregated ice accumulate in the wet meadows surrounding the ponds.

The raised ice-rich centers, however, are prone to thermal degradation and provide the conditions for development of true thaw lakes. These lakes become essentially permanent features of the landscape; drainage is unlikely as the lakes are surrounded by higher ground. According to this conceptual model, some true thaw lakes (formed by degradation of ice-rich sediments) occur on the coastal plain, but most lakes in the region are formed simply by impoundment of water in depressions. Based on this revised conceptual model of lake and basin evolution, the following discussion identifies the ecological changes associated with these changing physical conditions (Figures 24 and 25).

Lowland Lakes include both deep and shallow lakes. Deep lakes typically are those associated with the deep centers of the original persistent lakes formed in deep depressions. More rarely, they are thaw lakes that have formed in the ice-rich centers of basins. Shallow ponds typically are those that have formed around the margins of drained basins, but occasionally represent thaw lakes in basin centers. At the earliest stage (Ice-poor Thaw Basins that lack low-centered polygons), the ponds typically have irregular shorelines and are highly interconnected. As ice begins to aggrade in the sediments within and adjacent to the ponds (Ice-rich Thaw Basins with low-centered polygons), and organics accumulate along the margins, the ponds become smaller and less connected. Because the ponds are shallow (<1 m), they freeze to the bottom and are relatively thaw stable. At the oldest stage they have low, smooth, rounded shorelines, usually have reddish diatomaceous algal mats on the bottom or along the shoreline, appear to be relatively unproductive, and have stable shorelines.

The shallow water along the margins of lakes and ponds is often colonized by aquatic sedges and grasses. Lacustrine Grass Marsh, dominated by *Arctophila fulva,* typically occurs in slightly deeper water (30–100 cm) with younger, more nutrient-rich, circumneutral sediments. With sedimentation or lowering of the water table, Lacustrine Grass Marshes can be replaced by Lacustrine Sedge Marshes. Sedge marshes occur in shallower water (10–30 cm deep) and the vegetation is typically dominated by *Carex aquatilis, Eriophorum angustifolium,* and *Scorpidium scorpioides.* At these early successional stages, water pH averages 7.1 and 7.0, respectively, for the Lacustrine Grass and Sedge marshes.

In areas where the lakes have been recently drained, broad expanses of sandy sediments form Lacustrine Moist Barrens. After tapping, the Lacustrine Moist Barrens are rapidly colonized by *Carex aquatilis, Eriophorum angustifolium, Arctophila fulva, Puccinellia andersonii,* and/or *Deschampsia caespitosa,* depending on drainage conditions. Because most lake basins were tapped during the middle Holocene by the developing drainage network, recently drained basins with Lacustrine Moist Barrens are relatively rare, covering <0.1% of the study area.

Through colonization and growth, the barren areas are converted to Lacustrine Wet Sedge Meadows in poorly drained areas and Lacustrine Moist Sedge–Shrub Meadows in moderately drained areas. In the poorly drained areas, the surface generally is flooded during the early summer and remains saturated throughout the summer. Vigorous stands of *Carex aquatilis* and *Eriophorum angustifolium* can develop in Lacustrine Wet Sedge Meadows; these species are well adapted to exploiting newly available habitat with abundant nutrients. Due to the high productivity and anaerobic soil conditions, peat accumulation is rapid, resulting in relatively thick organic accumulations (mean = 20 cm). Lacustrine Moist Sedge–Shrub Meadows occur in better-drained conditions and are dominated by *Dryas integrifolia, Carex aquatilis,* and *Tomentypnum nitens,* with lesser amounts of *Salix reticulata, Carex bigelowii* and *E. angustifolium.* Lacustrine Moist Low Willow Shrub also occasionally occurs in young basins and is similar to Lacustrine Moist Sedge–Shrub Meadows, except that *Salix lanata* ssp. *richardsonii* and *S. planifolia* ssp. *pulchra* are sufficiently abundant to form an open shrub canopy. In these lacustrine environments, soil pH remains circumneutral.

Ice aggradation over time alters ecological processes by raising the ground surface, altering slope drainage, and creating a wider range of microsites (e.g., high- and low-centered polygons) for plant growth. This change marks the transition from lacustrine conditions, dominated by the properties of the newly exposed sediments and by large water-level fluctuations in the basins, to lowland conditions, characterized by less seasonal flooding, shallower thaw depths, greater cryoturbation of soils, greater microsite diversity, and increased acidity. During this transition, Lacustrine Wet Sedge Meadows develop into Lowland Wet Sedge Meadows. Productivity declines and minor changes in species composition occur, notably increases in cover of *Carex saxatilis, C. chordorrhiza*, and *Eriophorum russeolum*. With continued ice aggradation, the low-centered polygons become smaller, the polygon centers fill in with ice and organic material, and the surface is raised to such an extent that Lowland Moist Sedge–Shrub Meadows become more prevalent. With the better drainage *Dryas integrifolia, Salix reticulata,* and *Carex bigelowii* become more abundant. Lowland Moist Low Willow Shrub is similar to Lacustrine Moist Low Willow Shrub, except that it is more strongly acidic (mean pH of 5.5) and *S. lanata* ssp. *richardsonii* no longer occurs

The highest and oldest surfaces on the thaw lake plains consist of broad, gently rolling, hills that are barely distinguishable from the flat plain. Over time, these gentle slopes become dissected by erosion and mass wasting, thereby providing a modest differentiation in relief between swales, slopes, and ridges. Dense networks of ice-wedges, formed over many thousands of years, are present below the surface but frequently are not evident due to soil movement on the slopes. Upland Moist Tussock Meadow generally occurs on the better-drained portions of the slopes and on broad ridges, where groundwater is absent or at substantial depth (mean = 28 cm) during mid-summer. Thaw depths are shallow and the soils are highly turbated by freezing and thawing. In areas with circumneutral soils (mean pH of 6.6), the vegetation is dominated by *Eriophorum vaginatum* and numerous shrubs, including *Dryas integrifolia, Cassiope tetragona,* and *Salix reticulata*. On acidic soils (mean pH 5.4), the vegetation includes more *Ledum decumbens, S. planifolia pulchra, Vaccinium vitis-idaea*, and *Hylocomium splendens*.

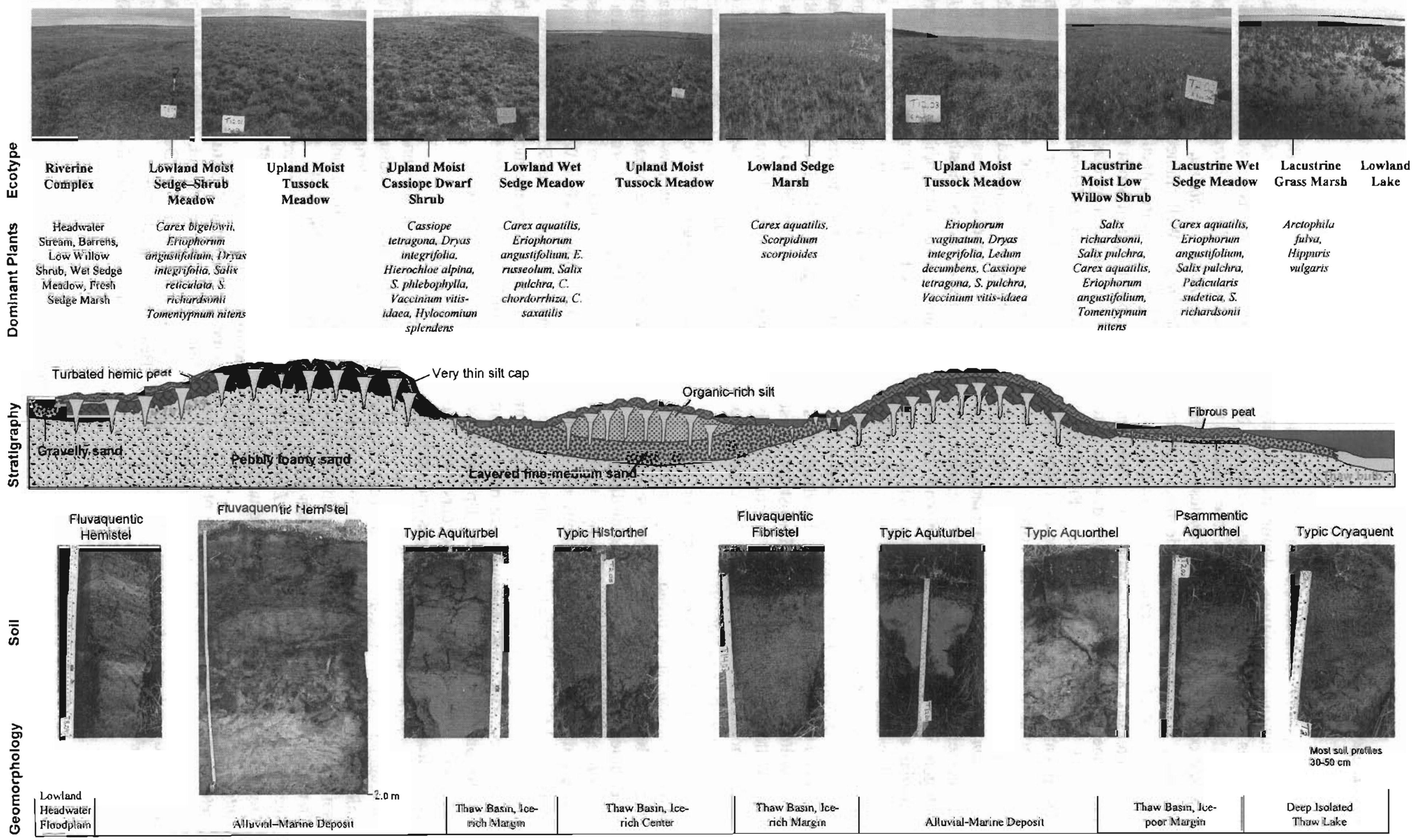
Steep or exposed ridges and bluffs with alkaline soils (mean pH of 7.4) typically support Upland Dry Dryas Dwarf Shrub, which is dominated by *Dryas integrifolia, Salix glauca, Arctostaphylos alpina*, and *Thamnolia vermicularis*. Well-drained, less exposed banks and ridges with circumneutral soils (mean pH = 6.0) support Upland Moist Cassiope Dwarf Shrub, which is dominated by *Cassiope tetragona, Dryas integrifolia, Salix phlebophylla*, and *Hylocomium splendens*. Groundwater is usually absent and accumulation of organic material is negligible. These ecotypes dominated by dwarf shrubs are relatively unproductive, as indicated by the low cover of graminoids (mostly *Carex bigelowii*) and deciduous shrubs, and high cover of slow-growing evergreen shrubs and lichens.

The upland ecotypes are relatively stable; successional patterns are indistinct and transitions are slow. Recently, analysis of natural degradation of ice-wedges in upland surfaces indicated that the uplands are susceptible to dramatic changes under a warming climate, however. (Jorgenson et al. 2003). In some areas, rapid degradation of ice wedges and development of high-centered, high-relief polygons has led to a loss of Upland Moist Tussock Meadows and an increase in Lowland Wet Sedge Meadows in the degrading polygon troughs. Lowering of the water table because of drainage into the troughs also has converted some Lowland Wet Sedge Meadows into Lowland Moist Sedge–Shrub Meadows. The extent of the natural thermokarst, however, has not been sufficient to create thermokarst lakes and initiate a thaw-lake cycle.

ECODISTRICTS

The landscape surrounding the study area was divided into seven ecodistricts that have unique physiographic characteristics and repeating assemblages of terrain units, surface forms, and vegetation (Table 14, Figure 26). These ecodistricts in turn were subdivided into 27 ecosubdistricts that further reduce the variation in ecological characteristics. The ecodistricts of principal interest to this study are the Beaufort Sea Shallow Nearshore Water, Central Beaufort Sea Coast, Colville River Delta, and the Western Beaufort Coastal Plain. The ecosubdistricts of principal interest include the Harrison Bay Shallow

Ecological Profile of Ublutuoch Upper Coastal Plain



LACUSTRINE PROCESSES

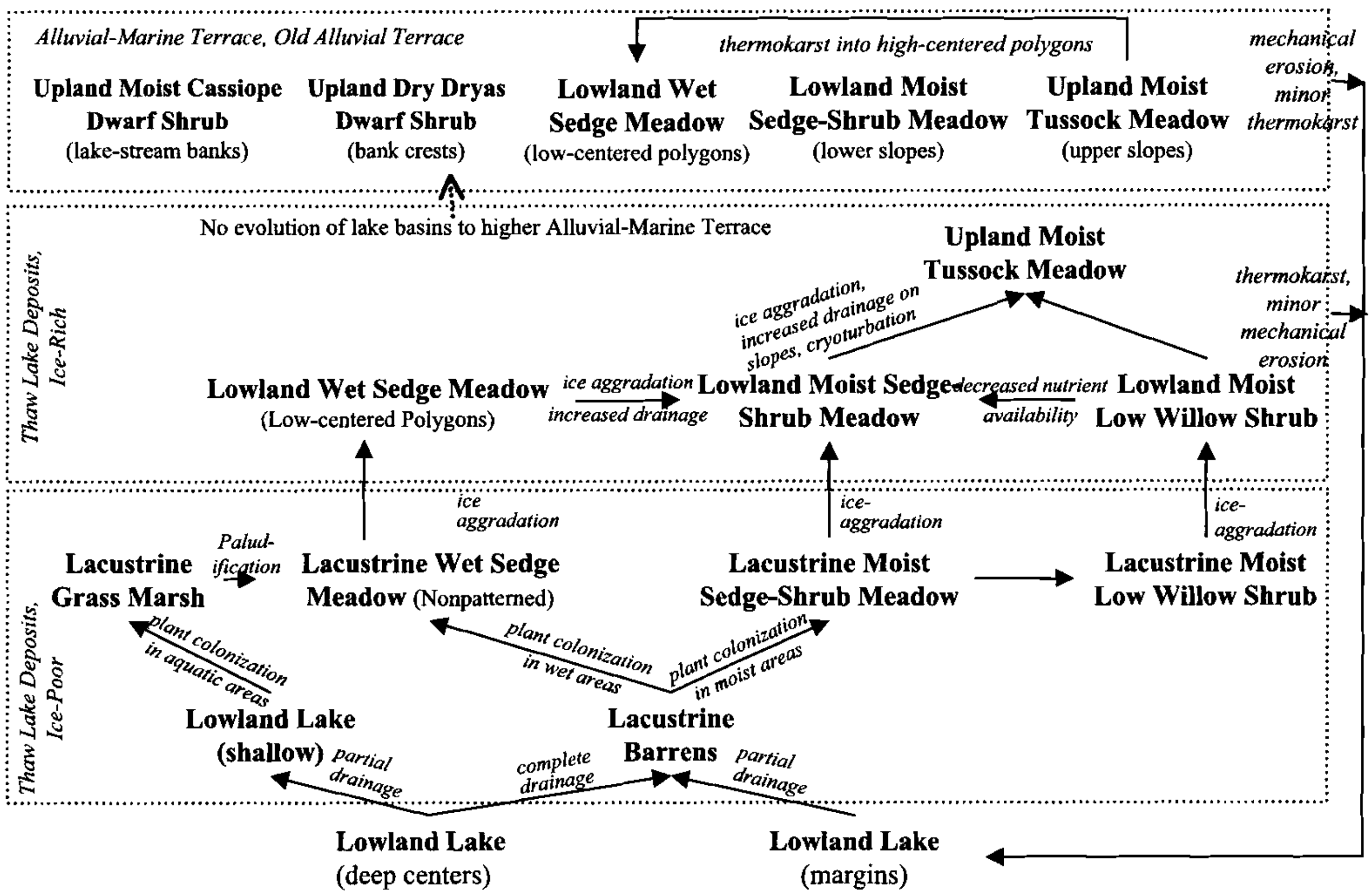


Figure 25. Conceptual model of the evolutionary pathways of ecosystem development on drained-lake basins on the coastal plain in the Northeastern Planning Area of the NPRA.

Table 14. Classification and description of ecodistrict and ecosubdistricts (landscape-scale ecosystems) in the Northeastern Planning Area of the NPRA, 2002.

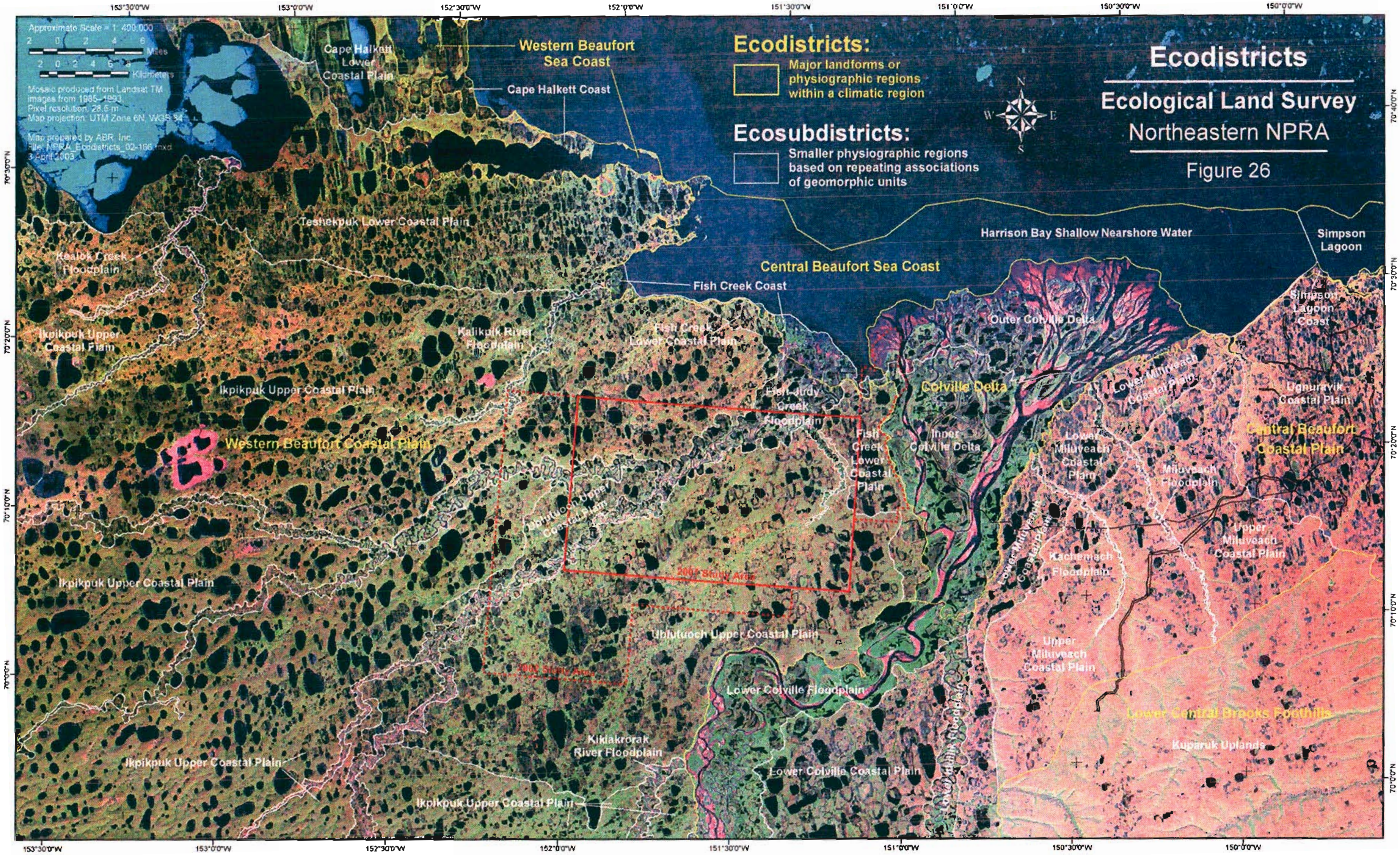
Ecodistrict	Ecosub-district	Description
Beaufort Sea Shallow Nearshore Water	Harrison Bay Shallow Nearshore Water	Shallow (<2 m) Nearshore Waters on the inner continental shelf of the Beaufort Sea extending 5 to 10 km out from the shoreline, sediments are sandy. Salinity of coastal water is highly variable depending on season, winds, proximity to rivers and channels and river discharge. Overall the mean direction of the surface current is to the west. Mean tidal variation is 10 cm, although tides are strongly affected by winds and fall storm surges commonly reach 1 m. Water can freeze to the bottom in winter.
	Simpson Lagoon	Shallow Nearshore Waters extending from the coastline to a series of barrier islands that parallels the coast. Effects of sea ice within the lagoon are minor.
Central Beaufort Sea Coast	Fish Creek Coast	A salt-affected coastal area at the mouth of Fish Creek near the Colville River Delta. The area lacks barrier islands and thus is exposed to wave action. Shoreline deposits are fine-grained muds and are accreting sediments discharged from the Colville River and Fish Creek. Common ecosystems include Coastal Lakes and Ponds, Coastal Barrens along beaches and mudflats, Coastal Wet Meadows on mudflats, and Coastal Salt-killed Meadows where storm surges have killed Lowland Wet and Moist Meadows.
	Simpson Lagoon Coast	A salt-affected coastal area between the Colville River Delta and Prudhoe Bay. Most of the area is protected by barrier islands and thus is less exposed to wave and ice action. Shoreline deposits are mostly sand and gravel and erosion rates average 1.4 m/yr. Common ecosystems are similar to those described for Fish Creek Delta.
Western Beaufort Sea Coast	Cape Halkett Coast	A salt-affected coastal area between Ikpikpuk River and Fish Creek. The area lacks barrier islands and is thus exposed to strong wave action. It has the highest coastal erosion rates along the Beaufort Sea coast, up to 10 m/yr. In addition to coastal erosion, saltwater intrusion extends up to 16 km through interconnected drained-lake basins. The soils are comprised of ice-rich marine silts, consequently thaw lakes and drained basins are particularly abundant. Common ecosystems are similar to those described for Fish Creek Coast.
Colville River Delta	Colville Outer Delta	The outer portion of the delta dominated by tidal action and sedimentation from the Colville River. Common ecosystems include Tidal Rivers associated with distributaries of the Colville River, and Coastal Lakes and ponds subject to infrequent coastal flooding. Coastal Barrens occur on Tidal Flats and tapped lake basins and Coastal Wet Meadows on infrequently inundated areas. Coastal Salt-killed Wet Meadows are found on Inactive-floodplain Cover Deposits that have been affected by storm surges. Coastal Dwarf Scrub occurs on higher areas and Coastal Marshes formed in deep, Low-centered Polygons resulting from permafrost degradation.
	Colville Inner Delta	The inner portion of the Colville River Delta is less affected by coastal processes, but still includes some salt-affected areas at lower elevations. Common ecosystems include Tidal Rivers associated with distributaries of the Colville River, and Riverine Shallow and Deep Lakes formed from thawing permafrost. Coastal Barrens occur on Delta Riverbed/Riverbars and Riverine Low and Tall Scrub on slightly higher areas receiving frequent sedimentation. Riverine Dwarf Scrub occurs on well-drained loamy river terraces and Riverine Marshes in channel ponds. Riverine Wet Meadows occur on poorly drained Active and Inactive-floodplain Cover Deposits subject to regular to occasional flooding, and Lowland Wet Meadows on Abandoned-floodplain Cover Deposits that rarely are flooded. Upland Sandy Low Scrub occurs on active Eolian Sand Dunes and Upland Sandy Dwarf Scrub on inactive Eolian Sand Dunes.
Colville River Floodplain	Lower Colville River Floodplain	The lower portion of the Colville River floodplain extending from the delta to the mouth of the Anaktuvuk River. Common ecosystems include Lower Perennial River, and Riverine Shallow and Deep Lakes formed from thawing permafrost and affected by occasional flooding. Riverine Barrens occur on Delta Riverbed/Riverbars and Riverine Low and Tall Scrub on areas of frequent sedimentation. Expansion of alder on the floodplain is especially notable. Riverine Dwarf Scrub is uncommon. Higher on the floodplain, Riverine Wet Meadows occur on poorly drained Inactive-floodplain Deposits that are occasionally flooded and Lowland Wet Meadows on Abandoned-floodplain Deposits that rarely are flooded.

Table 14. (Continued).

Ecodistrict	Ecosub-district	Description
Central Beaufort Coastal Plain	Miluveach Lower Coastal Plain	A relatively flat portion of the coastal plain near the Miluveach River. The area was affected by two marine transgressions between 70 and 130 thousand years ago that reached as high as 10 m. Surficial deposits primarily are eolian silt and sand over alluvial gravel and the area has been greatly affected by thaw lake processes. The soils are moderately to slightly acidic (typically pH = 5.5–6.5). Common ecosystems include Lowland Shallow and Deep Lakes, and Lacustrine Wet Meadows and Lacustrine Thaw Complexes in Ice-poor Thaw Basins. Lakes generally are 1?2 m deep. Lowland Thaw Complexes occur in older Ice-rich Thaw Basins. Lowland Wet Meadows and Lowland Moist Meadows occur in low-lying areas and swales that have been raised by ice aggradation. Upland Tussock Meadows occur on upper slopes and broad ridges.
	Miluveach Upper Coastal Plain	A gently rolling portion of the coastal plain near the Miluveach River. The area was affected several marine transgressions 0.5 to 3.5 million years ago that reached a maximum elevation of about 40–60 m. Surficial deposits are primarily eolian sands over alluvial and marine gravels and are circumneutral to slightly alkaline (typically 6.5–7.6). The area has been greatly affected by lacustrine processes and lake drainage, but erosion and drainage development over time has created a more rolling topography. Common ecosystems are similar to those described above for the Miluveach Lower Coastal Plain.
	Lower Colville Coastal Plain	A relatively flat portion of the coastal plain between the lower Colville and Itkillik rivers. Surficial deposits are primarily eolian silts over alluvial gravels and are circumneutral to slightly alkaline (typically 6.5–7.6). The area has been greatly affected by lacustrine processes and lake drainage. Common ecosystems are similar to those described above for the Miluveach Lower Coastal Plain.
	Kuparuk? Sagavanirktok Coastal Plain	A gently rolling portion of the coastal plain between Kalubik Creek and the Kuparuk River underlain by gravel deposited by braided-river processes on an alluvial plain. Some of the subsurface gravel is saline, indicative of deposition in a marine environment. The surface is covered with eolian sand and lacustrine deposits and thaw lake processes are prevalent. Common ecosystems are similar to those described above for the Miluveach Lower Coastal Plain.
	Kachemach River Floodplain	The narrow, meandering floodplain of the Kachemach River is affected by flooding, sedimentation, and river meandering. Channel deposits are gravelly and overbank deposits are mostly sandy. Near the headwater, the water is slightly saline from seepage of water through slightly saline marine sediments. Common ecosystems include Riverine Barrens on active channel deposits, Riverine Low and Tall Scrub on active overbank deposits with frequent sedimentation, Riverine Dwarf Scrub on well-drained sandy inactive floodplains, and Riverine Wet Meadows on poorly drained inactive floodplains.
	Miluveach River Floodplain	The narrow, meandering floodplain of the Kachemach River is affected by flooding, sedimentation, and river meandering. Channel deposits are gravelly and overbank deposits are mostly sandy. Near the headwater, the water is slightly saline from seepage of water through slightly saline marine sediments. Common ecosystems are similar to those described for the Kachemach River Floodplain.
	Lower Kuparuk River Floodplain	The broad, braided floodplain of the lower Kuparuk River is affected by flooding, sedimentation, and channel migration. Channel deposits are gravelly and inactive overbank deposits typically are sandy. Common ecosystems include Riverine Barrens on active channel deposits, Riverine Low and Tall Scrub on active overbank deposits with frequent sedimentation, Riverine Dwarf Scrub on well-drained sandy inactive floodplains, and Riverine Wet Meadows on poorly drained inactive floodplains.
	Lower Itkillik River Floodplain	The highly sinuous, meandering floodplain of the lower Itkillik River is affected by flooding, sedimentation, and channel migration. Channel deposits are sandy to gravelly and inactive overbank deposits are silty. Common ecosystems are similar to those described for the Lower Colville Floodplain.

Table 14. (Continued).

Ecodistrict	Ecosub-district	Description
Western Beaufort Coastal Plain	Teshekpuk Lower Coastal Plain	A relatively flat portion of the coastal plain near Teshekpuk Lake resulting from transgression of shallow seas. The massive to poorly stratified deposits are comprised of fine to medium sand includes pebbly chert, lenses of silty sand and organic material. Underlying permafrost has high ice content. Oriented lakes are abundant but usually small. Common ecosystems are similar to those described for the Fish Creek Lower Coastal Plain.
	Cape Halkett Lower Coastal Plain	A relatively flat portion of the coastal plain near Cape Halkett characterized by abundance of large drained lake basins due to its proximity to the coast. The area is underlain by very ice-rich, marine sandy silt containing scattered pebbles and lenses of sand, clay, pebbly sand, and fine gravel. Fossil shells, marine mammal bones, organic horizons, driftwood, and occasional erratic boulders up to 1 m in diameter. Nearly the entire surface has been affected by thaw lakes and basin drainage. Common ecosystems are similar to those described for the Fish Creek Lower Coastal Plain.
	Fish Creek Lower Coastal Plain	A relatively flat portion of the coastal plain near Fish Creek. Its genesis and dominant ecosystems are very similar to those described for the Miluveach Lower Coastal Plain.
	Ublutuoch Upper Coastal Plain	A gently rolling portion of the coastal plain near Ublutuoch Creek. Its genesis and dominant ecosystems are very similar to those described for the Miluveach Upper Coastal Plain. Lakes tend to be rather shallow (<2 m deep).
	Ikpikpuk Upper Coastal Plain	A gently rolling region of the coastal plain that extends from Fish Creek to the Meade River. The area was greatly affected by deposition of eolian sand during the late Pleistocene that created distinctive linear dunes up to several tens of meters thick. Due to the dunes, the drainage network is poorly developed. Abundant lakes that have formed in the depressions are due to impeded drainage and not thaw-lake processes, although shoreline erosion has contributed to a slight NW-SE orientation of the lakes. Surface soils are sandy and acidic to circumneutral, and underlying permafrost is ice-poor. Common ecosystems include Lowland Lakes in depressions, Lacustrine Wet Meadows along lake margins, Lowland Wet Meadows and Lowland Moist Meadows in low lying basins and swales with polygonal development, Upland Tussock Meadows on upper slopes, and Upland Dry Dwarf Shrub and Upland Moist Dwarf Shrub on more exposed dune ridges.
	Fish-Judy Creek Floodplains	The sinuous, meandering floodplains of Fish and Judy creeks are affected by flooding, sedimentation, and river meandering. Channel deposits are sandy and overbank deposits are loamy to sandy. Common ecosystems include Riverine Barrens on active channel deposits, Riverine Low and Tall Scrub on active overbank deposits with frequent sedimentation, Riverine Dwarf Scrub on well-drained sandy inactive floodplains, and Riverine Wet Meadows on poorly drained inactive floodplains. Riverine lakes are common in abandoned channels and thaw lakes form in ice-rich abandoned floodplains. Sand dunes are common along the point bars and support Upland Dry Tall Scrub and Upland Dry Dwarf Scrub.
	Kealok Creek Floodplain	The sinuous, meandering floodplain of Kealok Creek is affected by flooding, sedimentation, and river meandering. Channel deposits are sandy and overbank deposits are loamy to sandy. Common ecosystems are similar to those describe for Fish-Judy Creek Floodplains.
	Kalikpik River Floodplain	The sinuous, meandering floodplain of Kalikpik River is affected by flooding, sedimentation, and river meandering. Channel deposits are sandy and overbank deposits are loamy to sandy. Common ecosystems are similar to those describe for Fish-Judy Creek Floodplains.
	Kikiakrorak River Floodplain	The meandering floodplain of Kikiakrorak River is affected by flooding, sedimentation, and river meandering. Channel deposits are gravelly and overbank deposits are sandy to loamy. Common ecosystems are similar to those described for the Kachemach River Floodplain.
Lower Central Brooks Foothills	Kuparuk Uplands	A hilly area formed from Tertiary conglomerate and undifferentiated sand and gravelly sand. A thick layer of eolian silt and sand overlays the coarser material and thaw-lake development is reduced due to the sloping topography. Presence of isolated erratic boulders (up to 10 m) indicates portions the region was glaciated during the Tertiary. Subsurface deposits are saline in places. Common ecosystems include Upland Tussock Meadow on well-drained slopes, Lowland Moist Meadows on lower slopes, Lowland Wet Meadows in depressions and drainages, and Riverine Low Scrub in drainages.


Ecodistricts
Ecological Land Survey
Northeastern NPRA
Figure 26
Ecodistricts:
Major landforms or physiographic regions within a climatic region
Ecosubdistricts:
Smaller physiographic regions based on repeating associations of geomorphic units
Approximate Scale = 1: 400,000
Miles
Kilometers
Mosaic produced from Landsat TM images from 1985–1993
Pixel resolution: 28.5 m
Map projection: UTM Zone 6N, WGS 84
Map prepared by ABR, Inc.
3 April 2003
Western Beaufort Sea Coast
Cape Halkett Coast
Cape Halkett Lower Coastal Plain
Teshekpuk Lower Coastal Plain
Harrison Bay Shallow Nearshore Water
Simpson Lagoon
Central Beaufort Sea Coast
Fish Creek Coast
Outer Colville Delta
Simpson Lagoon Coast
Kealok Creek Floodplain
Ikpikpuk Upper Coastal Plain
Kalikpik River Floodplain
Fish Creek Lower Coastal Plain
Colville Delta
Ugnuravik Coastal Plain
Central Beaufort Coastal Plain
Western Beaufort Coastal Plain
Inner Colville Delta
Lower Miluveach Coastal Plain
Miluveach Floodplain
Upper Miluveach Coastal Plain
Kachemach Floodplain
Ublutuoch Upper Coastal Plain
Lower Colville Floodplain
Lower Central Brooks Foothills
Kuparuk Uplands
Kiklakrorak River Floodplain
Lower Colville Coastal Plain
153°30'0"W
153°0'0"W
152°30'0"W
152°0'0"W
151°30'0"W
151°0'0"W
150°30'0"W
150°0'0"W
70°40'0"N
70°30'0"N
70°20'0"N
70°10'0"N
70°0'0"N

Nearshore Water, Fish Creek Coast, Colville Outer Delta, Colville Inner Delta, Fish–Judy Creek Floodplains, Fish Creek Lower Coastal Plain, Ikpikpuk Upper Coastal Plain, and the Ublutuoch Upper Coastal Plain.

The ecodistricts provide a way of stratifying the distribution of ecotypes that frequently are contextually related. For example, Riverine Moist Barrens, Riverine Moist Tall Willow Shrub, Riverine Wet Sedge Meadow, Riverine Lake, and Upland Dry Dryas Dwarf Shrub are found almost exclusively in the Fish–Judy Creek Floodplains ecosubdistrict within the study area. Lacustrine Wet Sedge Meadow, Lowland Wet Sedge Meadow, Lowland Moist Sedge–Shrub Meadow, Upland Moist Tussock Meadow, and Lowland Lake are found within the Fish Creek Lower Coastal Plain, Ublutuoch Upper Coastal Plain, and Ikpikpuk Upper Coastal Plain ecosubdistricts. Coastal Moist Barrens, Coastal Wet Sedge Meadow, Coastal Moist Willow Dwarf Shrub, Coastal Salt-killed Wet Meadow, and Coastal Lake are found within the Fish Creek Coast and Colville Outer Delta ecosubdistricts.

ECOLOGICAL LAND EVALUATION

An ecological land evaluation involves the assessment of the capabilities or sensitivities of the terrain for specific ecological or engineering applications. In this section we illustrate four uses of the integrated-terrain-unit (ITU) map for land management applications: (1) development of a wildlife habitat map designed to differentiate characteristics important to waterbirds for habitat-use analyses (Burgess et al. 2003), (2) mapping of flooding regimes for facility siting, (3) mapping of sensitivity of ecosystems to oil spills, and (4) mapping of the sensitivity of ecosystems to winter off-road traffic.

WILDLIFE HABITAT

For analysis of wildlife habitat use, particularly for waterbirds, the ITUs were aggregated into a reduced set of habitat classes that emphasized slightly different ecological characteristics than did the ecotype classification (Table 15). For example, the habitat classification differentiated several waterbody characteristics (e.g., presence of islands, shoreline configuration) that are important for nest-site selection, and grouped barrens, shrub types, and wet meadow classes in different ways than did the ecosystem classification. While this classification is more suitable for analysis of waterbird habitats, a habitat classification for other animals may emphasize other ecological attributes. Our habitat classification system originally was developed in 1988 (Jorgenson et al. 1989) and has undergone only minor modifications (Appendix Table 7). We maintained the use of the old system in this study to facilitate comparison with habitat use results from previous studies in the Colville Delta (Johnson et al. 1997) and Prudhoe Bay (Johnson et al. 1990, Anderson et al. 1992, Murphy and Anderson 1993). In contrast, the ecotype classification incorporated greater emphasis on geomorphic and hydrologic linkages and was derived from analysis of results of field surveys.

For analysis of habitat selection, the 325 ITUs were reduced to 27 wildlife habitat classes (Figure 27, Table 15). This aggregation resulted in 14 terrestrial, 9 waterbody, and 4 complex types. The most abundant habitats included Moist Tussock Tundra (27.4% of total area), Moist Sedge–Shrub Meadow (23.2%), Old Basin Wetland Complex (8.8%), Deep Open Water without Islands (7.2%), and Deep Open Water with Islands (5.2%) (Table 10). Twelve habitats were relatively rare (<1% area). A comparison among habitats, ecotypes, and vegetation types is provided (Table 16).

The habitat map, in conjunction with wildlife survey data, was used to quantify habitat selection by various bird and mammal species (Burgess et al. 2003). Analyses revealed both large differences in habitat use among species, and strong seasonal patterns within species. For example, Canada Geese preferred Shallow Open Water with Islands for nest sites and Yellow-billed Loons preferred Deep Open Water with Islands. The analysis of habitat use, however, becomes exceedingly complex when differences in wildlife species, seasonal use (i.e., pre-nesting, nesting, brood-rearing, fall staging), and ecological regions (i.e., delta and coastal plain) must be considered and it becomes difficult to synthesize the information into simple mitigation objectives. One approach to dealing with this complexity is to summarize the information into an index of the diversity of habitat use that identifies those habitats

Table 15. Classification and descriptions of wildlife habitat classes in Northeastern Planning Area of the NPRA, 2002.

Habitat Class	Description
Open Nearshore Water	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (< 0.2m), but storm surges produced by winds may raise sea level as much as 2–3m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. An important habitat for some species of waterfowl for molting during spring and fall staging.
Brackish Water (Tidal Ponds)	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. Sediments may contain peat, reflecting a freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake with Low-water Connection	Waterbodies that have been partially drained by erosion of banks by adjacent river channels and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shorelines. Deeper lakes in this class do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes form important over-wintering habitat for fish.
Tapped Lake with High-water Connection	Similar to Tapped Lake with Low-water Connection except that the connecting channels are dry during low water and the lakes are connected only during flooding events. Water tends to be fresh. Small deltaic fans are common near the connecting channel due to deposition during seasonal flooding. These lakes form important fish habitat.
Salt Marsh	On the Beaufort Sea coast, arctic Salt Marshes generally occur in small, widely dispersed patches, most frequently on fairly stable mudflats associated with river deltas. The surface is flooded irregularly by brackish or marine water during high tides, storm surges, and river flooding events. Salt Marshes typically include a complex assemblage of small brackish ponds, Halophytic Sedge Wet Meadow, Halophytic Willow Dwarf Shrub Tundra, and small barren patches. Dominant plant species usually include *Carex subspathacea, C. ursina, Puccinellia phryganodes, Dupontia fisheri, P. andersonii, Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea*. Salt Marsh is important habitat for brood-rearing and molting waterfowl.
Tidal Flat	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flats occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flats frequently are associated with lagoons and estuaries and may vary widely in actual salinity levels. Tidal Flats are considered separately from other barren habitats because of their importance to estuarine and marine invertebrates and shorebirds.
Salt-killed Tundra	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and are being colonized by salt-tolerant plants. Colonizing plants include *Puccinellia andersonii, Dupontia fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, Stellaria humifusa, Cerastium beeringianum,* and *Salix ovalifolia*. This habitat typically occurs either on low-lying areas that originally supported Patterned Wet Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that originally supported Moist Sedge–Shrub Meadow and Upland Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizers.
Deep Open Water without Islands	Deep (≥ 1.5m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes. Most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. They do not freeze to the bottom during winter and usually are not connected to rivers. Sediments are fine-grained silt in centers with sandy margins. Deep Open Waters without Islands are differentiated from those with islands because of the lack of nest sites for waterbirds that prefer islands.
Deep Open Water with Islands or Polygonized Margins	Similar to above except that they have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many species of waterbirds.

Table 15. (Continued).

Habitat Class	Description
Shallow Open Water without Islands	Ponds and small lakes < 1.5m deep with emergent vegetation covering < 5% of the waterbody's surface. Due to the shallow depth, water freezes to the bottom during winter and thaws by early to mid-June. Maximal summer temperatures are higher than those in deep water. Sediments are loamy to sandy.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex low-center polygon shorelines, otherwise similar to Shallow Open Water without Islands. Distinguished from Shallow Open Water without Islands because shoreline complexity appears to be an important feature of nesting habitat for many species of waterbirds.
River or Stream	All permanently flooded channels large enough to be mapped as separate units. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of Judy Creek are slightly saline, whereas other streams are non-saline.
Aquatic Sedge Marsh	Permanently flooded waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤ 0.5m deep. Water and bottom sediments of this shallow habitat freeze completely during winter, but the ice melts in early June. The sediments generally consist of a peat layer (20–50cm deep) overlying loam or sand.
Aquatic Sedge with Deep Polygons	A habitat associated with inactive and abandoned floodplains and deltas in which thermokarst of ice-rich soil has produced deep (> 50cm), permanently flooded polygon centers. Emergent vegetation, mostly *Carex aquatilis*, usually is found around the margins of the polygon centers. Occasionally, centers will have the emergent grass *Arctophila fulva*. Polygon rims are moderately well drained and dominated by sedges and dwarf shrubs, including *Carex aquatilis, Eriophorum angustifolium, C. bigelowii, Dryas integrifolia, Salix reticulata*, and *S. ovalifolia*.
Aquatic Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva*. Due to shallow water depths (< 1m), the water freezes to the bottom in the winter, and thaws by early June. *Arctophila fulva* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in recently drained lake basins and is more productive than Aquatic Sedge Marsh. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (Ice-poor)	Complex habitat found in recently drained lake basins and characterized by a mosaic of open water, Aquatic Sedge and Grass Marshes, Nonpatterned Wet Meadows, and Moist Sedge–Shrub Meadows in patches too small (< 0.5ha) to map individually. During spring breakup, basins may be entirely inundated, though water levels recede by early summer. Basins often have distinct banks marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of basins and the presence of several drained lake stages. Soils generally are loamy to sandy, moderately to richly organic, and ice-poor. Because there is little segregated ground ice the surface form is nonpatterned ground or disjunct polygons and the margins of waterbodies are indistinct and often interconnected. Ecological communities within young basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating these two types.
Old Basin Wetland Complex (Ice-rich)	Similar to above but characterized by well-developed low- and high-centered polygons resulting from ice-wedge development and aggradation of segregated ice. Complexes in basin margins generally include Aquatic Sedge Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadows, and small ponds (< 0.25ha). The waterbodies in old basins are concentrated in basin margins and tend to have smoother, more rectangular shorelines and are not as interconnected as those in more recently drained basins. The vegetation types in basin centers generally include Moist Sedge–Shrub Meadow and Moist Tussock Tundra on high-centered polygons, and Patterned Wet Meadows. Aquatic Grass Marsh generally is absent. Soils have a moderately thick (20–50cm) organic layer overlying loam or sand.
Riverine Complex	Permanently flooded streams and associated floodplains characterized by a complex mosaic of water, Barrens, Riverine Dwarf Shrub, Riverine Low and Tall Shrub, Aquatic Sedge and Grass Marsh, Nonpatterned and Patterned Wet Meadow, and Moist Sedge–Shrub Meadow in patches too small (< 0.5ha) to map individually. Surface form varies from nonpatterned point bars and meadows to mixed high- and low-centered polygons and small stabilized dunes. Small ponds tend to have smooth, rectangular shorelines resulting from the coalescing of low centered polygons. During spring flooding these areas may be entirely inundated, following breakup water levels gradually recede.

Table 15. (Continued).

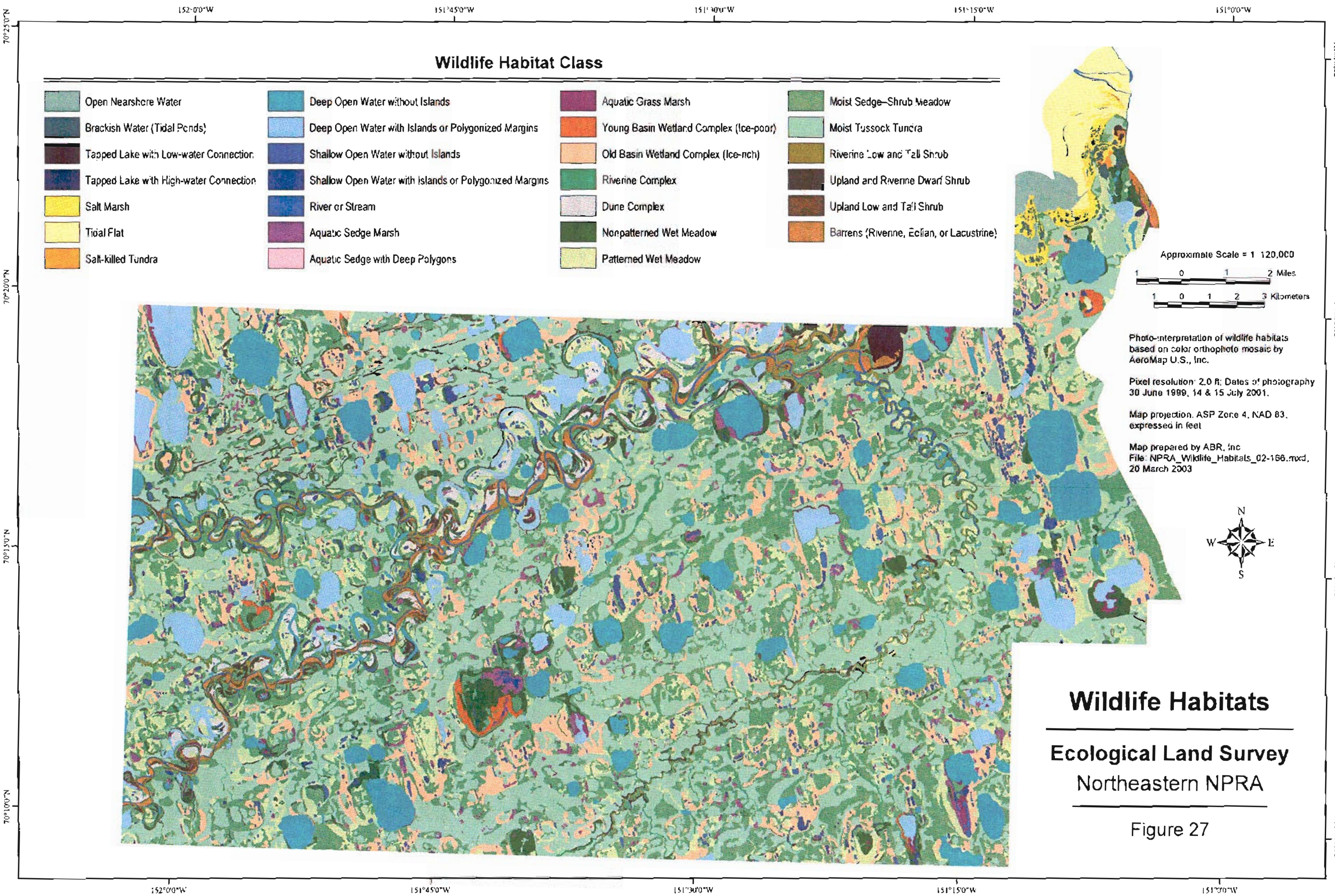
Habitat Class	Description
Dune complex	Complex formed from the action of river flooding on inactive sand dunes, most commonly on point bars. A series of narrow swale and ridge features develop in parallel with river flow that are too small to map separately. Swales are moist or saturated while dune ridges are moist to dry. Habitat classes in swales typically are Riverine Low Shrub, Nonpatterned Wet Meadow, or Fresh Sedge Marsh, while ridges commonly are Upland Dwarf Shrub or Upland Low Shrub.
Nonpatterned Wet Meadow	Sedge-dominated meadows that occur within recently drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strang cover < 5% of the ground surface. The surface generally is flooded during early summer (depth < 30cm) and drains later, but water remains close to the surface throughout the growing season. The uninterrupted movement of water (and dissolved nutrients) in nonpatterned ground results in more robust growth of sedges than occurs in polygonized habitats. Usually dominated by *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be common. Low and dwarf willows (*Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) occasionally are present. Soils generally have a moderately thick (10–30cm) organic horizon overlying loam or sand.
Patterned Wet Meadow	Lowland areas with low-centered polygons or strang within drained lake basins, level floodplains, and flats and water tracks on terraces. Polygon centers are flooded in spring and water remains close to the surface throughout the growing season. Polygon rims or strang interrupt surface and groundwater flow, so only interconnected polygon troughs receive downslope flow and dissolved nutrients; in contrast, the input of water to polygon centers is limited to precipitation. As a result, vegetation growth typically is more robust in polygon troughs than in centers. Vegetation is dominated by sedges, usually *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present including *C. rotundata, C. saxatilis, C. membranacea, C. chordorrhiza*, and *E. russeolum*. On polygon rims, willows (e.g. *Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) and the dwarf shrubs *Dryas integrifolia* and *Cassiope tetragona* may be abundant along with other species typical of moist tundra.
Moist Sedge–Shrub Meadow	High-centered, low-relief polygons and mixed high- and low-centered polygons on gentle slopes of lowland, riverine, drained basin, and solifluction deposits. Soils are saturated at intermediate depths (> 15cm) but generally are free of surface water during summer. Vegetation is dominated by *Dryas integrifolia*, and *Carex bigelowii*. Other common species include *C. aquatilis, Eriophorum angustifolium, Salix reticulata, S. lanata richardsonii*, and the moss *Tomentypnum nitens*. The active layer is relatively shallow and the organic horizon is moderate (10–20cm).
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins. Vegetation is dominated by tussock-forming plants, most commonly *Eriophorum vaginatum*. High-centered polygons of low or high relief are associated with this habitat. Soils are loamy to sandy, somewhat well-drained, acidic to circumneutral, with moderately thick (10–30cm) organic horizons and shallow (< 40cm) active layer depths. On acidic sites, associated species include *Ledum decumbens, Betula nana, Salix planifolia pulchra, Cassiope tetragona*, and *Vaccinium vitis-idaea*. On circumneutral sites common species include *Dryas integrifolia, S. reticulata, Carex bigelowii*, and lichens. Mosses are common at most sites.
Riverine Low and Tall Shrub	Both open and closed stands of low (≤ 1.5 m) and tall (> 1.5 m) willows along riverbanks. Tall willows occur mainly on active riverine deposits along larger streams and rivers, where the vegetation is dominated by open (< 75% cover) stands of *Salix alaxensis* with a sparse understory including *Equisetum arvense, Gentiana propinqua, Chrysanthemum bipinnatum, Festuca rubra*, and *Aster sibiricus*. Soils are well-drained riverine sands with little to no organic horizon. Low willow stands, which can occur on active and inactive deposits, typically have an open to closed canopy of *S. lanata richardsonii* occasionally mixed with *S. planifolia pulchra*. Understory plants include *Equisetum arvense, Astragalus alpinus, Drepanocladus* sp. *Arctagrostis latifolia, Petasites frigidus*, and *Tomentypnum nitens*. Soils are interbedded layers of riverine sands, silts, and organics.
Upland Low and Tall Shrub	Open to closed stands of low (≤ 1.5 m) and tall (> 1.5 m) willow often found on banks, dunes, and high-centered polygons. Upland Tall Shrub can be found on active sand dunes and is defined by the presence of *Salix alaxensis*. Low Shrub stands are found on short, steep banks of basins and on inactive sand dunes. Sites are dominated by *Salix glauca*, with *Dryas integrifolia, Salix lanata richardsonii, Arctostaphylos rubra*, and mosses in the understory. Included in this class are sites dominated by low shrub birch, *Betula nana*.

Table 15. (Continued).

Habitat Class	Description
Upland and Riverine Dwarf Shrub	Dwarf scrub tundra on upland ridges, stabilized sand dunes and river terraces dominated by *Dryas integrifolia* or *Cassiope tetragona*. Upland *Dryas* sites typically are dry and sandy with deep thaw depths (> 1.0m), common associated species include *Salix glauca, S. reticulata, Arctostaphylos alpina, Arctagrostis latifolia, Thamnolia vermicularis,* and *Cetraria cuculata*. Riverine *Dryas* sites occur on well-drained, sandy river terraces, co-dominant species often include *Equisetum variegatum* and *Salix reticulata,* with *S. lanata richardsonii, Arctostaphylos rubra, Oxytropis deflexa, Tomentypnum nitens,* and *Thamnolia vermicularis* as associated species. *Cassiope tetragona* is found on slightly moister sites such as banks of thaw basins, riverbanks, and slopes of older, well-stabilized dunes. On intermediate sites *Dryas integrifolia* may be co-dominant. Species found in association with *Cassiope* include *S. phlebophylla, Salix reticulata, Vaccinium vitis-idaea, Carex bigelowii, Hierochloe alpina,* and *Arctagrostis latifolia*. Cryptogams present include crustose lichens, *Hylocomium splendens, Dicranum* sp., *Tomentypnum nitens,* and *Rhytidium rugosum*. All sites have a wide variety of forbs.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (< 30% plant cover) areas related to riverine, eolian, or thaw basin processes. Riverine Barrens on river flats and bars are underlain by moist sands and are flooded seasonally. Early colonizers are *Deschampsia caespitosa, Poa hartzii, Festuca rubra, Salix alaxensis,* and *Equisetum arvense*. Eolian Barrens are active sand dunes that are too unstable to support more than a few pioneering plants (< 5% cover). Typical species include *Salix alaxensis, Festuca rubra,* and *Chrysanthemum bipinnatum*. Lacustrine Barrens occur within recently drained lakes and ponds. These areas may be flooded seasonally or can be well drained. Typical colonizers are forbs, graminoids, and mosses including *Carex aquatilis, Dupontia fisheri, Scorpidium scorpioides,* and *Calliergon* sp. on wet sites and *Poa* spp., *Festuca rubra, Deschampsia caespitosa, Stellaria humifusa, Senecio congestus,* and *Salix ovalifolia* on drier sites. Barrens may receive intense use seasonally by caribou as mosquito-relief habitat.

Table 16. Crosswalk of habitat classes, ecotypes, and vegetation classes used in integrated- terrain-unit mapping in the Northeastern Planning Area of the NPRA, 2002.

Habitat Class	Ecotype	Vegetation Type – Level IV
Upland and Riverine Dwarf Shrub	Upland Dry Dryas Dwarf Shrub	Dryas Dwarf Shrub Tundra
	Upland Moist Cassiope Dwarf Shrub	Cassiope Dwarf Shrub Tundra
	Riverine Dry Dryas Dwarf Shrub	Dryas Dwarf Shrub Tundra
Upland Low and Tall Shrub	Upland Dry Tall Willow Shrub	Open Tall Willow Shrub
	Upland Moist Low Willow Shrub	Open Low Willow Shrub
Riverine Low and Tall Shrub	Riverine Moist Tall Willow Shrub	Closed or Open Tall Willow Shrub
	Riverine Moist Low Willow Shrub	Closed or Open Low Willow Shrub
Moist Sedge–Shrub Meadow	Lowland Moist Low Willow Shrub	Open Low Willow Shrub
	Lacustrine Moist Low Willow Shrub	Open Low Willow Shrub
	Lacustrine Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Tundra
	Lowland Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Tundra
	Riverine Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Tundra
Moist Tussock Tundra	Upland Moist Tussock Meadow	Tussock Tundra
Nonpatterned Wet Meadow	Lacustrine Wet Sedge Meadow	Wet Sedge Meadow Tundra
	Riverine Wet Sedge Meadow	Wet Sedge Meadow Tundra
Patterned Wet Meadow	Lowland Wet Sedge Meadow	Wet Sedge Meadow Tundra
	Riverine Wet Sedge Meadow	Wet Sedge Meadow Tundra
Aquatic Sedge Marsh	Lowland Sedge Marsh	Fresh Sedge Marsh
	Lacustrine Sedge Marsh	Fresh Sedge Marsh
	Riverine Sedge Marsh	Fresh Sedge Marsh
Aquatic Sedge with Deep Polygons	Lowland Deep-polygon Complex	Deep Polygon Complex
	Riverine Deep-polygon Complex	Deep Polygon Complex
Aquatic Grass Marsh	Lacustrine Grass Marsh	Fresh Grass Marsh
	Riverine Grass Marsh	Fresh Grass Marsh
Old Basin Wetland Complex	Lowland Basin Complex	Old Basin Wetland Complex
Young Basin Wetland Complex	Lacustrine Basin Complex	Young Basin Wetland Complex
Barrens	Riverine Moist Barrens	Barren or Partially Vegetated
	Coastal Moist Barrens	Barren or Partially Vegetated
	Lacustrine Moist Barrens	Barren or Partially Vegetated
	Upland Dry Barrens	Barren or Partially Vegetated
Riverine Complex	Riverine Complex	Riverine Complex
Deep Open Water with Islands or Polygonized Margins	Lowland Lake	Water
	Riverine Lake	Water
Deep Open Water wihtout Islands	Lowland Lake	Water
	Riverine Lake	Water
Shallow Open Water without Islands	Lowland Lake	Water
	Riverine Lake	Water
Shallow Open Water with Islands or Polygonized Margins	Lowland Lake	Water
	Riverine Lake	Water
Tapped Lake with High-water Connection	Riverine Lake	Water
Tapped Lake with Low-water Connection	Coastal Lake	Water
Salt-killed Tundra	Coastal Salt-killed Wet Meadow	Salt-killed Wet Meadow
Salt Marsh	Coastal Wet Sedge Meadow	Halophytic Sedge Wet Meadow
	Coastal Moist Willow Dwarf Shrub	Halophytic Willow Dwarf Shrub Tundra
Tidal Flat	Coastal Moist Barrens	Barren or Partially Vegetated
River or Stream	Tidal River	Water
	Lower Perennial River	Water
	Headwater Stream	Water
Brackish Water (tidal ponds)	Coastal Lake	Water
Nearshore Water	Nearshore Water	Water
Dune Complex	Riverine Dune Complex	Dune Complex


Wildlife Habitat Class
Open Nearshore Water
Brackish Water (Tidal Ponds)
Tapped Lake with Low-water Connection
Tapped Lake with High-water Connection
Salt Marsh
Tidal Flat
Salt-killed Tundra
Deep Open Water without Islands
Deep Open Water with Islands or Polygonized Margins
Shallow Open Water without Islands
Shallow Open Water with Islands or Polygonized Margins
River or Stream
Aquatic Sedge Marsh
Aquatic Sedge with Deep Polygons
Aquatic Grass Marsh
Young Basin Wetland Complex (Ice-poor)
Old Basin Wetland Complex (Ice-rich)
Riverine Complex
Dune Complex
Nonpatterned Wet Meadow
Patterned Wet Meadow
Moist Sedge–Shrub Meadow
Moist Tussock Tundra
Riverine Low and Tall Shrub
Upland and Riverine Dwarf Shrub
Upland Low and Tall Shrub
Barrens (Riverine, Eolian, or Lacustrine)
Approximate Scale = 1 120,000
1 0 1 2 Miles
1 0 1 2 3 Kilometers
Photo-interpretation of wildlife habitats based on color orthophoto mosaic by AeroMap U.S., Inc.
Pixel resolution: 2.0 ft; Dates of photography 30 June 1999, 14 & 15 July 2001.
Map projection, ASP Zone 4, NAD 83, expressed in feet
Map prepared by ABR, Inc
File: NPRA_Wildlife_Habitats_02-166.mxd, 20 March 2003
N
W
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152°0'0"W
151°45'0"W
151°30'0"W
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151°0'0"W
70°25'0"N
70°20'0"N
70°15'0"N
70°10'0"N
Wildlife Habitats
Ecological Land Survey
Northeastern NPRA
Figure 27

that are most used by the most species (Parametrix 1997).

FLOOD FREQUENCY

We developed a simple spatial model of the distribution of six flooding regimes within the Northeastern Planning Area, based on previous analyses of flooding frequency in the Colville Delta (Jorgenson et al. 1997). The earlier analyses incorporated data on the relative heights of geomorphic units, the amount of flooding observed for each during 1992–1996, and sedimentation rates to model the distribution of flooding frequency. The same relationships among factors were used to assign approximate flooding frequencies to geomorphic units within the Northeastern Planning Area (Figure 28).

The High Flood-Frequency class included Delta Active Channel Deposit, Active Channel Deposit, Meander Fine Inactive Channel Deposit, Delta Ice-poor Thaw Basin, Active Tidal Flat, Inactive Tidal Flat, Rivers, and connected and tapped Riverine Lakes. On the channel deposits, flooding is sufficiently frequent that vegetation cannot develop (except pioneer vegetation along margins) and organic matter does not accumulate. This class was assigned a flood frequency of every 1–2 yr because, on the Colville Delta, most of the geomorphic units in this class were flooded every year from 1992–1996.

The Moderate Flood-Frequency class included Meander Active Overbank Deposits, Delta Active Overbank Deposits, and Lowland Headwater Floodplains. Indications of frequent flooding in these geomorphic units include extensive development of riverine shrub communities that depend on the input of nutrients from sediment deposition, lack of organic matter accumulation, and abundant driftwood. This class was assigned a flood frequency of every 3–4 yr because these geomorphic units were partially flooded by intermediate flood levels on the Colville Delta in 1993 (1 of 5 years of observation).

The Low Flood-Frequency class included Meander Inactive Overbank Deposits, Delta Inactive Overbank Deposits, and Isolated (shallow and deep) Riverine Lakes. The terrestrial deposits have well-established vegetation and some accumulation of peat, indicating that flood frequency is substantially lower than in the Moderate Flood-Frequency class. However, surface soils still show distinct interbedding of peat and mineral horizons resulting from periodic flooding. This class was assigned a flood frequency of every 5–25 yr because of observations on the Colville Delta, where most of these geomorphic units were not flooded during 1992–1995, but were flooded in 1989 and 2000. Obviously, substantial uncertainty remains about the end of the estimated range of flood frequency, because we have no observations of high flood stages in this area.

The Very Low Flood-Frequency class includes Meander Abandoned Overbank Deposits and Delta Abandoned Overbank Deposits. The absence of fluvial sediment near the surface, and the lack of driftwood on these deposits, indicate that flooding is rare. This class was assigned a flood frequency of every 26–200 yr. The flood frequency of this class is substantially uncertain, however, because of the lack of long-term observations.

Basin Impoundments are seasonally flooded low-lying areas in lake basins. While they are not affected by river flooding, they can accumulate 5–30 cm of standing water during snowmelt. Thus, they are of concern for construction of facilities because of potential cross-drainage problems.

Lakes (permanently flooded) are non-riverine waterbodies that retain water permanently. While they are not affected by river flooding, the water levels can fluctuate from snowmelt and subsequent evaporation. These lakes are of concern for facilities because of the permanent standing water and cross-drainage problems.

The Non-Flooded class includes Eolian Active Sand Deposit, Eolian Inactive Sand Deposit, Old Alluvial Terrace, and Alluvial–Marine Deposit. We do not consider these units to be affected by flooding under the current flooding regime.

The delineation of areas with different flooding regimes through this simplified modeling approach can help with initial siting of facilities to avoid areas prone to flooding, thus minimizing the obstruction of flood water and avoiding cross-drainage problems. While there is substantial uncertainty regarding the actual return periods for the various flooding regimes, the model

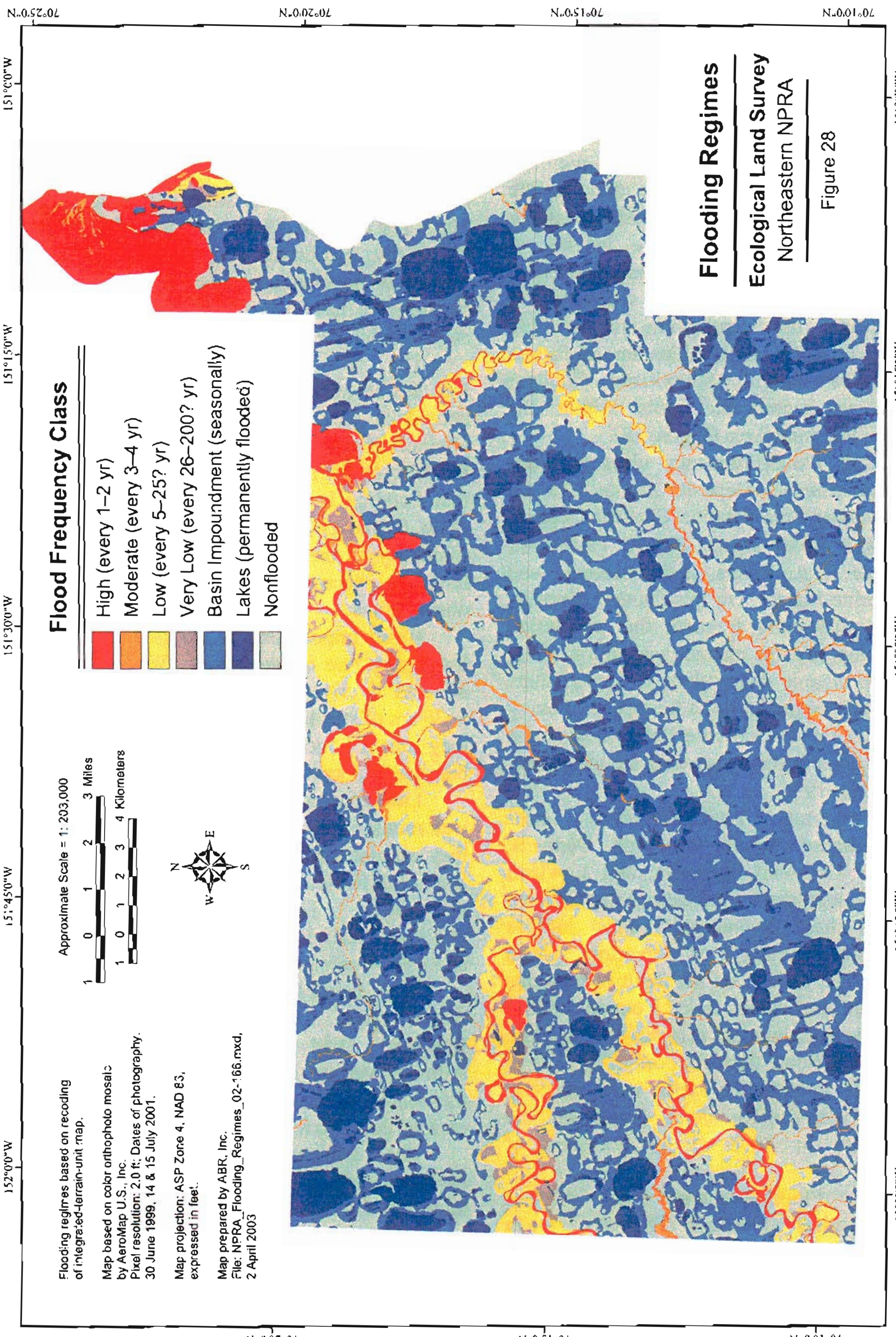

Figure 28. Map of general flooding regimes associated with terrain units mapped in the 2001 study area within the Northeastern Planning Area of the NPRA, 2002.

provides general categories of flooding regimes based on paleo-flood indicators. Design of bridges and cross-drainage structures, however, would require more intensive hydrologic analyses.

OIL SPILL SENSITIVITY

The spatial model of the sensitivity of ecosystems to damage from oil spills and associated cleanup activities was based on relative water depth, cover of evergreen shrubs, and microrelief (Figure 29, Table 17). Water depth is important because water affects infiltration of oil into the soil and removal of oil with fluid-based methods. High cover of evergreen shrubs can increase sensitivity, because they are slow growing and sensitive to hydrocarbons. Microrelief is important to oil spill operations because flat, nonpatterned areas are much easier to flush and clean than are sites with high and complex microrelief.

The model indicates that the ecotypes most sensitive to oiling are Upland Moist Low Willow Shrub, Upland Dry Dryas Dwarf Shrub, Upland Moist Cassiope Dwarf Shrub, Upland Moist Tussock Meadow, and Riverine Dry Dryas Dwarf Shrub. The ecotypes generally have well-drained soil, deep active layers that make the soils highly susceptible to oil infiltration, and abundant evergreen shrubs that are easily damaged by oil. Vegetated ecotypes that are least sensitive include Upland Dry Barrens, Lowland Wet Sedge Meadow, Lacustrine Wet Sedge Meadow, Riverine Wet Sedge Meadow, and Lowland Sedge Marsh. These wet ecotypes have water near the surface that reduces oil infiltration and have vegetation dominated by sedges that are relatively insensitive to oiling. Upland Dry Barrens is only partially vegetated by pioneering plants, so damage to plants is minimal. Aquatic ecotypes were assigned the lowest sensitivity because oil has little effect on the rooting zone of emergent vegetation (when present) and oil is relatively easy to remove. This model does not consider the potential effects of oil spills on fish and aquatic invertebrates, which also can be of concern.

These sensitivity rankings based on soil and vegetation characteristics are consistent with the case histories developed from numerous oil spills and experiments in northern Alaska. Sites dominated by wet soils and graminoid vegetation tend to have relatively low initial damage and high recovery rates (Cater and Jorgenson 1999). Little information is available on response to oil spills in better-drained ecotypes with more evergreen shrubs, because spilled oil tends to flow into lower, wetter areas. Experimental treatments by Walker et al. (1978) indicated that Dryas Tundra showed much more initial damage than Wet Sedge Meadow Tundra.

WINTER TRAFFIC SENSITIVITY

We developed a spatial model of the sensitivity of ecosystems to damage from winter vehicle traffic, based on relative water depth, cover of evergreen shrubs, total vegetation cover, microrelief, and macrorelief (Figure 30, Table 17). Water depth is important because water affects the ice-bonding of frozen soils; higher ice content can help protect the soil surface from scuffing. Evergreen shrubs are important because they are slow-growing and brittle at low temperatures. Total vegetation cover is important because it is a measure of how much biomass can be damaged. Both microrelief and macrorelief are important primarily because of their relationships to snow depth, as snow protects the ground surface from damage. At both the micro- and macro- scales, snow generally is thinner on higher areas and deeper in lower areas.

The model indicates that the ecotypes most sensitive to winter traffic are Upland Moist Tall Willow Shrub, Upland Dry Dryas Dwarf Shrub, Upland Moist Cassiope Dwarf Shrub, and Riverine Dry Dryas Dwarf Shrub. These ecotypes generally occur on windswept ridges where little snow accumulates and have well-drained soils with deep active layers that are poorly bonded when frozen. The vegetation includes abundant evergreen shrubs, which are susceptible to damage by vehicles. Among vegetated ecotypes, those least sensitive to winter traffic include Upland Dry Barrens, Lowland Wet Sedge Meadow, Lacustrine Wet Sedge Meadow, Riverine Wet Sedge Meadow, and Lowland Sedge Marsh. These ecotypes have water above or just below the surface, which greatly limits the depth of surface abrasion, and their vegetation dominated by sedges that recover rapidly from damage. Aquatic ecotypes (with or without emergent vegetation) were assigned the

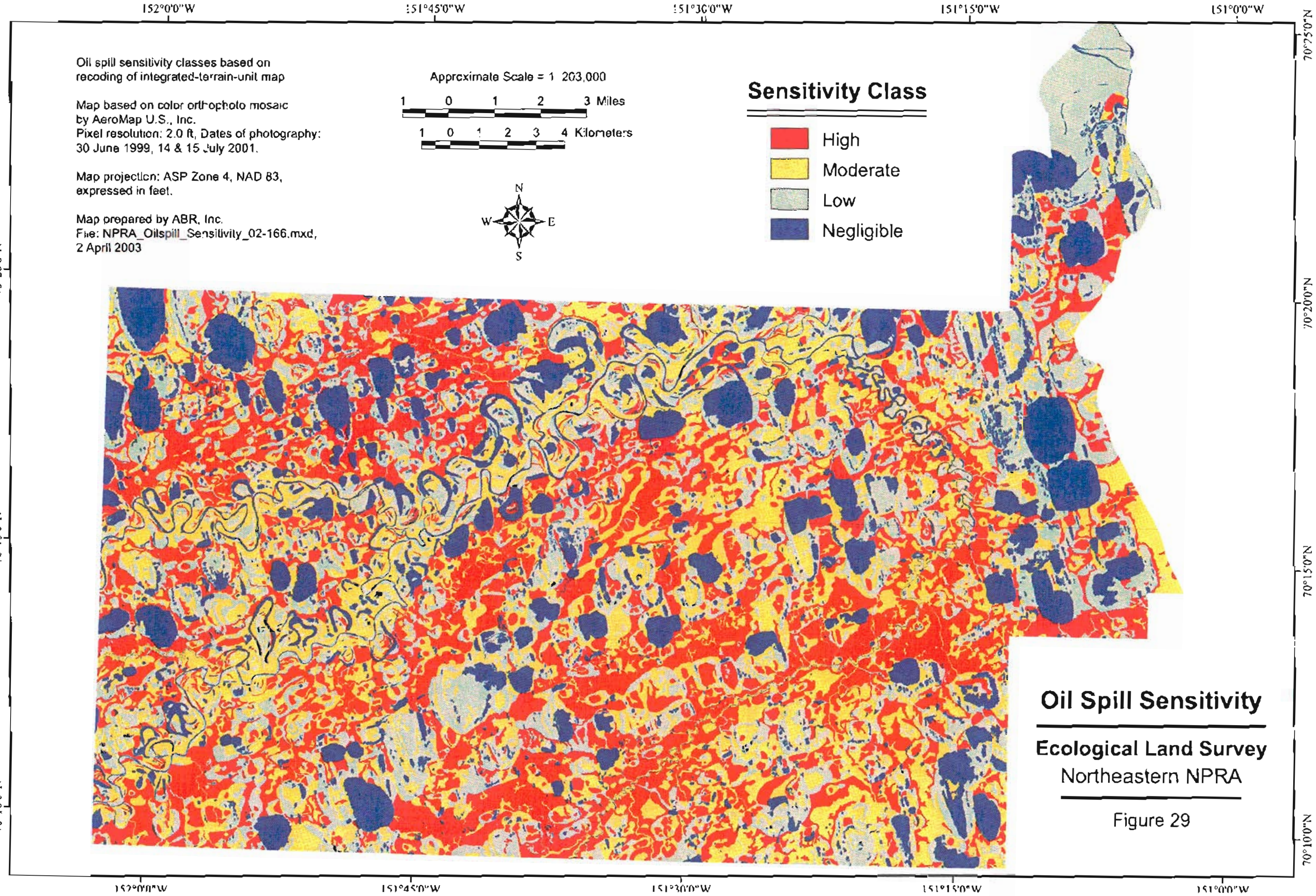

Figure 29. Map of generalized sensitivity of ecotypes to potential oilspills (including both initial oiling and cleanup) in the 2001 study area within the Northeastern Planning Area of the NPRA, 2002.

Table 17. Factors used in characterizing the sensitivity of ecotypes to oil spills and winter off-road travel in the Northeastern Planning Area of the NPRA, 2002.

Ecotype	Water Depth Rank[1]	Evergreen Shrub Rank[1]	Total Vegetation Cover Rank[1]	Micro-relief Rank[1]	Macrorelief Rank[1]	Organic Thickness[1]	OilSpill Sensitivity Rank[2]	Winter Traffic Sensitivity Rank[3]
Upland Dry Tall Willow Shrub	3	1	2	2	3	3	**2**	**3**
Upland Moist Low Willow Shrub	3	2	3	2	2	3	**3**	**2**
Upland Dry Dryas Dwarf Shrub	3	3	3	2	3	3	**3**	**3**
Upland Moist Cassiope Dwarf Shrub	3	3	3	2	3	2	**3**	**3**
Upland Moist Tussock Meadow	3	2	3	3	2	2	**3**	**2**
Upland Dry Barrens	3	0	0	1	3	2	**1**	**2**
Lowland Moist Low Willow Shrub	2	1	3	2	1	2	**2**	**2**
Lowland Moist Sedge–Shrub Meadow	2	2	3	2	1	1	**2**	**1**
Lowland Wet Sedge Meadow	1	1	2	2	0	1	**1**	**1**
Lowland Sedge Marsh	0	0	2	1	0	1	**0**	**0**
Lowland Lake	0	0	0	0	0	0	**0**	**0**
Lowland Basin Complex	1	0	2	2	1	1	**1**	**1**
Lowland Deep-polygon Complex	1	0	2	3	1	1	**1**	**1**
Lacustrine Moist Low Willow Shrub	2	1	3	1	0	2	**2**	**1**
Lacustrine Moist Sedge–Shrub	2	1	3	1	0	2	**2**	**1**
Lacustrine Wet Sedge Meadow	1	0	2	1	0	1	**1**	**1**
Lacustrine Sedge Marsh	2	0	1	0	0	1	**0**	**0**
Lacustrine Grass Marsh	2	0	1	0	0	1	**0**	**0**
Lacustrine Moist Barrens	3	0	0	0	0	0	**1**	**0**
Lacustrine Basin Complex	1	0	2	1	0	1	**1**	**1**
Riverine Moist Tall Willow Shrub	3	0	2	1	1	0	**2**	**1**
Riverine Moist Low Willow Shrub	3	1	3	1	1	3	**2**	**2**
Riverine Dry Dryas Dwarf Shrub	3	3	3	1	3	3	**3**	**3**
Riverine Moist Sedge–Shrub Meadow	3	1	3	2	1	2	**2**	**1**
Riverine Wet Sedge Meadow	1	0	3	2	1	2	**1**	**1**
Riverine Sedge Marsh	0	0	2	0	0	1	**0**	**0**
Riverine Grass Marsh	0	0	1	0	0	0	**0**	**0**
Riverine Lake	0	0	0	0	0	0	**0**	**0**
Riverine Moist Barrens	3	0	0	0	1	0	**1**	**0**
Riverine Complex	2	1	2	1	1	1	**2**	**1**
Riverine Dune Complex	2	2	2	2	3	1	**2**	**2**
Riverine Deep-polygon Complex	1	1	2	3	1	1	**2**	**2**
Coastal Moist Willow Dwarf Shrub	2	0	2	0	1	2	**1**	**1**
Coastal Wet Sedge Meadow	2	0	2	0	1	1	**1**	**1**
Coastal Salt-killed Wet Meadow	2	0	1	1	1	1	**1**	**1**
Coastal Lake	0	0	0	0	0	0	**0**	**0**
Coastal Moist Barrens	3	0	0	0	1	0	**1**	**0**
Nearshore Water	0	0	0	0	0	0	**0**	**0**
Tidal River	0	0	0	0	0	0	**0**	**0**
Lower Perennial River	0	0	0	0	0	0	**0**	**0**
Headwater Stream	0	0	0	0	0	0	**0**	**0**

[1] Variable Ranking. Water Depth: 0 = water >0 cm, 1 = 0 to -10cm, 2 = -10 to -30cm, 3 = water below -30cm. Evergreen Shrub: 0 = <1% cover, 1 = 1 to 10%, 2 = 10 to 30%, 3 = >30%. Total Live Vegetation: 0 = <1% cover, 1 = 11 to 50%, 2 = 51 to 100%, 3 = >100%. Microrelief: 0 = 0 to 10 cm, 1 = 11 to 30cm, 2 = 31 to 50cm, 3 = >50 cm. Macrorelief: 0 = basins or drainages, 1 = flats, 2 = lower slopes, 3 = upper slopes, ridges. Organic Thickness: 0 = 0 cm, 1 = >20 cm, 2 = >5 to 20 cm, 3 = 1 to 5 cm.

[2] Oil spill sensitivity based on average rank of water depth, evergreen shrub cover, total live cover, and microrelief.

[3] Winter traffic sensitivity based average rank of all six factors.

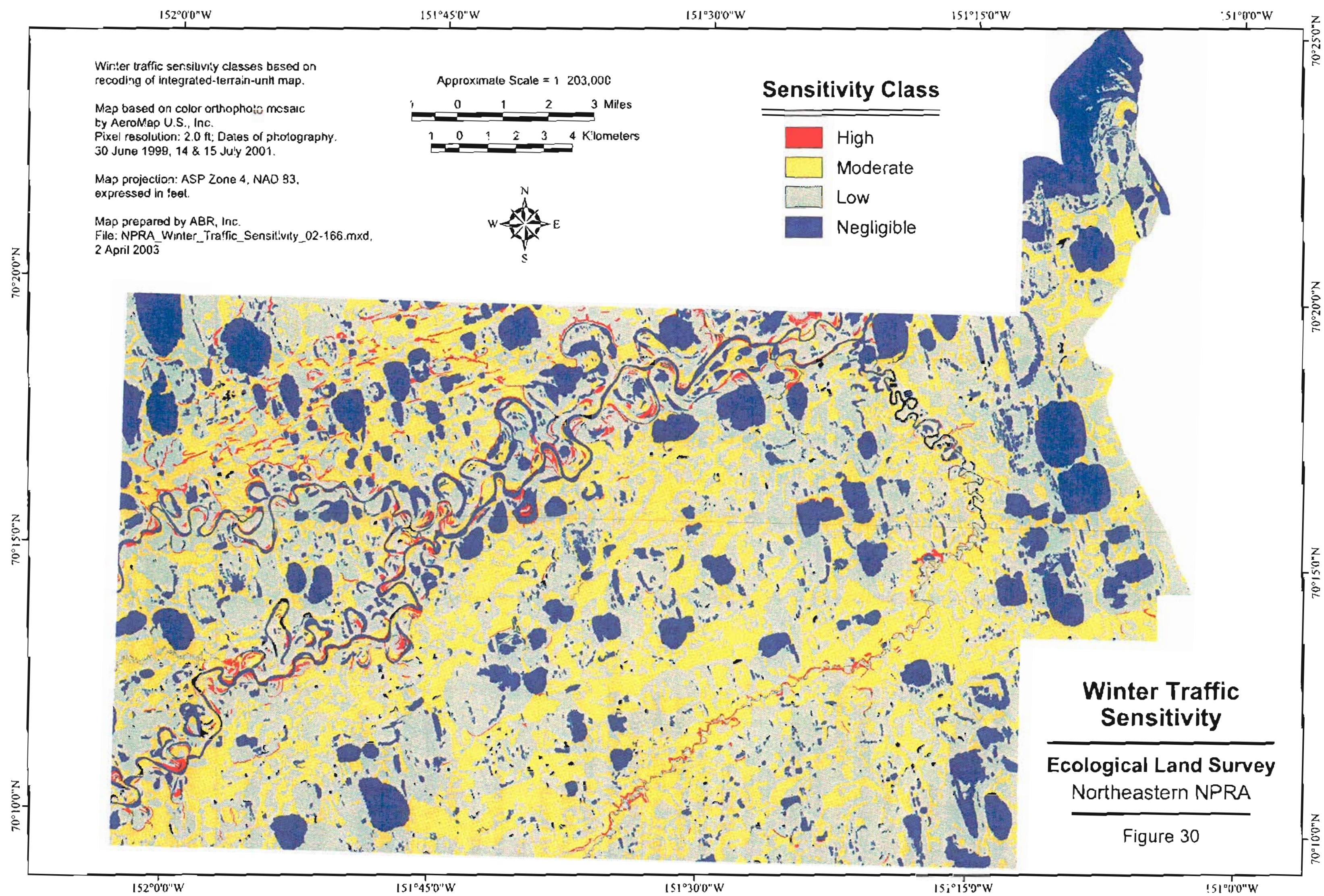

Figure 30. Map of generalized sensitivity of ecotypes to disturbance from winter off-road activity in the 2001 study area within the Northeastern Planning Area of the NPRA, 2002.

lowest sensitivity, as the frozen water at the surface is not susceptible to damage.

The results of this modeling approach are consistent with observations of damage associated with winter seismic exploration programs (Emers et al. 1995, Emers and Jorgenson 1997, Jorgenson et al. 2002a) and Rolligon trails (Jorgenson et al. 2002b). In wet ecotypes dominated by sedges, initial damage levels generally are low and recovery usually occurs within a few years. In Upland Moist Tussock Meadow, initial damage levels are typically intermediate, and recovery requires 5–10 years. The highest levels of initial damage and the slowest recovery rates tend to occur in drier ecotypes dominated by *Dryas*.

An important factor not incorporated in this model, however, is ice volume in the underlying permafrost. Soil ice volume can strongly affect the long-term responses of ecotypes to disturbance because severe disturbances on ice-rich soils can initiate thermokarst. Modeling of long-term responses, however, is complicated by the level of initial disturbance, rate of recovery, and thaw-settlement properties of the soil (Lawson 1986). With the type of information we currently have, development of a model incorporating such complexities is impractical. Thus the model focuses on the sensitivity to initial disturbance and is less applicable to long-term recovery.

SUMMARY AND CONCLUSION

This report presents the results of an ecological land survey that inventoried, classified, mapped, and evaluated the ecological characteristics of a portion of the northeastern National Petroleum Reserve–Alaska (NPRA) that is being considered for oil development. By analyzing the dynamic physical processes associated with the coastal, riverine, and coastal plain environments, and the abundance and distribution of its diverse ecological resources, this study contributed to efforts to mitigate potential ecological impacts of oil development in the NPRA.

Field surveys during August 2001 and 2002 collected information on the geomorphic, topographic, hydrologic, pedologic, and vegetative characteristics of ecosystems across the entire range of environmental gradients in the 69,582 ha (171,867 acre) study area. Data collected at 285 plots were used to analyze relationships among the various ecological components.

Individual ecological components (e.g., geomorphic unit, vegetation type) were determined using standard classification schemes for Alaska, but modified when necessary to differentiate unique characteristics in the study area. The hierarchical relationships among ecological components were used to derive a set of ecotypes (local-scale ecosystems) that best partition the variation in ecological characteristics across the entire range of aquatic and terrestrial environments.

Mapping was done at both local (1:10,000) and landscape (1:250,000) scales. At the local scale, mapping used an integrated terrain unit (ITU) approach that incorporated geomorphic units (surficial geology and waterbodies), surface forms (related to permafrost processes), and vegetation (Alaska Vegetation Classification Level IV). A total of 25 terrestrial geomorphic units, 19 aquatic geomorphic units (waterbodies), 24 surface forms, and 22 vegetation classes were identified for mapping and combined into 325 ITUs. These ITUs were combined into a reduced set of 42 ecotypes based on associations between geomorphic, surface form, and vegetative characteristics identified in the analysis of the field survey data. At the landscape level (1:250,000 scale), the study area and surrounding coastal plain were divided into 8 ecodistricts (e.g., Western Beaufort Coastal Plain, Central Beaufort Sea Coast) and 26 ecosubdistricts (e.g., Ikpikpuk Upper Coastal Plain, Fish Creek Coast) representing physiographic regions with a repeating assemblage of geomorphic units and vegetation.

Large differences were found between coastal plain, riverine, and coastal physiographic regions. The most common ecosystems on the coastal plain included Upland Moist Tussock Meadows (27.4% of area), Lowland Moist Sedge–Shrub Meadows (19.5%), Lowland Lakes (deep and shallow combined, 11.4%), Lowland Wet Sedge Meadows (9.4%), Lowland Basin Complex (8.8%), and Lacustrine Wet Sedge Meadows (1.4%). Floodplains were dominated by Riverine Lakes (3.7%), Riverine Wet Sedge Meadows (3.6%), Riverine Moist Sedge–Shrub Meadows (2.8%), Riverine Dune Complex (1.1%), and Riverine Moist Low Willow Shrub (0.9%), and Lower Perennial River (0.8%). Coastal areas were dominated by Coastal Moist Barrens (1.4%), Coastal Wet Sedge Meadows (0.5%), Nearshore Water (0.5%), and Coastal Lakes (0.4%). Overall map accuracy was 79% for the 41 ecotypes.

Multiple environmental factors contributed to the distribution of ecotypes and their associated plant species. Strong gradients were found for six physical and chemical characteristics examined (surface organic-horizon thickness, cumulative organic-horizon thickness, thaw depth, water depth, pH, and electrical conductivity), although the first four characteristics were highly correlated. Deeper thaw depths generally were associated with sandy soils found in early successional ecosystems (e.g., Riverine Moist Tall Willow Shrub, Riverine Moist Barrens) and well-drained soils on dunes and streambanks (Upland Dry Dryas Dwarf Shrub). Deeper thaw depth lowers groundwater levels, improves soil aeration, and provides a larger rooting environment for acquisition of nutrients by plants. Shrubs were usually abundant in these environments. Thicker organic accumulations typically were found in flat and low-lying areas that had wetter soils with shallower thaw depths (e.g., Riverine Wet Sedge Meadow, Lowland Wet Sedge Meadow), which typically have a greater percentage of graminoids. Many plant species and ecosystems, however, show broad ecological tolerances to these environmental characteristics, making the accurate classification and mapping of ecosystems more difficult.

On the coastal plain, lacustrine processes, basin drainage, and ice aggradation are the primary geomorphic processes that modify the landscape. Lowland Lakes form from a variety of processes including impoundment of water in low-lying basins, thermokarst of ice-rich sediments in old drained basins, and reconfiguration of small, shallow waterbodies by ice-aggradation and organic matter accumulation in the margins of old basins. Breaching and drainage of large deep lakes creates Lacustrine Moist Barrens depending on how much of the basin is drained. Lacustrine Wet Sedge and Moist Sedge–Shrub Meadows develop on the newly exposed areas and usually are dominated by *Carex aquatilis, Eriophorum angustifolium, Salix ovalifolia,* and *Dryas integrifolia*, depending on drainage conditions. Lowland Wet Sedge Meadows evolve from Lacustrine Wet Sedge Meadows in the basins after ice aggradation causes development of polygonal rims and raises the ground surface. The higher Old Alluvial Terrace, Alluvial–Marine Deposit, and Eolian Inactive Sand Deposit that surround the basins were stabilized during the early Holocene and have been modified only slightly by slope processes, organic accumulation, ice aggradation, and minor thermokarst. These older surfaces are dominated by Upland Moist Tussock Meadows on moderately well-drained upper slopes and Lowland Moist Sedge–Shrub Meadow on somewhat poorly drained lower slopes. Upland Dry Dryas Dwarf Shrub, while rare, occurs on dry, windswept ridges. The abundant ice wedges in these deposits are highly susceptible to thermokarst, forming areas of thermokarst pits and high-centered polygons, but the ice volumes are not sufficient to initiate thermokarst lakes.

In riverine areas along Fish and Judy creeks, fluvial processes predominate, although eolian and ice-aggradation processes also contribute to ecological development. Riverine Moist Barrens occur along the margins of active channels and along the fringe of the delta, are subject to frequent flooding and sedimentation and have scattered colonizers such as *Deschampsia caespitosa, Chrysanthemum bipinnatum,* and *Salix alaxensis.* Riverine Sedge Marshes and Riverine Grass Marshes occur in high-water channels and small ponds created by channel meandering and frequently are colonized by *Arctophila fulva* and *Carex aquatilis*. Riverine Moist Tall Willow Shrub occurs as narrow strips slightly higher on the floodplain, is subject to less flooding and sedimentation, has well-drained soils, and is dominated by *Salix alaxensis, Chrysanthemum bipinnatum, Bromus pumpellianus, Equisetum arvense*, and legumes. Riverine Moist Low Willow Shrub slowly replaces the tall willows as soils become seasonally saturated and *Salix lanata richardsonii, S. reticulata*, and *Equisetum variegatum* become dominant. Riverine Wet Sedge Meadows, which occur on still higher, inactive floodplains, are characterized by saturated soils with interbedded mineral and organic sediments resulting from occasional sedimentation and are dominated by *Carex aquatilis, Eriophorum* *angustifolium*, and *S. lanata richardsonii*. Lowland Wet Sedge Meadows occur on abandoned floodplains that represent the oldest portions of the landscape. This ecosystem type has saturated soils underlain by extremely ice-rich permafrost that has contributed to raising of the floodplain surface and is dominated by plants similar to those on Riverine Wet Sedge Meadows, but includes more *Dryas integrifolia* and other dwarf shrubs. At this stage, ice contents are sufficiently high that permafrost becomes susceptible to thermokarst and subsequent development of deep Riverine Lakes. Finally, eolian sand is frequently deposited in large dunes downwind of large, barren sandbars contributing to the development of Upland Dry Barrens, Upland Dry Tall Willow Shrub, Upland Moist Low Willow Shrub, and Upland Dry Dryas Dwarf Shrub.

Knowledge of the patterns and processes of ecological development on the landscape form the basis for evaluating the capabilities of the land to support wildlife and for evaluating the potential impacts of land management activities. Accordingly, the ITU map and simplified conceptual model rules were used to derive wildlife habitats, predict flood distribution and frequency, and differentiate the sensitivity of ecosystems to oil spills and winter off-road traffic. For wildlife analyses, the ITUs were combined into 27 habitat classes that emphasized habitat characteristics important to waterbirds. The terrain unit map and limited flooding information were used to develop a map of flood distribution regimes associated with both river flooding and impoundment of snowmelt. The sensitivity of the terrain to oil spills and winter traffic was based on the water depths, evergreen shrub cover, total vegetation cover, organic horizon thickness, microrelief, and slope position associated with the various ecotypes.

Overall, there are three main benefits from this ecological land survey approach. First, it analyzes landscapes as ecological systems with functionally related parts and recognizes the importance that geomorphic and hydrologic processes have on disturbance regimes, the flow of energy and material, and ecological development. The hierarchical approach, which incorporates numerous ecological components into ecotypes with co-varying properties, allows users to partition the variability of a wide range of ecological characteristics. Second, the mapping of ITUs based on these relationships provides a spatial database structure that preserves the diversity of environmental characteristics across the landscape. Third, this linkage of ecological characteristics within a spatial database improves our ability to predict the response of ecosystems to human impacts and facilitates the production of thematic maps for specialized engineering and environmental applications and analyses. Some of the diverse uses of the ITU map included development of wildlife habitat maps emphasizing characteristics important to waterbirds, analysis of fish use, analysis of flooding regimes, and sensitivity of ecosystems to oil spills and winter traffic. Together, this systematic approach to analyzing and aggregating ecological characteristics facilitates our efforts to understand and manage complicated ecological systems.

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Appendix Table 1. Comparison of hierarchical systems for differentiating ecosystems at various scales.

Ecological Units					Scale		
Bailey (1997), Forman (1997)	Delcourt and Delcourt (1988)	ECOMAP (1993)	Canadian (Wiken 1981)	Klijn and Udo de Haes (1994)	Typical Map Scale	Typical Areal Extent	Differentiating Characteristics Used In This Study
Region (Forman)	Continent	Domain		Ecozone	1: 20,000,000	10^{12} m^2 1,000,000 km^2	Continents with related climate.
Or Ecoregion (Bailey)		Division		Ecoprovince	1: 10,000,000	10^{11} m^2 100,000 km^2	Climatic subzones with broad vegetation regions.
(macro-scale)	Macroregion	Province	Ecoregion	Ecoregion	1:5,000,000	10^{10} m^2 10,000 km^2	Climate, a geographic group of landscape mosaics (e.g., Interior Highlands).
Landscape (Forman) or Landscape	Mesoregion	Section	Ecodistrict	Ecodistrict	1:1,000,000	10^9 m^2 1,000 km^2 100,000 ha	Major landforms or Physiographic units within a climatic region (e.g. Delta Highlands).
Mosaic (Bailey) (meso-scale)	Microregion	Subsection		(Eco-subdistricts by ABR)	1:250,000	10^8 m^2 100 km^2 10,000 ha	Physiographic units at larger scale based on associations of geomorphic units (e.g., grouping of weathered bedrock on crests, residual soil on upper slopes, retransported lowland deposits at toe of slopes, and headwater streams in drainages).
		Landtype Association	Ecosection	Ecosection	1:100,000	10^7 m^2 10 km^2 100 ha	Geomorphic units with homogeneous lithology, mode of deposition, depth, texture, and water properties. Similar concepts include soil catena, toposequence, and soil association (e.g., bedrock or floodplain cover deposit).
Local Eco-system (Forman) or Site (Bailey) (micro-scale)	Macrosite	Landtype	Ecosite	Ecoseries	1: 25,000–50,000	10^4-10^6 1 km^2 10 - 100 ha	A subdivision of a geomorphic unit that has a uniform topoclimate based on elevation, aspect, slope position, and soil drainage. Similar concepts include soil series, homogeneous abiotic site conditions, climax vegetation, assemblages of vegetation types on soil series (e.g., Ester soil series on north slopes of bedrock soils).
	Mesosite	Landtype Phase	Ecoelement	Ecotype (Ecotope)	1: 5,000–25,000	10^2-10^4 0.1-10 ha	Vegetation type or successional stage (e.g., Balsam poplar on floodplain cover deposit).
	Microsite	Site		Ecoelement	1: 1000– 5,000	10^{-2} - 10^2 <0.1 ha	Uniform microsites within stand (e.g., polygon rim vs. center).

Appendix Table 2. Data file listing of ecological components of ground reference plots in the Northeastern Planning Area of the NPRA, 2002.

Site No.	Date	Lat (dd83)	Long (dd83)	Physiog	Slope (deg)	Aspect (deg)	Geom Unit	Micro Topo	Microrelf (cm)	Soil Class	Veg Class	Ecotype	Plant Association	Most Abundant Plant Species
C3.1/E3.1	17-Aug-02	70.2737	-151.6193	U	0	0	Mp	Phl	100		Hgmt	Upland Moist Tussock Meadow	erivag-dryint	erivag-dryint-salpla-salret-arcrub-betnan-castet-arcrub
C3.2	17-Aug-02	70.2747	-151.6173	L	0	0	Mp	Phl	70		Slow	Lowland Moist Low Willow Shrub	salpul-caraqu	nd
E3.3	17-Aug-02	70.2749	-151.6172	L	0	0	Mp	Phl	70		Slow	Lowland Moist Sedge–Shrub Meadow	salpul-caraqu	nd
C5 1	18-Aug-02	70.1456	-151.9354	P	0	0	Ltnc	N	10		Slow	Lacustrine Moist Low Willow Shrub	salpul-caraqu	moss-sallan-caraqu-eriang-salpla-salret
C5.2	18-Aug-02	70.1453	-151.9315	P	0	0	Ltnc	Mi	35		Hgmss	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-caraqu-eriang-erisch-sallan-salpla
C5.3	18-Aug-02	70.1451	-151.9302	P	0	0	Ltnc	Mi	45		Hgmss	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	nd
C5.4	18-Aug-02	70.1464	-151.9256	P	0	0	Ltnm	Pd	20		Hgmss	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-dryint-eriang-caraqu-arcrub-equvar-sallan-salret
C6.1	19-Aug-02	70.2041	-151.6715	P	0	0	Ltnc	Pd	20		Slow	Lacustrine Moist Low Willow Shrub	salpul-caraqu	moss-salpla-lichen-betnan-caraqu-eriang
C6.2	19-Aug-02	70.2040	-151.6650	P	0	0	Ltnm	Pd	20		Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	moss-caraqu-eriang-carex-sallan-salpla
C6.3	19-Aug-02	70.2045	-151.6597	L	0	0	Ltim	Pll	30		Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	caraqu-eriang-carcho-carsax-salpla-moss
C6.8	20-Aug-02	70.2047	-151.6532	U	0	0	Mp	Tm	50		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-moss-leddec-lichen-betnan-salpla-vacvit
C7.1	20-Aug-02	70.3015	-151.6974	U	0	0	Esi	Es	20		Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	dryint-castet-moss-lichen-salphl-carbig-hiealp
C7.3	20-Aug-02	70.2979	151.6994	L	0	0	Ltim	Pll	10		Nd	Lowland Wet Sedge Meadow	eriang-salpul-sphag	nd
C8.1	18-Aug-02	70.2005	151.6407	L	0	0	Ltim	N	10		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	nd
C8.2	18-Aug-02	70.2004	151.6407	L	0	0	Ltim	N	10		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	nd
C9.1	21-Aug-02	70.2535	151.0935	U	0	0	Ltic	Tm	50		Hgmt	Upland Moist Tussock Meadow	na	nd
C9.2	21-Aug-02	70.2568	151.0895	L	0	0	Ltim	Pd	20		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	nd
E4.1	16-Aug-02	70.2893	-151.5127	U	0	0	Mp	Phl	30		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	salphl-erivag-salpla-moss-leddec-vacvit
G1.01	05-Aug-02	70.3674	-151.1377	C	0	0	Mta	N	10		Hgwhs	Coastal Wet Sedge Meadow	carsub-pucphr	carsub-caldes-salova-carcon-cocoff-puclan
G1.02	05-Aug-02	70.3676	-151.1372	C	0	0	Mta	N	10		Sdwgh	Coastal Moist Willow Dwarf Shrub	salova-carsub	salova-carsub-caldes-lichen-moss
G1.03	11-Aug-02	70.3747	-151.1362	C	0	0	Mti	N	5		Hgwhs	Coastal Wet Sedge Meadow	carsub-pucphr	carsub-pucphr-stehum
G1.04	11-Aug-02	70.3727	-151.1348	C	0	0	Mti	Phl	10		Sdwgh	Coastal Moist Willow Dwarf Shrub	salova-carsub	salova-caraqu-mosses
G1.05	11-Aug-02	70.3707	-151.1341	C	0	0	Mti	N	10		Hgwhs	Coastal Wet Sedge Meadow	carsub-pucphr	carsub-elyare-pucphr-salova-carura
G1.06	11-Aug-02	70.3672	-151.1433	C	0	0	Mti	N	5		Bpv	Coastal Moist Barrens	elymol-stehum	elyare-stehum-sedros
G1.07	11-Aug-02	70.3651	-151.1478	C	0	0	Welt	W	0		Hafm	Coastal Herb Marsh	hipvul	hipvul
G1.08	11-Aug-02	70.3644	-151.1398	C	0	0	Mti	N	5		Hgwhs	Coastal Wet Sedge Meadow	carsub-pucphr	pucphr-carsub-carura-salova
G11.01	11-Aug-01	70.2630	-151.3482	U	15	0	Ltic	Phl	30		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-betnan-castet-vacvit-salpul-dicra
G14.01	04-Aug-01	70.3207	-151.7323	U	0	0	Esi	Fh	20	Typic Haploturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	castet-clado-dryint-hiealp-lichc-salphl
G14.02	04-Aug-01	70.3189	-151.7503	U	0	0	Esi	Fh	20	Typic Psammoturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	castet-salphl-leddec-dicra-dryint-rhyrug
G15.01	12-Aug-01	70.2673	-151.8253	U	0	0	Llip	Phh	150	Aquic Haploturbel	Sddt	Upland Dry Dryas Dwarf Shrub	na	dryint-castet-salphl-arcalp-vaculi-arclat
G15.02	12-Aug-01	70.2886	-151.8392	U	nd	nd	Esi	Pd	nd		Nd	Upland Moist Tussock Meadow	na	nd
G22.01	05-Aug-02	70.3196	-151.4549	R	0	0	Fdoi	Pd	10		Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	moss-caraqu-eriang-pedsud
G22.02	05-Aug-02	70.3232	-151.4530	L	0	0	Fdob	Pllh	35		Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	moss-caraqu-carbig-dryint-eriang-carcho-sallan
G22.03	05-Aug-02	70.3262	-151.4614	L	0	0	Fdob	Pllh	45		Hgwfs	Lowland Sedge Marsh	caraqu	caraqu-moss-carcho
G3.01	10-Aug-02	70.3196	-152.2502	R	0	0	Wrln	W	0		W	Lower Perennial River	Water	water
G3.02	10-Aug-02	70.3195	-152.2498	R	0	0	Fmraf	N	20		Bpv	Riverine Moist Barrens	descae-salala	desbre-equarv-junarc-juncas-moss
G3.03	10-Aug-02	70.3195	-152.2488	R	0	0	Fmoa	N	60		Sddt	Riverine Dry Dryas Dwarf Shrub	dryint-oxydef	salpol-salala-junarc-fesrub-
G3.04	10-Aug-02	70.3190	-152.2485	R	0	0	Fmoi	N	10		Sddt	Riverine Dry Dryas Dwarf Shrub	dryint-oxydef	dryint-equvar-moss-salret-arcrub-oxydef-caraqu
G3.05	10-Aug-02	70.3189	-152.2459	R	0	0	Fmoi	N	15		Sddt	Riverine Dry Dryas Dwarf Shrub	dryint-oxydef	dryint-moss-lichen-salret-equvar-arcrub-caraqu-carsci
G3.06	10-Aug-02	70.3175	-152.2388	U	0	0	Esi	N	8		Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-lichen-artbor-oxyarc-carrup-sllaca
G3.07	10-Aug-02	70.3162	-152.2347	R	0	0	Fmoi	Pd	10		Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-caraqu-equvar-castet-eriang-salret-arcrub
G3.08	10-Aug-02	70.3086	-152.2397	R	0	0	Fmrif	N	0		Hgwfs	Riverine Sedge Marsh	caraqu	moss-caraqu-calpal
G5.01	11-Aug-02	70.1504	-151.6561	R	0	0	Wrhl	W	0		W	Headwater Stream	Water	potam-hipvul-arcful-caraqu
G5.02	11-Aug-02	70.1509	-151.6601	R	0	0	Fmoi	N	10		Slcw	Riverine Moist Low Willow Shrub	salpul-sallan-arclat	salpla-moss-caraqu-arclat-
G5.03	11-Aug-02	70.1529	-151.6582	P	0	0	Ltnm	N	5		Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	caraqu-eriang-carsax-juntri-pedsud
G5.04	11-Aug-02	70.1534	-151.6531	P	0	0	Ltnm	Ms	20		Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	caraqu-eriang-salpla-moss
G5.05	11-Aug-02	70.1596	-151.6511	U	5	260	Mp	Mu	35		Slobe	Upland Moist Low Willow Shrub	salgla-arcrub	moss-betnan-arcrub-dryint-lichen-salret-vacvit-salpla
G5.06	11-Aug-02	70.1594	-151.6550	P	0	0	Ltnm	Ms	20		Hgwfs	Lacustrine Sedge Marsh	caraqu	eriang-moss-erirus-carcho-caraqu-carmem-pedsud
G5.07	11-Aug-02	70.1604	-151.6625	U	0	0	Ltic	Phl	15		Hgmt	Upland Moist Tussock Meadow	erivag-dryint	moss-dryint-erivag-carbig-lichen-castet-salret
G5.08	11-Aug-02	70.1629	-151.6746	L	0	0	Ltim	Pll	30		Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-dryint-eriang-sallan-caraqu-pyrgra-salret
G5.09	11-Aug-02	70.1642	-151.6701	L	0	0	Ltim	N	15		Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-dryint-caraqu-carbig-salret-arcrub
G5.10	11-Aug-02	70.1644	-151.6706	U	3	160	Mp	Mu	25		Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	moss-dryint-castet-lichen-arclat-carbig-salret
G6.12	10-Aug-01	70.2642	-152.0102	R	0	0	Fmoi	Pll	30	Typic Aquorthel	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-caraqu-dryint-drepa-eriang
G6.13	10-Aug-01	70.2643	-152.0124	U	18	120	Cs	Mg	20	Typic Haplorthel	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-salgla-salret-oxydef-arcrub-castet
G6.14	10-Aug-01	70.2637	-152.0150	U	14	180	Cl	Mu	50	nd	Bpv	Upland Dry Barrens	salala-chrbip	salala-salgla-chrbip-anenar
G6.01	06-Aug-02	70.2798	-151.6055	R	2	290	Fmoa	N	10		Stow	Riverine Moist Tall Willow Shrub	salala-chrbip	salala-equarv-mose-caacau-chrbip-oxydef-oxyvis
G6.02	06-Aug-02	70.2786	-151.6064	R	0	0	Fmoa	N	10		Slow	Riverine Moist Low Willow Shrub	sallan-equvar	moss-sallan-arcrub-equarv-salala-equsci-equvar-fesrub-salret
G6.03	06-Aug-02	nd	nd	R	0	0	Fmoi	N	3		Slow	Riverine Moist Low Willow Shrub	salpul-sallan-arclat	moss-salpla-caraqu-equsci-petfri
G6.04	06-Aug-02	70.2937	-151.6202	R	0	0	Fmoa	Mu	30		Stow	Riverine Moist Tall Willow Shrub	salala-chrbip	salala-(chrbip-equarv-fesrub-poa-poahar)
G6.05	06-Aug-02	70.2940	-151.6178	R	0	0	Fmraf	Mu	15		Bpv	Riverine Moist Barrens	descae-salala	descae-fesrub-agrop-equarv
G6.06	06-Aug-02	70.2858	-151.6074	R	0	0	Wlsir	W	0		Hgwfg	Riverine Grass Marsh	arcful	arcful-moss
G6.07	06-Aug-02	70.2894	-151.5963	R	0	0	Wlsir	W	0		Hgwfg	Riverine Grass Marsh	arcful	arcful
G6.08	06-Aug-02	70.2932	-151.5922	R	0	0	Fmrif	N	0		Hgwfs	Riverine Sedge Marsh	caraqu	caraqu-eriang-erisch-ranpal-calpal
G6.09	06-Aug-02	70.2941	-151.5972	R	0	0	Wlslt	N	0		Hgwfg	Riverine Grass Marsh	arcful	arcful-potfri-hipvul
T1.01	03-Aug-01	70.2835	-151.2209	L	0	0	Flo	Pll	25	Fluvaquentic Hemistel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	caraqu-enang-aulac-carbig-drepa-dryint-erirus-salret-vacvit
T1.02	03-Aug-01	70.2861	-151.2279	U	0	0	Flo	Pm	40	Fluvaquentic Hemistel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-aultur-carbig-castet-tomnit-betnan-salix
T1.03	03-Aug-01	70.2886	-151.2270	L	0	0	Ltim	Pll	42	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	eriang-aultur-caraqu-scosco-carbig-carsax
T1.03b	10-Aug-01	70.2889	-151.2282	L	0	0	Ltim	Plh	25	Aquic Haploturbel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	nd
T1.04	03-Aug-01	70.2898	-151.2308	U	0	0	Ltic	Phh	110	Typic Histoturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	vacvit-castet-drepa-salpul-betnan-carbig-leddec
T1.04b	10-Aug-01	70.2914	-151.2246	L	0	0	Ltim	Pd	5	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-enang
T1.05	03-Aug-01	70.2921	-151.2174	L	0	0	Ltim	Pd	15	Fluvaquentic Hemistel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	eriang-moss-aulpal-caraqu-caratr-dicra-scosco
T1.06	03-Aug-01	70.2930	-151.2169	P	0	0	Wlslt	W	0	nd	W	Lowland Lake	Water	water

Appendix Table 2. (Continued).

Site No.	Date	Lat (dd83)	Long (dd83)	Physiog	Slope (deg)	Aspect (deg)	Geom Unit	Micro Topo	Microrelf (cm)	Soil Class	Veg Class	Ecotype	Plant Association	Most Abundant Plant Species
T10.01	06-Aug-01	70.1676	-151.5054	R	0	0	Wrhl	W	0	nd	W	Headwater Stream	Water	water
T10.02	06-Aug-01	70.1675	-151.5054	R	4	62	Fhl	N	5	Typic Psammorthel	Slcw	Riverine Moist Low Willow Shrub	salpul-sallan-arclat	salgla-sallan-petfri-arclat-hylspl-poagla-salpul
T10.03	06-Aug-01	70.1677	-151.5082	R	0	0	Fhl	N	20	Typic Aquiturbel	Hgmsa	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	hylspl-arclat-rhyrug-carbig-salgla-salpul-tomnit
T10.04	06-Aug-01	70.1683	-151.5134	U	2	120	Mp	N	20	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-hylspl-aultur-dicra-salpul-rhyrug-salphi-vacvit
T10.05	06-Aug-01	70.1695	-151.5236	L	0	0	Ltim	Pll	25	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carcho-carsax-caraqu-erirus-salpul
T10.06	06-Aug-01	70.1682	-151.5261	L	2	230	Ltim	Pd	20	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carsax-erirus-limrev-salpul-caraqu
T10.07	06-Aug-01	70.1679	-151.5275	P	0	0	Wlslt	W	0	nd	W	Lowland Lake	Water	water
T10.08	06-Aug-01	70.1887	-151.5321	U	1.5	120	Ltic	N	20	Hemistel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-salpul-dicra-hylspl-vacvit-leddec-rhyrug-betnan-castet
T10.09	06-Aug-01	70.1900	-151.5383	U	4	160	Mp	N	30	Hemistel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	betnan-vacvit-leddec-erivag-dicra-castet-salphi
T10.10	06-Aug-01	70.1899	-151.5333	L	0	0	Ltim	Pd	10	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carsax-erirus-caraqu-carcho-carrot
T11.01	03-Aug-01	70.2613	-151.3133	L	0	0	Ltic	Pll	25	Fluvaquentic Hemistel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	eriang-caraqu-carhol-erirus-aulpal-salix-scosco
T11.01b	11-Aug-01	70.2625	-151.3141	L	nd	nd	Ltim	Pd	nd	Typic Histoturbel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	nd
T11.02	03-Aug-01	70.2643	-151.3167	U	0	0	Mp	Pm	40	Fluvaquentic Hemistel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-vacvit-betnan-dicapa-salpul-leddec
T11.02b	11-Aug-01	70.2660	-151.3193	L	nd	nd	Ltim	Pd	nd	Typic Fibristel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	caraqu-salret-dryint-tomnit
T11.03	03-Aug-01	70.2678	-151.3210	L	0	0	Ltic	Plh	45	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	aultur-dicang-dicelo-salpul-erivag-eriang-sphag
T11.03b	03-Aug-01	70.2694	-151.3131	L	0	0	Ltim	Pd	15	Typic Histoturbel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	scosco-caraqu-eriang-erirus-carmem-carcho
T11.04	03-Aug-01	70.2699	-151.3106	L	0	0	Ltim	Pll	25	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	drebre-eriang-salpul-caraqu-dicelo-hylspl-oncwah-erirus-sallan
T11.05	03-Aug-01	70.2718	-151.3043	L	0	0	Ltim	Plhh	60	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	oncwah-erirus-eriang-caraqu-betnan-aultur-sphag
T11.06	03-Aug-01	70.2718	-151.2967	U	1	235	Ltic	Phl	50	Typic Histoturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	aulpal-betnan-erivag-vacvit-leddec-carbig-hylspl
T12.01	06-Aug-01	70.1963	-151.6890	U	0	0	Mp	N	18	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	dicra-erivag-salpul-vacvit-leddec-
T12.02	06-Aug-01	70.1969	-151.6895	U	12	320	Mp	Fh	37	Aquic Haploturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	hylspl-castet-salrot-dryint-salpul-betnan-salret
T12.03	06-Aug-01	70.1972	-151.6898	P	0	0	Ltnm	Pd	30	Typic Psammoturbel	Hgmss	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-sallan-salret-caraqu-dryint-pticil
T12.04	06-Aug-01	70.2019	-151.7006	L	0	0	Ltic	Pm	45-150	Typic Aquorthel	Slow	Lowland Moist Low Willow Shrub	salpul-caraqu	salpul-aultur-dicra-hylspl-salret-sanunc-pyrgra-salgla-sauang
T12.05	06-Aug-01	70.2020	-151.7082	P	0	0	Ltnc	Pd	35	Typic Historthel	Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	scosco-caraqu-eriang-carcho-erirus
T12.06	06-Aug-01	70.2022	-151.7130	P	0	0	Wlsit	W	2	nd	Hgwfs	Lacustrine Sedge Marsh	caraqu	caraqu-eriang-ranpal
T12.07	06-Aug-01	70.2073	-151.7330	P	0	0	Ltnm	N	24	Psammentic Aquiturbel	Hgmsa	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-dryint-caraqu-sallan-salret
T12.08	06-Aug-01	70.2049	-151.7376	L	0	0	Ltim	Pm	40	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-erirus-scosco-eriang-carcho-carrot
T12.09	06-Aug-01	70.2040	-151.7424	U	0	0	Ltic	Phh	70	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	betnan-vaculi-erivag-leddec-salpul
T12.10	06-Aug-01	70.2038	-151.7667	U	nd	nd	Mp	Phl	>300	Aquic Haploturbel	Nd	Upland Moist Tussock Meadow	na	nd
T13.01	08-Aug-01	70.2362	-151.9401	U	0	0	Mp	Phl	20	Fluvaquentic Sapristel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-leddec-salpul-aultur-dicra-rhyrug-salphi-vacvit
T13.02	08-Aug-01	70.2363	-151.9397	P	0	0	Wldit	W	0	nd	W	Lowland Lake	Water	water
T13.03	08-Aug-01	70.2350	-151.9325	P	0	0	Ltnm	N	10	Typic Aquiturbel	Hgmss	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-caraqu-dryint-eriang-hylspl-salret
T13.04	08-Aug-01	70.2341	-151.9310	P	0	0	Ltnm	N	5	Psammentic Aquorthel	Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	caraqu-eriang-limrev-scosco-carsste-
T13.05	08-Aug-01	70.2343	-151.9561	L	0	0	Ltim	Ms	15	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	scosco-eriang-erirus-limrev
T13.06	08-Aug-01	70.2313	-151.9687	U	0	0	Ltic	Pm	15	Typic Histoturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-leddec-hylspl-rhyrug-vacvit-betnan-castet-salphi
T13.07	08-Aug-01	70.2314	-151.9689	L	0	0	Ltic	Pm	20	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	scosco-caraqu-carcho-carhol-eriang-limrev
T13.08	08-Aug-01	70.2290	-151.9802	U	0	0	Mp	Phl	40	Typic Histoturbel	Hgmt	Upland Moist Tussock Meadow	na	nd
T14.01	04-Aug-01	70.3172	-151.7041	L	1	90	Ltic	Pm	20	Fibristel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-carbig-lichens-salpul-erivag-betnan-leddec
T14.02	04-Aug-01	70.3176	-151.7079	U	5	90	Ltip	Phh	60	Aquic Haploturbel	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-arclat-tomnit-salgla-dicra
T14.03	04-Aug-01	70.3175	-151.7101	L	0	0	Ltim	Pd	5	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-eriang-polyt-scosco
T14.04	04-Aug-01	70.3184	-151.7160	L	0	0	Ltim	Pll	30	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carsax-erirus-scosco-caraqu
T14.05	04-Aug-01	70.3186	-151.7186	P	0	0	Wldit	W	0	nd	Hgwfg	Lacustrine Grass Marsh	arcful	arcful
T14.06	04-Aug-01	70.3208	-151.7205	U	0	0	Esi	Tm	40	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	dicra-erivag-vacvit-aultur-hylspl-leddec
T15.01	04-Aug-01	70.3049	-151.8647	R	0	0	Fhl	Tb	50	Psammentic Aquorthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	eriang-cinlat-ditfle-caraqu
T15.02	04-Aug-01	70.3038	-151.8662	U	0	0	Ltic	Phl	12	Psammentic Aquorthel	Hgmt	Upland Moist Tussock Meadow	erivag-dryint	erivag-rhyrug-carbig-dicra-dryint-salret-salarc
T15.03	04-Aug-01	70.3011	-151.8646	U	0	0	Esi	Phl	17	Aquic Haploturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	castet-salrot-dicra-erivag-carbig-eriang-leddec-vacvit
T15.04	04-Aug-01	70.3014	-151.8621	U	0	0	Esi	Phl	11	Psammentic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	dicra-erivag-vacvit-leddec-polyt-carbig-salphl
T15.05	04-Aug-01	70.3007	-151.8610	L	0	0	Ltim	Pllh	17	Terric Fibristel	Slow	Lowland Moist Low Willow Shrub	salpul-caraqu	salpul-caraqu-carsste-carsax-eriang-aulpal
T15.06	04-Aug-01	70.3007	-151.8587	P	0	0	Wlslt	W	0	nd	W	Lowland Lake	Water	water
T15.07	04-Aug-01	70.2994	-151.8564	U	0	0	Ltic	Phl	10	Typic Aquorthel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	dicra-erivag-carbig-cladi-salpul-vacvit
T15.08	04-Aug-01	70.2997	-151.8508	L	0	0	Ltim	Pd	9	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-scosco-eriang-erirus
T15.09	08-Aug-01	70.2990	-151.8565	U	nd	nd	Ltic	Phl	nd		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	vacvit-dicra-aulpal-leddec-salpul-betnan-carbig-dryint-castet-salphl
T15.09a	13-Aug-01	70.2990	-151.8550	U	nd	nd	Ltic	Phl	nd		Nd	Upland Moist Tussock Meadow	na	nd
T15.11	08-Aug-01	70.2956	-151.8582	U	3	78	Esi	Phl	25	Typic Histoturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-salphi-dicra-leddec-pyrgra-castet-vacvit
T15.12	08-Aug-01	70.2952	-151.8600	U	5	78	Esi	Fh	20	Typic Psammoturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	salphi-castet-dryint-pyrgra-carbig-hiealp-vacvit
T16.01	04-Aug-01	70.3134	-151.9617	U	0	0	Ltic	Phl	10	Typic Psammorthel	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	lichen-dryint-castet-salret-diecap-dicelo-plesch
T16.02	04-Aug-01	70.3112	-151.9593	L	0	0	Ltim	Ms	25	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	eriang-aulpal-sphfim-salpul-caraqu-castet-scosco
T16.03	04-Aug-01	70.3094	-151.9608	U	0	0	Ltic	Phh	12	Sapristel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	vacvit-leddec-carbig-erivag-sphag-dicelo-betnan-rubcha
T16.04	*04-Aug-01*	*70.3083*	*-151.9626*	*L*	*0*	*0*	*Ltim*	*Pll*	*20*	*Typic Historthel*	*Hgwst*	*Lowland Wet Sedge Meadow*	*eriang-salpul-sphag*	*eriang-erirus-aulso-betnan-caraqu*
T16.05	04-Aug-01	70.3074	-151.9644	U	0	0	Esi	Phl	15	Psammentic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	vacvit-dicra-drepa-erivag-carbig-castet
T16.06	04-Aug-01	70.3040	-151.9651	P	0	0	Ltnu	N	8	Fibristel	Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	caraqu-erirus-eriang-carsax-compal
T16.07	04-Aug-01	70.3054	-151.9649	P	0	0	Wlsl	W	0	nd	W	Lowland Lake	Water	water
T16.08	04-Aug-01	nd	nd	L	nd	nd	Esi	Es	50	nd	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	dryint-arclat-pyrgra-salret-polem
T17.01	09-Aug-01	70.2572	-151.7454	R	3	265	Fmraf	N	5	Aquic Cryofluvent	Bpv	Riverine Moist Barrens	deecae-salala	chrbip-equarv-astalb-stehum
T17.02	09-Aug-01	70.2584	-151.7457	R	0	0	Fmoa	N	3	Typic Cryofluvent	Stow	Riverine Moist Tall Willow Shrub	salala-chrbip	salala-astalb-equarv-chrbip-festub
T17.03	09-Aug-01	70.2585	-151.7446	R	2	70	Fmoa	N	10	Typic Aquorthel	Slow	Riverine Moist Low Willow Shrub	sallan-equvar	tomnit-arcalp-salgla-sallan-salret-dryint-equisetum
T17.04	09-Aug-01	70.2581	-151.7430	R	0	0	Fmoi	N	5	Typic Historthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	drebre-limosa-caraqu-eriang-mestri
T17.05	09-Aug-01	70.2590	-151.7407	L	0	0	Esi	N	10	Psammentic Aquorthel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-dryint-salret-sallan-caraqu-carbig
T17.06	09-Aug-01	70.2593	-151.7353	U	2.5	230	Esi	Phl	20	Typic Haplorthel	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-castet-salgla-rhyrug-salret
T17.07	09-Aug-01	70.2594	-151.7372	U	0	0	Esi	Fr	20	Typic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-oxyvis-kobre-thamn-cetniv-lichc
T17.08	09-Aug-01	70.2613	-151.7317	R	0	0	Wlsr	W	0	nd	Hgwfg	Riverine Grass Marsh	arcful	arcful
T18.01	10-Aug-01	70.2692	-151.2468	R	0	0	Wrin	W	0	nd	W	Lower Perennial River	Water	water

Appendix Table 2. (Continued).

Site No.	Date	Lat (dd83)	Long (dd83)	Physiog	Slope (deg)	Aspect (deg)	Geom Unit	Micro Topo	Microrelief (cm)	Soil Class	Veg Class	Ecotype	Plant Association	Most Abundant Plant Species
T18.02	10-Aug-01	70.2691	-151.2478	R	0	0	Fmoi	Phh	80	Aquic Haplorthel	Slow	Riverine Moist Low Willow Shrub	salpul-sallan-arclat	salpul-sallan-salgla-salalp-petfri-polbis-pyrgra
T18.03	10-Aug-01	70.2687	-151.2503	R	0	0	Fmoi	Pll	20	Fluvaquentic Fibristel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	caraqu-eriang-salpul-aultur-erirus-sphag
T18.04	10-Aug-01	70.2693	-151.2509	P	0	0	Wlsit	W	0	nd	W	Lowland Lake	Water	water
T18.05	10-Aug-01	70.2682	-151.2533	U	19	50	Mp	Fr	25	Typic Haploturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	castet-dryint-hylspl-tomnit-cetcuc-salret-salgla
T18.06	10-Aug-01	70.2679	-151.2544	U	0	70	Mp	Phl	15	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-dryint	erivag-salret-salpul-tomnit-aulpal-carbig-dryint-pyrgra-vacvit
T18.07	10-Aug-01	70.2663	-151.2569	L	0	0	Mp	Pll	50	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carsax-erirus-aultur-camste-caraqu-carmem-sphag
T18.08	10-Aug-01	70.2636	-151.2712	L	0	0	Ltim	Pll	30	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carsax-aulpal-caraqu-caratr-erirus
T19.01	05-Aug-02	70.3254	-151.1526	U	0	0	Ltic	Phl	0		Hgmt	Upland Moist Tussock Meadow	erivag-dryint	moss-erivag-dryint-lichen-carbig-salpla-salret-pyrgra
T19.02	05-Aug-02	70.3264	-151.1574	L	0	0	Ltim	Pll	10		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-moss-carsax-caraqu-carvag-caratrf
T19.03	05-Aug-02	70.3239	-151.1615	L	0	0	Ltim	Pll	10		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-moss-carsax-caraqu-carmem-carrot-pedsud
T19.04	05-Aug-02	70.3224	-151.1590	L	0	0	Ltic	Plhh	30		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	moss-eriang-carcho-carex-carrar-carsax-erirus
T19.05	05-Aug-02	70.3215	-151.1476	L	0	0	Ltim	Pll	10		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	moss-eriang-caraqu-carsax-erirus-pedsud
T19.06	05-Aug-02	70.3197	-151.1628	U	0	0	Fto	Tm	20		Hgmt	Upland Moist Tussock Meadow	erivag-dryint	moss-lichen-vacvit-erivag-dryint-salpla-castet-leddec-sauang
T19.07	05-Aug-02	70.3178	-151.1630	U	0	0	Fto	Phl	8		Hgmt	Upland Moist Tussock Meadow	erivag-dryint	moss-lichen-castet-erivag-vacvit-betnan-vaculi
T19.08	05-Aug-02	70.3160	-151.1556	L	0	0	Ltim	Dt	2		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-eriang
T19.09	05-Aug-02	70.3179	-151.1556	P	0	0	Wlsit	W	0		W	Lowland Lake	Water	arcful
T2.01	08-Aug-01	70.3272	-151.2648	P	0	0	Wldit	W	0	Typic Cryaquent	Hgwfg	Lacustrine Grass Marsh	arcful	arcful-hipvul-utric
T2.02	08-Aug-01	70.3274	-151.2638	P	0	0	Ltnu	N	3	Psammentic Aquorthel	Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	eriang-cinlat-caraqu-salpul-limrev-sallan-tomnit
T2.03	08-Aug-01	70.3273	-151.2623	P	0	0	Ltnu	N	16	Typic Aquiturbel	Hgmss	Lacustrine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	dicra-caraqu-carbig-erivag-rhyrug-aulpal-salpul-salret
T2.04	08-Aug-01	70.3273	-151.2607	U	0	0	Flo	Pm	106	Aquic Haploturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	castet-hylspl-salphl-carbig-erivag
T2.05	08-Aug-01	70.3270	-151.2576	L	0	0	Ltim	Pll	24	Typic Histoturbel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-caraqu-limrev-scosco
T2.06	08-Aug-01	70.3261	-151.2487	L	0	0	Ltic	Pll	50	Typic Histoturbel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	eriang-scosco-erirus-limrev
T2.07	08-Aug-01	70.3268	-151.2411	L	0	0	Ltic	Phh	129	Typic Aquiturbel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	arclat-carbig-salphl-castet-pyrgra-salpul-vacvit
T2.08	08-Aug-01	70.3285	-151.2343	L	0	0	Ltim	Pll	40	Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-eriang-dicra-scosco
T2.09	08-Aug-01	70.3289	-151.2306	U	0	0	Flo	Pm	112	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	hylspl-dicra-erivag-salpul-carbig
T2.10	08-Aug-01	70.3283	-151.2158	L	0	0	Ltim	Plhh	100	Typic Histoturbel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	eriang-caraqu-polyt-dicra-hylspl
T20.01	06-Aug-02	70.2828	-151.5364	L	0	0	Ltim	Ms	15		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	caraqu-carcho-moss-eriang
T20.02	06-Aug-02	70.2829	-151.5429	R	0	0	Fhl	Tb	0		W	Riverine Lake	Water	arcful-caraqu-potpal
T20.03	06-Aug-02	70.2817	-151.5473	R	0	0	Fhl	N	0		Hgwfs	Riverine Sedge Marsh	caraqu	caraqu-eriang-potpal
T22.01	05-Aug-02	70.3176	-151.4534	R	0	0	Wrin	W	0		W	Lower Perennial River	Water	water
T22.02	05-Aug-02	70.3177	-151.4535	C	1	170	Fdra	Dr	3		Bbg	Coastal Moist Barrens	descae-stahum	soil--barrens
T22.03	05-Aug-02	70.3181	-151.4540	R	4	170	Fdra	Es	15		Bpv	Riverine Moist Barrens	descae-salala	salala-chrbip-descae-fesrub
T22.04	05-Aug-02	70.3186	-151.4551	U	0	0	Esl	Es	30		Slow	Upland Moist Low Willow Shrub	salgla-arcrub	salgla-arcrub-oxynig-salala-dryint
T22.05	05-Aug-02	70.3192	-151.4566	R	0	0	Fdoi	Pll	8		Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	moss-sallan-caraqu-equvar-eriang-carsax
T22.06	05-Aug-02	70.3225	-151.4582	L	0	0	Fdob	Plt	10		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	moss-eriang-caraqu-equvar-
T22.07	05-Aug-02	70.3239	-151.4587	L	0	0	Fdob	Mu	50		Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-dryint-carbig-lichen-salpul-salret-erivag
T22.08	05-Aug-02	70.3242	-151.4590	U	0	0	Esi	Es	15		Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-castet-lichen-moss-salret
T22.09	05-Aug-02	70.3274	-151.4484	L	0	0	Fdob	W	0		Hgwfs	Lowland Sedge Marsh	caraqu	moss-caraqu-eriang
T23.01	11-Aug-02	70.2150	-152.1605	L	0	0	Esi	Dt	20		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	moss-caraqu-eriang-erirus-salpul-carcho
T23.02	11-Aug-02	70.2257	-152.1611	U	0	0	Esi	Phl	20		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	moss-lichen-erivag-castet-salpul-vacvit
T23.03	11-Aug-02	70.2150	-152.1722	U	1	180	Esl	Phl	15		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	moss-betnan-erivag-vacvit-lichen-carbig-leddec-salpul
T23.04	11-Aug-02	70.2162	-152.1600	U	0	0	Esi	Phl	10		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	moss-erivag-vacvit-leddec-lichen-carbig
T23.05	11-Aug-02	70.2155	-152.1899	L	0	0	Ltim	Pm	10		Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-salpul-salret-dryint-eriang-betnan-carbig
T23.06	11-Aug-02	70.2124	-152.1881	U	10	260	Esi	Fh	20		Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	castet-moss-dryint-salret-lichen-salphl
T23.07	11-Aug-02	70.2113	-152.1946	U	0	0	Ltic	Phh	50		Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	moss-salphl-vacvit-dryint-castet-carbig
T23.08	11-Aug-02	70.2160	-152.2146	U	0	0	Ltic	Phl	10		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	moss-erivag-lichen-leddec-vacvit-carbig-castet-dryint
T23.09	11-Aug-02	70.2161	-152.1984	L	0	0	Ltim	Pd	5		Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-moss-caraqu-carrot-carcho
T23.10	11-Aug-02	70.2161	-152.1963	P	0	0	Wlsit	W	0		W	Lowland Lake	Water	water
T25.01	10-Aug-02	70.1305	-152.2104	R	0	0	Wrin	W	0		W	Lower Perennial River	Water	water
T25.02	10-Aug-02	70.1305	-152.2098	R	1	260	Fmraf	N	4		Bbg	Riverine Moist Barrens	descae-salala	soil--barrens
T25.03	10-Aug-02	70.1304	-152.2086	R	0	0	Fmraf	N	10		Bpv	Riverine Moist Barrens	descae-salala	fesrub-poahar-agros-desbre-descae-equarv-junarc-poalan
T25.04	10-Aug-02	70.1309	-152.2079	R	0	0	Fmoa	N	20		Stow	Riverine Moist Tall Willow Shrub	salala-chrbip	moss-salala-fesrub-chrbip-carmari-equarv-genpro-sallan-juncas
T25.05	10-Aug-02	70.1329	-152.1982	R	0	0	Fmoi	Es	40		Slow	Riverine Moist Low Willow Shrub	sallan-equvar	arcrub-sallan-moss-salala-oxyvis-astalp
T25.06	10-Aug-02	70.1331	-152.1986	U	0	0	Esa	Es	40		Stow	Upland Dry Tall Willow Shrub	salala-chrbip	salala-chrbip-equarv-fesrub
T25.07	10-Aug-02	70.1325	-152.1992	U	0	0	Esi	Es	20		Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	arcrub-moss-dryint-oxyvis-salret-anenar-sallan
T25.08	10-Aug-02	70.1310	-152.1890	R	0	0	Wlsir	W	0		Hgwfg	Riverine Grass Marsh	arcful	arcful-ranhyp-myrspi-utrvul
T25.09	10-Aug-02	70.1314	-152.1901	R	0	0	Fmrif	N	20		Slow	Riverine Moist Low Willow Shrub	sallan-equvar	moss-sallan-salala-equarv-caraqu-arcrub-salpul
T25.10	10-Aug-02	70.1314	-152.1945	R	0	0	Fmoi	Phl	35		Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-arcrub-dryint-caraqu-eriang-salarc-sallan
T25.11	10-Aug-02	70.1317	-152.1947	R	0	0	Fmrif	W	0		Hgwfs	Riverine Sedge Marsh	caraqu	moss-caraqu-myrspi-eriang-utrint
T26.01	09-Aug-02	70.2226	-151.6621	U	0	0	Mp	Phl	25		Hgmt	Upland Moist Tussock Meadow	erivag-leddec	moss-erivag-vacvit-castet-salpla-lichen
T26.02	09-Aug-02	70.2236	-151.6615	P	0	0	Ltrm	N	12		Slow	Lacustrine Moist Low Willow Shrub	salpul-caraqu	moss-sallan-caraqu-equsci-eriang-dryint-equvar
T26.03	09-Aug-02	70.2223	-151.6571	P	0	0	Wlsct	W	0		Hgwfg	Lacustrine Grass Marsh	arcful	arcful-hipvul
T26.04	09-Aug-02	70.2214	-151.6611	P	0	0	Wlsil	W	0		W	Lowland Lake	Water	hipvul-caraqu-arcful
T26.05	09-Aug-02	70.2150	-151.6673	L	0	0	Ltim	Pll	17		Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	moss-caraqu-dryint-eriang-carbig-lichen
T26.06	09-Aug-02	70.2121	-151.6679	P	0	0	Ltrm	N	4		Hgwfs	Lacustrine Sedge Marsh	caraqu	caraqu-eriang
T26.06a	09-Aug-02	70.2121	-151.6679	P	0	0	Ltrm	N	10		Hgwst	Lacustrine Wet Sedge Meadow	caraqu-carsax	caraqu-fesviv-moss-potpal-stell-ranpal
T26.07	09-Aug-02	70.2074	-151.6743	P	0	0	Ltrm	N	0		Hgwfs	Lacustrine Sedge Marsh	caraqu	caraqu-moss-carcho-eriang-erirus
T26.08	09-Aug-02	70.2063	-151.6720	P	0	0	Ltnc	N	15		Hgmss	Lacustrine Moist Sedge–Shrub Meadow	eriang-salpul-sphag	moss-salpla-caraqu-eriang-carbig
T26.09	09-Aug-02	70.2010	-151.6659	P	4	335	Ltrm	N	10		Slow	Lacustrine Moist Low Willow Shrub	salpul-caraqu	salpla-caraqu-sallan-moss-saxcer
T3.01	07-Aug-01	70.3254	-151.3745	R	0	0	Wert	W	0	nd	W	Tidal River	Water	water
T3.02	07-Aug-01	70.3255	-151.3754	C	2	90	Fdra	Dr	3	Typic Aquorthel	Bbg	Coastal Moist Barrens	descae-stahum	equarv-descae-salala-arcial
T3.03	07-Aug-01	70.3260	-151.3781	C	0	0	Fdra	N	4	Typic Haplorthel	Bpv	Coastal Moist Barrens	descae-stahum	descae-equarv-stahum-fesrub-arclat-junarc

Appendix Table 2. (Continued).

Site No.	Date	Lat (dd83)	Long (dd83)	Physiog	Slope (deg)	Aspect (deg)	Geom Unit	Micro Topo	Microrelf (cm)	Soil Class	Veg Class	Ecotype	Plant Association	Most Abundant Plant Species
T3.04	07-Aug-01	70.3263	-151.3775	R	0	0	Fdoa	Es	30	Aquic Cryofluvent	Stow	Riverine Moist Tall Willow Shrub	salala-chrbip	salala-equarv-chrbip-cascau-fesrub-junarc
T3.05	07-Aug-01	70.3262	-151.3782	U	6	110	Esa	Es	3	Typic Cryorthent	Stow	Upland Dry Tall Willow Shrub	salala-chrbip	salala-astalp-discap-oxyvis-salgla
T3.06	07-Aug-01	70.3268	-151.3788	R	0	0	Fdoa	N	5	Typic Aquorthel	Slow	Riverine Moist Low Willow Shrub	sallan-equvar	tomnit-sallan-caraqu-sanunc
T3.07	07-Aug-01	70.3268	-151.3797	R	0	0	Fdol	N	4	Typic Historthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	limrev-caraqu-camste-equsci-eriang-sallan
T3.08	07-Aug-01	70.3271	-151.3802	U	0	0	Esl	Es	15	Typic Haplorthel	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-salret-salgla-astalp-lichen
T3.09	07-Aug-01	70.3282	-151.3922	R	0	0	Fdol	Pll	10	Typic Historthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	limrev-camste-sallan-caraqu-equsci-eriang-erirus-salarc
T3.10	07-Aug-01	70.3277	-151.4035	R	0	0	Fdol	N	2	Aquic Haplorthel	Sddt	Riverine Dry Dryas Dwarf Shrub	dryint-oxydef	dryint-equvar-arcalp-salgla-sallan-salret
T4.01	09-Aug-01	70.2939	-151.5486	R	0	0	Wlsir	W	0	nd	Hgwfg	Riverine Grass Marsh	arcful	arcful
T4.02	09-Aug-01	70.2943	-151.5493	R	0	0	Fmrf	N	5	Typic Aquorthel	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	aulpal-salret-dicra-drepa-dryint-sallan-carbig-eriang
T4.03	09-Aug-01	70.2958	-151.5494	U	8	175	Esl	Es	3	Typic Cryorthent	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-arcalp-cetcuc-lichc-oxyvis-salret
T4.04	09-Aug-01	70.2960	-151.5511	R	0	0	Fmoi	Pd	15	Typic Aquorthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	drebre-caraqu-orichr-tomnit-aulpal-eriang-salret
T4.05	09-Aug-01	70.2969	-151.5522	U	0	0	Esi	Fh	5	Typic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	lichc-dryint-cetcuc-salret-thamn
T4.06	09-Aug-01	70.2963	-151.5567	R	0	0	Wlsir	W	0	nd	W	Riverine Lake	Water	water
T4.07	09-Aug-01	70.2980	-151.5644	L	0	0	Fmob	Pllh	35	Fibristel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	drepa-equvar-carcap-caraqu-eriang
T4.08	09-Aug-01	70.3024	-151.5725	L	0	0	Fmob	Pllh	30	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	drebre-limrev-algae-caraqu
T4.09	09-Aug-01	70.3028	-151.5725	L	0	0	Fmob	Pllh	30	Typic Aquorthel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-dryint-salret-carbig-dicra-caraqu-eriang
T4.10	09-Aug-01	70.3034	-151.5721	L	0	0	Fmob	Plhh	55	Typic Histoturbel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	dryint-caraqu-carbig-tomnit-castet-eriang-erirus
T4.11	09-Aug-01	70.3034	-151.5721	P	0	0	Wlsil	Lp	55	nd	W	Lowland Lake	Water	scosco-caraqu
T5.01	07-Aug-01	70.2932	-151.6274	R	0	0	Wrin	W	0	nd	W	Lower Perennial River	Water	water
T5.02	07-Aug-01	70.2931	-151.6260	R	1	290	Fmraf	Dr	2	Typic Cryofluvent	Bbg	Riverine Moist Barrens	descae-salala	Barrens
T5.03	07-Aug-01	70.2929	-151.6253	R	6	310	Fmraf	Es	30	Typic Cryopsamment	Bpv	Riverine Moist Barrens	descae-salala	chrbip-salala-fesrub-poa-descae-equarv
T5.04	07-Aug-01	70.2928	-151.6247	U	0	0	Esa	Es	10	Typic Cryopsamment	Stow	Upland Dry Tall Willow Shrub	salala-chrbip	salala-chrbip-equarv-cerpur-sallan
T5.05	07-Aug-01	70.2927	-151.6244	R	0	0	Fmoi	Es	10	Typic Aquorthel	Slow	Riverine Moist Low Willow Shrub	sallan-equvar	sallan-drepa-camste-cinlat-dicra-equarv-salret
T5.06	07-Aug-01	70.2927	-151.6241	U	10	170	Esl	Es	5	Typic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	arcalp-dryint-cerpur-salret-equarv-tomnit
T5.07	07-Aug-01	70.2927	-151.6239	U	0	0	Esi	Es	5	Typic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-arcalp-cerpur-thamn
T5.08	07-Aug-01	70.2926	-151.6234	R	0	0	Fmoi	Es	10	Typic Aquorthel	Slow	Riverine Moist Low Willow Shrub	sallan-equvar	drepa-sallan-caraqu-camste
T5.09	07-Aug-01	70.2922	-151.6218	R	0	0	Fmol	Pd	10	Typic Aquorthel	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-sallan	hypnu-sallan-caraqu-cinlat-dicra-carbig-equvar-salret
T5.10	07-Aug-01	70.2920	-151.6202	R	0	0	Wlsir	N	0	Fibristel	Hgwfs	Riverine Sedge Marsh	caraqu	caraqu-scosco
T5.12	07-Aug-01	70.2907	-151.6178	R	0	0	Fmoi	Pll	25	Fibristel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	drebre-limcos-caraqu-erirus-psetur-carbig
T6.01	05-Aug-01	70.2533	-151.9854	R	0	0	Wrin	W	0	nd	W	Lower Perennial River	Water	water
T6.02	05-Aug-01	70.2539	-151.9854	R	1	10	Fmraf	Dr	3	Typic Cryofluvent	Bbg	Riverine Moist Barrens	descae-salala	Barrens
T6.03	05-Aug-01	70.2541	-151.9848	R	0	0	Fmoa	Es	40	Typic Cryofluvent	Stow	Riverine Moist Tall Willow Shrub	salala-chrbip	salala-equarv-junarc-chrbip-descae
T6.04	05-Aug-01	70.2544	-151.9861	R	0	0	Fmoa	Es	30	Typic Aquorthel	Slow	Riverine Moist Low Willow Shrub	sallan-equvar	sallan-arcalp-discap-equvar
T6.05	05-Aug-01	70.2548	-151.9849	U	0	0	Esi	Es	100	Typic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-thamn-cetcuc-licho-bropum-salbra
T6.06	05-Aug-01	70.2557	-151.9850	R	0	0	Fmoi	Pll	20	Fluvaquentic Fibristel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	drepa-caraqu-scosco-algae-eriang
T6.07	05-Aug-01	70.2560	-151.9852	L	3	180	Esi	N	10	Typic Aquorthel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	tomnit-carbig-dryint-discap-salret
T6.08	05-Aug-01	70.2581	-151.9867	R	0	0	Fmoi	Pllh	40	Typic Aquorthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	drepa-caraqu-eriang-mnium
T6.09	05-Aug-01	70.2638	-151.9891	L	0	0	Fmob	Plhh	60	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	limrev-algae-caraqu-scosco-carcho-erirus
T6.10	06-Aug-01	70.2673	-151.9900	L	9	210	Ca	Mg	30	Typic Aquiturbel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	hylspl-tomnit-carbig-salphl-salret-eriang-petfri-arclat-salpul
T6.11	05-Aug-01	70.2672	-151.9888	U	20	230	Esi	Fh	20	Typic Psammoturbel	Sdec	Upland Moist Cassiope Dwarf Shrub	castet-hiealp	castet-dryint-salret-hylspl-rhyrug-vaculi
T7.01	05-Aug-01	70.2406	-151.7814	R	0	0	Wrin	W	0	nd	W	Lower Perennial River	Water	water
T7.02	05-Aug-01	70.2403	-151.7813	R	1	10	Fmraf	Dr	50	Typic Cryopsamment	Bbg	Riverine Moist Barrens	descae-salala	descae-salala-artbor
T7.03	05-Aug-01	70.2398	-151.7843	R	0	0	Fmraf	Es	50	Typic Cryopsamment	Bpv	Riverine Moist Barrens	descae-salala	poa-artbor-equarv
T7.04	05-Aug-01	70.2389	-151.7801	U	0	0	Esa	Es	5	Typic Cryopsamment	Stow	Upland Dry Tall Willow Shrub	salala-chrbip	salala-artbor-equarv-fesrub
T7.05	05-Aug-01	70.2387	-151.7799	U	0	0	Esa	Eb	75	Typic Cryopsamment	Stow	Upland Dry Tall Willow Shrub	salala-chrbip	salala-arcrub-sallan-astalp
T7.06	05-Aug-01	70.2380	-151.7802	L	0	0	Esi	Eb	15	Typic Aquiturbel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	dryint-tomnit-camste-discap-ditfle-equvar-sallan-salret
T7.07	05-Aug-01	70.2363	-151.7817	R	0	0	Fmol	Fh	nd	Typic Aquorthel	Hgwst	Riverine Wet Sedge Meadow	caraqu-sallan-equvar	drebre-erirus-eriang-caraqu
T7.08	05-Aug-01	70.2351	-151.7823	U	0	0	Esi	Es	40	nd	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	nd
T7.09	05-Aug-01	70.2336	-151.7836	L	0	0	Fmob	Pll	20	Typic Historthel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	drepa-carbig-dryint-tomnit-eriang
T7.10	05-Aug-01	70.2319	-151.7876	L	0	0	Fmob	Phl	10	nd	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	dicra-dryint-sallan-arclat-carbig-tomnit
T8.01	05-Aug-01	70.1845	-151.9619	R	0	0	Wrin	W	0	nd	W	Lower Perennial River	Water	water
T8.02	05-Aug-01	70.1852	-151.9625	R	0	0	Fmraf	Dr	2	Typic Cryopsamment	Bbg	Riverine Moist Barrens	descae-salala	Barrens
T8.03	05-Aug-01	70.1849	-151.9643	U	33	310	Esa	Es	10	Typic Cryopsamment	Stow	Upland Dry Tall Willow Shrub	salala-chrbip	salala-chrbip-fesrub-poalan-elyala
T8.04	05-Aug-01	70.1857	-151.9670	U	0	0	Esi	N	5	Typic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-cetcuc-lichc-salgla-salret
T8.05	05-Aug-01	70.1859	-151.9678	R	0	0	Fmol	N	5	Typic Historthel	Slow	Riverine Moist Low Willow Shrub	sallan-equvar	limrev-sallan-carsax-drepa-eriang-caraqu
T8.06	05-Aug-01	70.1865	-151.9676	L	0	0	Fmob	N	5	Fluvaquentic Fibristel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	limrev-caraqu-eriang-scosco-carsax-drepa
T8.07	05-Aug-01	70.1880	-151.9635	U	0	0	Esi	Phl	15	Aquic Cryopsamment	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-castet-dicra-lichc-moss-rholap
T8.08	05-Aug-01	70.1886	-151.9717	P	0	0	Wlsil	N	0	Fluvaquentic Hemistel	Hgwfs	Lacustrine Sedge Marsh	caraqu	caraqu-scosco-eriang-erirus-carcho
T8.09	05-Aug-01	70.1896	-151.9736	L	0	0	Mp	Plhh	40	Hemistel	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-sallan	caraqu-eriang-carstr-salpul
T9.01	06-Aug-01	70.1599	-151.3643	U	0	0	Mp	Phl	10	Typic Histoturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	erivag-vacvit-dicra-leddec-salpul-tomnit-betnan
T9.02	06-Aug-01	70.1601	-151.3592	L	0	0	Ltim	Pllh	15	Fluvaquentic Hemistel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-carsax-scosco-carbig-carcho
T9.03	06-Aug-01	70.1610	-151.3542	P	0	0	Wlsit	W	0	nd	W	Lowland Lake	Water	water
T9.04	06-Aug-01	70.1616	-151.3493	L	0	0	Ltim	Pd	8	Typic Historthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	eriang-caraqu-scosco-carsax
T9.05	06-Aug-01	70.1629	-151.3483	L	0	0	Ltic	Pllh	20	Ruptic Histoturbel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	betnan-caraqu-dicra-erivag-tomnit-salpul-salret
T9.06	06-Aug-01	70.1624	-151.3418	L	0	0	Ltic	N	5	Typic Aquorthel	Hgwst	Lowland Wet Sedge Meadow	eriang-salpul-sphag	aultur-drepa-sphag-aulpal-camste-eriang-caraqu
T9.07	06-Aug-01	70.1621	-151.3397	L	0	0	Ltic	N	10	Typic Aquorthel	Slow	Lowland Moist Low Willow Shrub	salpul-caraqu	salpul-polstr-aulpal-dicang-pohnut-caraqu-carbig-sphag
T9.08	06-Aug-01	70.1626	-151.3364	P	0	0	Wlsit	W	2	Typic Aquorthel	Hgwfg	Lacustrine Grass Marsh	arcful	limrev-arcful-erirus
T9.09	06-Aug-01	70.1628	-151.3214	L	0	0	Ltim	Pd	10	Typic Aquorthel	Hgwst	Lowland Wet Sedge Meadow	caraqu-carsax	carsax-eriang-scosco-carlax-sallan
T9.10	06-Aug-01	70.1639	-151.3066	U	0	0	Ltic	N	15	Typic Aquiturbel	Hgmt	Upland Moist Tussock Meadow	erivag-leddec	leddec-rhyrug-salpul-betnan-carbig-castet-erivag-vacvit

Appendix Table 3. Data file listing of environmental characteristics of ground reference plots in the Northeastern Planning Area of the NPRA, 2002.

Site No.	NWI Regime[1]	Water Depth	Saturated<30 cm	Drainage[2]	Soil Moisture[3]	Mottle Depth	Low Matrix	Hydric Soil	Cryo-turb	SurfOrg (cm)	CumOrg 40 (cm)	DomMineral40	DomText 40	Loess Thick (cm)	Thaw Depth	Frost Boil(%)	Site pH	Site EC	Site Chemistry
C3.1/E3.1	U	nd	n	Wm	M	12	>32	y	y	8	22	L	O	12	32	0.1	5.8	50	Circumneutral
C3.2	U	nd	n	Wm	M	P	P	y	y	0	37	S	O	0	42	1	6	60	Circumneutral
E3.3	U	nd	n	Wm	M	P	P	y	y	0	35	S	O	0	nd	1	6	160	Circumneutral
C5.1	Nsa	-17	y	Ps	M	14	18	y	n	12	12	L	L	0	28	0	6.7	190	Circumneutral
C5.2	U	nd	n	Wm	M	P	P	y	n	27	27	O	O	0	21	0	nd	nd	
C5.3	U	nd	n	Wm	M	P	P	y	n	31	31	O	O	0	22	0	nd	nd	
C5.4	Nsa	-38	n	Ps	M	5	>60	y	y	5	16	S	S	0	60	1	6.9	140	Circumneutral
C6.1	Nsa	-16	y	Ps	M	12	24	y	y	12	12	L	L	0	24	0	5.2	80	Acidic
C6.2	Nsa	-2	y	Pv	W	P	10	y	y	10	11	S	S	0	60	0	5.1	90	Acidic
C6.3	Nsp	2	y	Pv	W	P	P	y	y	24	27	S	S	0	50	0	5.2	130	Acidic
C6.6	Nsa	-24	y	Wm	M	19	>27	y	y	11	24	L	O	8	27	0.1	3.9	70	Acidic
C7.1	U	-60	n	W	M	10	47	n	y	4	8	S	S	8	80	1	5.8	50	Circumneutral
C7.3	Nsa	-5	y	Pv	W	nd	5	y	y	60	40	O	O	0	40	0	6.1	200	Circumneutral
C8.1	Nsa	nd	y	Pv	W	P	P	y	n	61	40	O	O	0	35	0	5.3	170	Acidic
C8.2	Nsp	10	y	F	W	P	P	y	n	61	40	O	O	0	35	0	5.3	170	Acidic
C9.1	Nsa	nd	y	P	m	P	P	y	y	33	33	L	O	0	25	0.1	6.1	70	Circumneutral
C9.2	Nsa	-2	y	Pv	W	P	P	y	n	51	40	O	O	0	34	0	6.1	210	Circumneutral
E4.1	Nsa	nd	n	Wm	M	15	>26	y	y	7	25	L	O	10	26	0.1	5.4	240	Acidic
G1.01	Ti	-12	y	P	W	3	12	y	n	1	3	L	L	0	40	0	6.1	8330	Saline
G1.02	Ti	-26	y	Ps	M	9	13	y	n	0	3	L	L	0	44	0	5.9	11700	Saline
G1.03	Ti	-35	y	Ps	M	35	5	y	n	1	4	L	L	0	57	0	6.7	21000	Saline
G1.04	Ti	-25	y	Ps	M	A	a	y	n	40	40	O	O	0	34	0	6.9	1740	Circumneutral
G1.05	Ti	-20	y	Ps	M	A	a	y	n	27	27	L	O	0	34	0	6.5	5600	Saline
G1.06	Ti	-42	y	Wm	M	15	a	y	n	2	8	L	O	0	42	0	7.1	2150	Saline
G1.07	Ti	12	y	F	A	nd	nd	y	n	nd	nd	O	O	0	nd	0	7.1	13400	Saline
G1.08	Ti	-7	y	Pv	W	14	a	y	n	25	35	L	O	0	44	0	6.9	12600	Saline
G11.01	Nsa	-34	y	Wm	M	P	p	y	y	8	32	S	O	6	34	nd	nd	nd	nd
G14.01	U	-100	n	W	M	A	A	n	y	1	3	S	S	13	68	0	5.8	30	Circumneutral
G14.02	U	-100	n	W	M	A	A	n	y	2	2	S	S	16	82	0	5.5	50	Acidic
G15.01	U	-100	n	Wm	M	A	A	n	y	8	8	L	L	42	65	0	nd	nd	nd
G15.02	nd	nd	nd	Wm	M	6	nd	n	y	6	19	L	L	nd	nd	nd	nd	nd	nd
G22.01	Nsp	1	y	Pv	W	25	A	y	n	24	26	L	O	0	38	0	7	610	Circumneutral
G22.02	Nsp	5	y	Pv	W	A	A	y	n	40	40	O	O	0	41	0	7.3	580	Circumneutral
G22.03	Np	30	y	F	A	26	A	y	n	24	34	S	O	0	40	0	7.8	370	Alkaline
G3.01	Np	40	y	F	A	nd	nd	nd	nd	0	0	S	S	0	150	0	7.8	190	Alkaline
G3.02	Nse	-50	n	W	M	0	A	n	n	0	1	S	S	0	150	0	7.4	410	Circumneutral
G3.03	Nse	-75	n	W	D	0	A	n	n	0	2	S	S	0	107	0	8	120	Alkaline
G3.04	Nse	-75	n	W	D	6	A	n	n	6	8	S	S	0	88	0	8.2	70	Alkaline
G3.05	Nse	-75	n	W	D	12	23	n	n	12	14	S	S	0	78	0	8	120	Alkaline
G3.06	U	-75	n	W	D	0	A	n	n	0.5	2	S	S	0	103	0	8.4	50	Alkaline
G3.07	Nse	-60	n	Wm	M	0.5	nd	n	n	0	4	S	S	0	74	0	8	140	Alkaline
G3.08	Nsp	9	y	F	W	4	A	y	n	7	10	S	S	0	83	0	6.9	580	Circumneutral
G5.01	Np	75	y	F	A	nd	nd	y	nd	13	14	S	S	0	150	0	6.9	150	Circumneutral
G5.02	Nsa	-36	y	Ps	M	12	14	y	y	11	12	L	L	0	36	0	6.2	220	Circumneutral
G5.03	Nsa	0	y	Pv	W	nd	nd	y	n	24	24	S	O	0	64	0	6.4	400	Circumneutral
G5.04	Nsa	1	y	Pv	W	A	A	y	n	23	23	S	O	0	44	0	5.8	150	Circumneutral
G5.05	U	-50	n	Wm	M	A	12	y	n	9	9	L	L	0	20	0	6.2	100	Circumneutral
G5.06	Nsp	12	y	F	A	A	A	y	n	45	40	O	O	0	44	0	6.4	170	Circumneutral
G5.07	Nsa	-30	y	Wm	M	A	A	y	y	7	8	S	S	0	30	0	6.5	220	Circumneutral
G5.08	Nsa	-22	y	Ps	M	22	A	y	n	15	15	S	S	0	48	0	6.6	800	Circumneutral
G5.09	Nsa	-20	y	Ps	M	A	20	y	n	5	7	S	S	0	68	0	6.9	1050	Circumneutral
G5.10	U	-49	n	Wm	M	4	5	y	y	4	4	L	L	0	49	1	6.9	140	Circumneutral
G6.12	Nsa	-32	y	Ps	M	A	9	y	n	5	10	L	L	0	40	0	7.7	620	Alkaline
G6.13	U	-50	n	W	M	nd	nd	n	n	0	0	L	L	0?	88	0	6.5	40	Circumneutral
G6.14	U	-50	n	W	M	nd	nd	n	n	0	0	L	L	nd	nd	0	6.8	70	Circumneutral
G6.01	U	-150	n	W	M	A	A	n	n	0.2	2	S	S	0	135	0	8.2	160	Alkaline
G6.02	Nsa	-28	y	Ps	M	10	50	y	n	1	1	L	L	0	82	0	7.6	330	Alkaline
G6.03	Nse	-77	n	W	M	A	10	y	n	1	8.5	S	S	0	77	0	nd	160	nd
G6.04	U	-150	n	W	M	A	A	n	n	0	0	S	S	0	150	0	8.7	50	Alkaline
G6.05	U	-75	n	W	M	A	A	n	n	0	8.5	S	S	0	100	0	8	180	Alkaline
G6.06	Np	40	y	F	A	nd	nd	y	nd	nd	nd	nd	nd	0	50	0	8.1	510	Alkaline
G6.07	Np	40	y	F	A	nd	nd	y	nd	nd	nd	S	S	0	59	0	8.1	320	Alkaline
G6.08	Nsp	11	y	F	A	nd	nd	y	nd	60	40	O	O	0	60	0	8	140	Alkaline
G6.09	Np	47	y	F	A	nd	nd	y	nd	nd	nd	L	L	0	58	0	7.9	150	Alkaline
T1.01	Nsa	0	y	Pv	W	A	18	y	n	18	25	L	O	0	36	0	5.8	140	Circumneutral
T1.02	Nsa	-17	y	Ps	M	10	10	y	n	10	10	L	L	0	20	0	5	90	Acidic
T1.03	Nsa	0	y	Pv	W	P	P	y	n	22	22	O	O	0	22	0	5.3	160	Acidic
T1.03b	Nsa	-15	y	Pv	W	225	P	y	y	13	17	L	L	0	18	0	6.1	120	Circumneutral
T1.04	U	-50	n	Wm	M	P	17	y	y	25	25	L	O	0	25	0	5	10	Acidic
T1.04b	Nsp	4	y	Pv	W	P	P	y	n	51	40	O	O	0	32	0	6.7	180	Circumneutral
T1.05	Nsa	0	y	Pv	W	P	27	y	n	27	27	S	S	0	37	0	5.8	220	Circumneutral
T1.06	Np	100	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
T10.01	Np	45	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.8	80	Circumneutral
T10.02	U	-50	n	W	M	A	A	n	n	2	5	S	S	0	85	0	5	10	Acidic
T10.03	Nsa	-29	y	Ps	M	11	22	y	y	10	11	S	S	0	29	0	5.3	60	Acidic
T10.04	Nsa	-19	y	Wm	M	6	14	y	y	11	16	L	S	4	19	0	5.3	80	Acidic

Appendix Table 3. (Continued).

Site No.	NWI Regime*	Water Depth	Saturated< 30 cm	Drainage*	Soil Moisture*	Mottle Depth	Low Matrix	Hydric Soil	Cryo-turb	SurfOrg (cm)	CumOrg 40 (cm)	DomMineral40	DomText 40	Loess Thick (cm)	Thaw Depth	Frost Boil(%)	Site pH	Site EC	Site Chemistry
T10.05	Nsp	-3	y	Pv	W	A	A	y	n	22	22	L	O	0	40	0	5.5	180	Acidic
T10.06	Nsp	-2	y	Pv	W	A	A	y	n	23	23	L	O	0	35	0	5.5	180	Acidic
T10.07	Np	24	y	F	A	nd	nd	y	nd	nd	nd	nd	nd	nd	67	nd	6	210	Circumneutral
T10.08	Nsa	-26	y	Wm	M	A	A	y	y	26	26	O	O	0	26	0	4.7	60	Acidic
T10.09	Nsa	-21	y	Wm	M	A	A	y	y	21	21	O	O	0	21	0	5	90	Acidic
T10.10	Nsp	5	y	Pv	W	A	A	y	n	33	33	O	O	0	33	0	5.5	200	Acidic
T11.01	Nsp	5	y	Pv	W	A	A	y	n	32	32	O	O	0	32	0	5.8	160	Circumneutral
T11.01b	nd	nd	nd	nd	nd	21	21	y	y	21	21	S	O	0	nd	nd	nd	nd	nd
T11.02	Nsa	-22	y	Wm	M	14	16	y	y	12	14	L	L	9	22	0	4.4	50	Acidic
T11.02b	nd	23	y	nd	nd	140	P	y	n	72	40	O	O	nd	23	nd	nd	nd	nd
T11.03	Nsp	-5	y	Pv	W	A	20	y	n	18	19	L	O	0	31	0	4.7	50	Acidic
T11.03b	Nsp	0	y	Pv	W	A	24	y	y	24	24	S	O	0	45	0	6	200	Circumneutral
T11.04	Nsp	-3	y	Pv	W	A	26	y	n	22	22	S	O	0	42	0	5.8	160	Circumneutral
T11.05	Nsa	-5	y	Pv	W	A	A	y	n	32	32	O	O	0	32	0	5	80	Acidic
T11.06	Nsa	-20	y	Wm	M	23	A	y	n	20	20	L	L	>1	21	0	5.3	60	Acidic
T12.01	Nsa	-27	y	Wm	M	A	24	y	y	5	8	L	L	22	27	0.1	6.2	60	Circumneutral
T12.02	U	-50	n	Wm	M	A	A	n	y	3	3	L	L	26	29	0	5.8	20	Circumneutral
T12.03	Nsa	-20	y	Ps	M	A	29	y	n	5	5	S	S	0	66	0	7.1	310	Circumneutral
T12.04	Nsa	-30	y	Ps	M	A	4	y	n	4	4	L	L	0	30	0	5.5	30	Acidic
T12.05	Nsp	5	y	Pv	W	P	22	y	n	21	21	L	O	0	36	0	5.6	90	Circumneutral
T12.06	Nsp	12	y	F	A	nd	nd	y	n	nd	nd	nd	nd	nd	33	nd	nd	nd	nd
T12.07	Nsa	-27	y	Ps	M	30	13	y	y	5	5	S	S	nd	52	0	7.4	340	Circumneutral
T12.08	Nsp	3	y	Pv	W	P	P	y	n	40	40	O	O	0	33	0	5.5	110	Acidic
T12.09	Nsa	-24	y	Wm	M	P	P	y	y	15	15	L	L	>9	24	0	5	20	Acidic
T12.10	U	nd	n	W	M	nd	nd	nd	nd	5	15	L	L	nd	nd	nd	nd	nd	nd
T13.01	Nsa	nd	nd	Wm	M	P	P	y	y	9	32	L	O	8	nd	0	5.2	150	Acidic
T13.02	Np	150	y	F	A	A	A	y	n	0	3	S	S	0	nd	0	8	200	Alkaline
T13.03	Nsa	-20	y	Ps	M	A	16	y	y	16	16	S	S	0	28	0	6.8	630	Circumneutral
T13.04	Nsp	4	y	Pv	W	A	13	y	n	13	13	S	S	0	69	0	7.1	200	Circumneutral
T13.05	Nse	0	y	Pv	W	P	P	y	n	45	40	O	O	0	40	0	6.4	240	Circumneutral
T13.06	Nse	-50	n	Wm	M	P	P	y	y	9	20	L	L	9	23	0	5.5	40	Acidic
T13.07	Nse	-4	y	Pv	W	P	27	y	n	27	27	L	O	0	40	0	5.6	90	Circumneutral
T13.08	nd	nd	nd	nd	M	P	P	nd	y	5	15	L	L	40	nd	0	6.5	90	Circumneutral
T14.01	Nsa	-10	y	Ps	W	P	11	y	n	21	21	L	O	0	20	0	5.7	130	Circumneutral
T14.02	U	-43	n	Wm	M	25	a	n	y	10	10	L	L	24	43	3	6.2	110	Circumneutral
T14.03	Nsp	4	y	Pv	W	P	P	y	n	37	37	O	O	0	37	0	6.2	120	Circumneutral
T14.04	Nse	-3	y	Pv	W	P	P	y	y	40	40	O	O	0	40	0	5.7	110	Circumneutral
T14.05	Np	50	y	F	A	nd	nd	nd	nd	0	0	S	S	0	nd	0	7.6	100	Alkaline
T14.06	Nsa	-14	y	Wm	M	13	15	y	y	14	15	L	L	>8	22	0	5.4	10	Acidic
T15.01	Nse	-24	y	Ps	M	A	12	y	n	2	4	S	S	0	100	0	6.5	540	Circumneutral
T15.02	Nsa	-17	y	Wm	M	A	A	y	n	12	12	S	S	0	19	0	5.8	680	Circumneutral
T15.03	U	-50	n	Wm	M	A	A	n	y	3	3	S	S	0	29	0	6.5	10	Circumneutral
T15.04	U	-50	nd	Wm	M	6	10	n	y	9	9	L	L	0	18	0	6.8	10	Circumneutral
T15.05	Nsa	0	y	Pv	W	P	26	y	n	30	30	O	O	0	30	0	5	80	Acidic
T15.06	Np	100	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	5.3	110	Acidic
T15.07	Nsa	-20	y	Wm	M	A	5	y	nd	9	9	L	L	0	22	0	6.1	320	Circumneutral
T15.08	Nsa	0	y	Pv	W	P	P	y	n	35	35	O	O	0	35	0	5.3	110	Acidic
T15.09	nd	nd	nd	nd	nd	nd	nd	nd	nd	7	12	L	L	nd	nd	nd	nd	nd	nd
T15.09a	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.50	200.00	nd
T15.11	Nsa	-31	y	Wm	M	8	23	y	y	7	10	S	S	3	32	0	4.7	110	Acidic
T15.12	U	-73	n	W	M	A	nd	n	y	3	4	S	S	0	75	2	7.7	80	Alkaline
T16.01	U	-83	n	W	M	72	A	n	n	3	3	S	S	0	86	0	8.5	130	Alkaline
T16.02	Nsp	4	y	Pv	W	A	32	y	n	32	32	S	O	0	40	0	6.1	140	Circumneutral
T16.03	U	-50	n	Wm	M	A	A	y	y	10	33	S	O	0	25	0	4.5	50	Acidic
T16.04	Nsa	-6	y	Pv	W	A	16	y	n	16	24	L	O	0	41	0	5.8	180	Circumneutral
T16.05	Nsa	-30	y	Wm	M	A	9	y	y	9	12	S	S	0	35	0	5.2	30	Acidic
T16.06	Nsp	0	y	Pv	W	P	P	y	n	40	40	O	O	0	31	0	5.8	150	Circumneutral
T16.07	Np	30	y	F	A	nd	nd	y	n	nd	nd	nd	nd	nd	56	0	7.7	130	Alkaline
T16.08	nd	nd	n	nd	M	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
T17.01	Nse	-110	n	W	M	3	A	n	n	0	2	S	S	0	123	0	7.2	140	Circumneutral
T17.02	Nse	-120	n	W	M	A	A	n	n	0	2	S	S	0	120	0	7.1	80	Circumneutral
T17.03	Nsa	-70	y	W	M	11	22	y	n	4	4	L	L	0	70	0	7.4	230	Circumneutral
T17.04	Nsp	0	y	Pv	W	A	39	y	n	38	38	L	O	0	48	0	7.4	360	Circumneutral
T17.05	Nsa	-29	y	Wm	M	22	23	y	n	2	3	S	S	0	40	0.1	6.8	390	Circumneutral
T17.06	U	-100	n	W	M	A	A	n	n	1	3	S	S	0	95	0.5	6.5	50	Circumneutral
T17.07	U	-150	n	Es	D	A	A	n	n	0	0.5	S	S	0	150	2	6.8	20	Circumneutral
T17.08	Np	40	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.1	210	Circumneutral
T18.01	Np	100	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	nd	nd	nd	nd	nd
T18.02	Nse	-56	n	Wm	M	29	A	n	n	2	7	L	L	0	56	0	5.6	nd	Circumneutral
T18.03	Nsa	-2	y	Pv	W	A	A	y	y	7	24	L	O	0	28	0	5.3	70	Acidic
T18.04	Np	100	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
T18.05	U	-100	n	Wm	M	A	A	n	n	3	2	L	L	15	56	0	6.6	210	Circumneutral
T18.06	Nsa	-22	y	Wm	M	13	A	y	y	11	13	L	L	5	22	0	5.3	80	Acidic
T18.07	Nsp	5	y	Pv	W	A	A	y	n	23	26	L	O	0	42	0	5.9	150	Circumneutral
T18.08	Nsa	-5	y	Pv	W	A	A	y	n	26	26	L	O	0	40	0	5.9	210	Circumneutral
T19.01	Nse	-24	y	Wm	M	A	A	y	n	6	6	L	L	0	24	nd	8.7	50	Alkaline

Appendix Table 3. (Continued).

Site No.	NWI Regime[1]	Water Depth	Saturated<30 cm	Drainage[2]	Soil Moisture[3]	Mottle Depth	Low Matrix	Hydric Soil	Cryo-turb	SurfOrg (cm)	CumOrg 40 (cm)	DomMineral40	DomText40	Loess Thick (cm)	Thaw Depth	Frost Boil(%)	Site pH	Site EC	Site Chemistry
T19.02	Nsa	-2	y	Pv	W	A	A	y	n	27	27	L	O	0	25	0	5.9	350	Circumneutral
T19.03	Nsa	-2	y	Pv	W	A	A	y	n	27	27	L	O	0	43	0	6	360	Circumneutral
T19.04	Nsa	-2	y	Pv	W	A	A	y	n	29	29	O	O	0	39	0	6.4	220	Circumneutral
T19.05	Nsa	-3	y	Pv	W	A	A	y	n	24	24	L	O	0	32	0	6.4	330	Circumneutral
T19.06	U	-26	n	Wm	M	A	A	n	n	6	6	L	L	0	26	0	7.7	10	Alkaline
T19.07	Nsa	-27	y	Wm	M	10	A	y	n	5	5	L	L	0	27	0	nd	nd	nd
T19.08	Nsa	nd	y	Pv	W	A	A	y	n	34	34	O	O	0	30	0	6.6	320	Circumneutral
T19.09	Np	nd	y	F	A	A	A	nd	nd	nd	nd	nd	nd	nd	nd	0	7.4	280	Circumneutral
T2.01	Np	23	y	F	A	A	2	y	n	2	2	S	S	0	100	0	7.4	280	Circumneutral
T2.02	Nse	1	y	Pv	W	A	21	y	n	10	10	S	S	0	62	0	6.8	140	Circumneutral
T2.03	Nsa	-24	y	Ps	M	18	18	y	y	7	7	S	S	0	32	0	6.1	210	Circumneutral
T2.04	U	-50	n	W	M	A	A	n	y	2	2	L	L	9	36	0	5.5	20	Acidic
T2.05	Nse	0	y	Pv	W	A	A	y	y	25	28	L	O	0	36	0	6.1	210	Circumneutral
T2.06	Nsp	0	y	Pv	W	A	A	y	y	25	25	L	O	8	33	0	6.1	220	Circumneutral
T2.07	Nsa	-30	y	Ps	M	A	A	n	y	7	7	L	L	23	30	1	5.3	30	Acidic
T2.08	Nse	0	y	Pv	W	P	P	y	nd	35	35	O	O	0	35	0	6.1	210	Circumneutral
T2.09	Nsa	-20	y	Wm	M	A	A	y	y	9	9	L	L	11	20	0	5.3	30	Acidic
T2.10	Nsa	-17	y	Pv	M	A	A	y	n	24	24	L	L	9	33	0	5.5	190	Acidic
T20.01	Nsp	8	y	Pv	W	P	P	y	n	30	30	O	O	nd	40	0	6.1	180	Circumneutral
T20.02	Np	125	y	F	A	nd	nd	y	nd	nd	nd	nd	nd	nd	107	0	7.4	150	Circumneutral
T20.03	Nsp	10	y	F	A	P	P	y	n	40	40	O	O	nd	50	0	7.4	150	Circumneutral
T22.01	Np	200	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	150	0	7.3	150	Circumneutral
T22.02	Nse	-101	n	W	M	A	A	n	n	0	0	S	S	nd	101	0	6.8	50	Circumneutral
T22.03	Nse	-100	n	Es	D	A	A	n	n	0	5.5	S	S	0	75	0	8	90	Alkaline
T22.04	U	-120	n	Es	D	A	A	n	n	0.5	0.5	S	S	0	150	0	8.5	80	Alkaline
T22.05	Nsa	-5	y	Pv	W	11	A	y	n	13	39.5	L	O	0	46	0	6.6	1080	Circumneutral
T22.06	Nsa	-1	y	Pv	W	A	A	y	n	40	40	O	O	0	40	0	6.9	860	Circumneutral
T22.07	Nsa	-18	y	Ps	M	A	A	y	y	18	26.5	O	O	0	27	0	6.9	500	Circumneutral
T22.08	U	-95	n	Es	D	A	A	n	n	0	0	S	S	0	95	0	6.6	80	Circumneutral
T22.09	Np	17	y	F	A	nd	nd	y	n	26	26	O	O	0	26	0	6.7	240	Circumneutral
T23.01	Nse	0	y	Pv	W	A	A	y	n	22	22	L	O	0	38	0	5.6	150	Circumneutral
T23.02	Nsa	-28	y	Wm	M	A	A	y	n	10	10	L	L	0	28	0	6.4	6	Circumneutral
T23.03	Nsa	-28	y	Wm	M	A	11	y	n	11	11	L	L	0	28	0	6.2	30	Circumneutral
T23.04	Nsa	-27	y	Wm	M	A	13	y	n	12	12	L	L	0	27	0	5.9	50	Circumneutral
T23.05	Nsa	-23	y	Ps	M	A	A	y	n	15	15	S	S	0	35	0	5.8	170	Circumneutral
T23.06	U	-43	n	Wm	M	A	A	n	n	4	4	S	S	0	43	0	6.6	100	Circumneutral
T23.07	Nsa	-24	y	Wm	M	A	A	y	n	4	4	L	L	0	24	0	5.9	30	Circumneutral
T23.08	Nsa	-30	y	Wm	M	A	A	y	n	15	15	L	L	0	30	0	4.8	70	Acidic
T23.09	Nsp	0	y	Pv	W	A	A	y	n	29	29	S	S	0	43	0	5.7	200	Circumneutral
T23.10	Np	30	y	F	A	nd	nd	y	n	0	0	S	S	0	70	0	6.4	200	Circumneutral
T25.01	Np	100	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	150	0	7.2	190	Circumneutral
T25.02	Nse	-120	n	E	M	A	A	n	n	0	0	S	S	0	120	0	8.3	60	Alkaline
T25.03	Nse	-150	n	E	M	A	A	n	n	0	0	S	S	0	150	0	8.2	50	Alkaline
T25.04	Nse	-150	n	E	M	A	A	n	n	0	1	S	S	0	150	0	8	50	Alkaline
T25.05	U	-150	n	E	M	A	A	n	n	0	1	S	S	0	150	0	8.2	50	Alkaline
T25.06	U	-150	n	E	D	A	A	n	n	0	0	S	S	0	150	0	8.4	50	Alkaline
T25.07	U	-115	n	Es	M	A	A	n	n	2	4	S	S	0	115	0	8.1	60	Alkaline
T25.08	Np	120	y	F	A	nd	nd	y	nd	nd	nd	L	L	nd	nd	0	7.5	120	Alkaline
T25.09	Nsa	-20	y	Ps	M	nd	nd	y	n	9	9	S	S	0	100	0	6.7	1100	Circumneutral
T25.10	U	-44	n	Wm	M	27	A	y	n	3	12	S	S	0	55	0	6.6	70	Circumneutral
T25.11	Np	30	y	F	A	nd	nd	y	nd	nd	nd	L	O	0	55	0	8.2	450	Alkaline
T26.01	U	-37	n	Wm	M	A	10	n	y	8	11	S	S	0	37	0	6.7	100	Circumneutral
T26.02	Nsa	-28	y	Ps	M	10	14	y	y	9	14	S	S	0	96	0	6.6	880	Circumneutral
T26.03	Np	42	y	F	A	A	A	y	n	62	40	O	O	0	62	0	6.9	120	Circumneutral
T26.04	Np	37	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	0	150	0	7.3	90	Circumneutral
T26.05	Nsa	-23	y	Ps	M	15	A	y	y	26	26	S	O	0	26	0	6.7	210	Circumneutral
T26.06	Nsp	10	y	F	A	A	A	y	n	46	40	O	O	0	46	0	6.7	170	Circumneutral
T26.06a	Nsa	-15	y	Ps	M	nd	nd	y	n	nd	nd	O	nd	0	nd	0	nd	nd	nd
T26.07	Nsp	12	y	F	A	A	A	y	n	42	40	O	O	0	42	0	6.5	120	Circumneutral
T26.08	Nsa	-32	n	Ps	M	13	8	y	y	9	9	L	L	0	32	0	5.7	40	Circumneutral
T26.09	U	-34	N	Ps	M	A	11	y	y	10	22	L	O	0	34	0	6.7	40	Circumneutral
T3.01	Np	150	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	nd	nd	7.7	130	Alkaline
T3.02	Nse	-49	n	Wm	M	27	8	n	n	0	5	S	S	0	89	0	7.2	780	Circumneutral
T3.03	U	-72	n	W	M	A	A	n	n	0	14	S	S	0	72	0	7.7	210	Alkaline
T3.04	U	-85	n	W	M	10	10	n	n	0	0	S	S	0	120	0	7.8	140	Alkaline
T3.05	U	-173	n	Es	D	A	A	n	n	0	0	S	S	0	173	0	8.5	100	Alkaline
T3.06	Nsa	-30	y	Ps	M	9	9	y	n	2	2	L	L	0	70	0	6.9	800	Circumneutral
T3.07	Nsa	-2	y	Pv	W	29	29	y	n	23	25	L	O	0	54	0	7.6	470	Alkaline
T3.08	U	-60	n	W	D	A	A	n	n	0.5	0.5	S	S	0	85	0	8.1	110	Alkaline
T3.09	Nsa	-4	y	Pv	W	P	P	y	n	7	30	L	O	0	34	0	7.1	390	Circumneutral
T3.10	U	-55	n	Wm	M	29	A	n	n	0	0	S	S	0	84	0	7.6	220	Alkaline
T4.01	Np	30	y	F	A	nd	nd	y	n	nd	nd	nd	nd	0	33	0	7.9	210	Alkaline
T4.02	Nsa	-24	y	Ps	M	7	18	y	n	7	7	S	S	0	43	0	7	650	Circumneutral
T4.03	U	-104	n	W	D	A	A	n	n	0	0	S	S	0	104	0	8.2	70	Alkaline
T4.04	Nsa	4	y	Pv	W	A	8	y	n	8	10	S	S	0	55	0	7.7	390	Alkaline
T4.05	U	-100	n	Es	D	A	A	n	n	0	0	S	S	0	102	0	8.3	120	Alkaline

Appendix Table 3. (Continued).

Site No.	NWI Regime[1]	Water Depth	Saturated<30 cm	Drainage[2]	Soil Moisture[3]	Mottle Depth	Low Matrix	Hydric Soil	Cryo-turb	SurfOrg (cm)	CumOrg 40 (cm)	DomMineral40	DomText 40	Loess Thick (cm)	Thaw Depth	Frost Boil(%)	Site pH	Site EC	Site Chemistry
T4.06	Np	60	y	F	A	nd	nd	y	nd	nd	nd	nd	nd	nd	45	0	8.3	250	Alkaline
T4.07	Nsa	-33	y	Ps	M	P	P	y	n	6	22	S	O	0	53	0	7.6	160	Alkaline
T4.08	Nsa	-10	y	Pv	W	P	P	y	n	4	37	O	O	0	43	0	7.1	420	Circumneutral
T4.09	Nsa	-42	y	Ps	M	A	21	y	n	5	5	L	L	0	48	0	6.8	180	Circumneutral
T4.10	Nsa	-20	y	Ps	M	A	22	y	y	22	22	L	O	0	40	0	6.9	80	Circumneutral
T4.11	Np	30	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	46	0	8.4	290	Alkaline
T5.01	Np	200	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	nd	nd	6.5	120	Circumneutral
T5.02	U	-80	n	Es	M	A	A	n	n	0	2	S	S	0	80	0	6.5	50	Circumneutral
T5.03	U	-100	n	Es	M	A	A	n	n	0	2	S	S	0	85	0	6.5	30	Circumneutral
T5.04	U	-100	n	Es	M	A	A	n	n	0	0	S	S	0	85	0	6.5	40	Circumneutral
T5.05	Nsa	-44	y	Wm	M	17	20	y	n	3	6	S	S	0	57	0	7	530	Circumneutral
T5.06	U	-50	n	W	D	A	A	n	n	2	4	S	S	0	100	0	6.5	60	Circumneutral
T5.07	U	-50	n	W	D	A	A	n	n	2	4	S	S	0	90	0	6.5	40	Circumneutral
T5.08	Nsa	-36	y	Ps	M	15	28	y	n	4	6	S	S	0	67	0	7	650	Circumneutral
T5.09	Nsa	-32	y	Ps	M	A	25	y	n	3	6	L	L	0	70	0	6.8	900	Circumneutral
T5.10	Np	25	y	F	A	nd	nd	y	nd	32	32	S	O	0	32	0	6.5	320	Circumneutral
T5.12	Nsa	-3	y	Pv	W	nd	nd	y	n	34	34	O	O	0	34	0	7.1	450	Circumneutral
T6.01	Np	150	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	nd	nd	5.8	110	Circumneutral
T6.02	U	-72	n	W	M	A	A	n	n	0	0	S	S	0	102	0	7	30	Circumneutral
T6.03	U	-90	n	W	M	A	A	n	n	0	0	S	S	0	123	0	6.5	40	Circumneutral
T6.04	U	-62	n	Wm	M	26	A	y	n	1	3	L	L	0	94	0	6.1	100	Circumneutral
T6.05	U	-100	n	W	D	A	A	n	n	2	8	S	S	0	100	0	6.8	60	Circumneutral
T6.06	Nsp	2	y	Pv	W	P	P	y	n	3	35	L	O	0	45	0	6.8	560	Circumneutral
T6.07	Nsa	-15	y	Ps	M	8	A	y	n	3	10	S	S	0	53	0	6.8	810	Circumneutral
T6.08	Nse	-8	y	Pv	W	P	10	y	n	2	16	L	L	0	52	0	7.1	910	Circumneutral
T6.09	Nse	-4	y	Pv	W	P	8	y	y	27	32	L	O	0	40	0	5.3	100	Acidic
T6.10	Nsa	-14	y	Ps	M	5	A	y	y	5	15	S	S	0	34	0	5.6	110	Circumneutral
T6.11	U	-100	n	W	M	A	A	n	y	13	19	S	S	0	75	0	5	50	Acidic
T7.01	Np	100	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	nd	nd	5.6	180	Circumneutral
T7.02	Nse	-125	n	E	M	A	A	n	n	1	1	S	S	0	120	0	5.3	40	Acidic
T7.03	Nse	-125	n	E	M	A	A	n	n	0	0	S	S	0	120	0	5.3	30	Acidic
T7.04	U	-125	n	E	M	A	A	n	n	0	0	S	S	0	120	0	5.3	10	Acidic
T7.05	U	-125	n	E	M	A	A	n	n	0	0	S	S	0	120	0	nd	20	nd
T7.06	Nsa	-35	y	Ps	M	32	14	y	n	2	2	S	S	0	120	0	5.8	720	Circumneutral
T7.07	Nsa	-3	y	Pv	W	A	A	y	n	12	12	S	S	0	56	0	6.8	640	Circumneutral
T7.08	U	-50	n	W	D	nd	nd	nd	nd	nd	nd	nd	S	nd	nd	nd	nd	nd	nd
T7.09	Nsa	-17	y	Ps	M	A	16	y	n	16	16	S	S	0	43	0	6.5	610	Circumneutral
T7.10	nd	nd	nd	Wm	nd	nd	nd	nd	nd	3	13	L	L	nd	72	nd	nd	nd	nd
T8.01	Np	200	y	F	A	nd	nd	nd	nd	0	0	nd	nd	nd	nd	0	8.3	150	Alkaline
T8.02	U	nd	n	Es	M	A	A	n	n	0	0	S	S	0	115	0	8.5	40	Alkaline
T8.03	U	-150	n	E	D	A	A	n	n	0	0	S	S	0	150	0	8.3	40	Alkaline
T8.04	U	-110	n	W	D	91	A	n	n	0	0	S	S	0	125	0	8.3	40	Alkaline
T8.05	Nsa	-15	y	Ps	W	A	30	y	n	18	22	L	O	0	82	0	7.1	230	Circumneutral
T8.06	Nsp	5	y	Pv	W	P	P	y	n	16	38	O	O	0	42	0	7.4	510	Circumneutral
T8.07	U	-108	n	Es	M	9	A	n	y	0	0	S	S	9	108	0	8	100	Alkaline
T8.08	Np	15	y	F	A	P	P	y	y	40	40	O	O	0	38	0	8.3	320	Alkaline
T8.09	Nsa	-20	y	Ps	M	P	P	y	n	50	40	O	O	0	48	0	7	720	Circumneutral
T9.01	Nsa	-23	y	Wm	M	12	A	y	y	8	13	L	L	10	23	0	5.4	120	Acidic
T9.02	Nsp	-2	y	Pv	W	A	28	y	y	9	33	S	O	0	38	0	5.8	210	Circumneutral
T9.03	Np	100	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.6	120	Circumneutral
T9.04	Nsp	4	y	Pv	W	A	29	y	n	25	25	L	O	0	46	0	7.1	160	Circumneutral
T9.05	Nsa	-4	y	Pv	W	A	18	y	n	18	18	L	L	0	28	0	5.4	60	Acidic
T9.06	Nsa	-6	y	Pv	W	A	18	y	n	18	18	L	L	0	20	0	5.7	80	Circumneutral
T9.07	Nsa	-13	y	P	W	A	13	y	n	13	13	L	L	0	22	0	5.5	50	Acidic
T9.08	Nsp	0	y	Pv	W	A	12	y	n	16	16	L	L	0	36	0	6.3	300	Circumneutral
T9.09	Nsa	-8	y	Pv	W	A	14	y	n	14	16	S	S	0	63	0	6.4	350	Circumneutral
T9.10	U	-20	n	Wm	M	A	A	y	y	9	9	L	L	>11	20	0	5.6	60	Circumneutral

[1] NWI Regime. Tidal: Ti = Irregularly flooded. Non-tidal: Np = Permanently flooded, Nsp = Semi-permanently flooded, Nse = Seasonally flooded, Nsa = Saturated. U = Upland. nd = no data.

[2] Drainage. E = Excessive, Es = Somewhat excessive, W = Well, Wm = Moderately well, Ps = Somewhat poorly, P = Poorly, Pv = Very poorly, F = Flooded, nd = no data.

[3] Soil Moisture. D = Dry, M = Moist, W = Wet, A = Aquatic, nd = no data.

Appendix Table 4. System for aggregating geomorphic, surface form and vegetation classes into ecotypes (local-scale ecosystems) and wildlife habitats in the Northeastern Planning Area of the NPRA, 2002.

ECOTYPE	HABITAT CLASS	ITU CODE	
Upland Dry Tall Willow Shrub	Upland Low and Tall Shrub	Esa/Ek/Stow	Esa/Es/Stow
Upland Moist Low Willow Shrub	Upland Low and Tall Shrub	Esi/Ek/Slow	Ltim/Sb/Slow
		Esi/Es/Slow	Ltip/Phh/Slow
		Esi/Sb/Slow	Mp/Sb/Slow
		Ltic/Sb/Slow	
Upland Dry Dryas Dwarf Shrub	Upland and Riverine Dwarf Shrub	Esi/Ek/Sddt	Ltim/Phl/Sddt
		Esi/Es/Sddt	Ltip/Phl/Sddt
		Esi/Phh/Sddt	Mp/N/Sddt
		Esi/Phl/Sddt	Mp/Phl/Sddt
		Fto/Phl/Sddt	
Upland Moist Cassiope Dwarf Shrub	Upland and Riverine Dwarf Shrub	Esi/Es/Sdec	Ltic/Sb/Sdec
		Esi/Phl/Sdec	Ltim/Sb/Sdec
		Esi/Sb/Sdec	Mp/Sb/Sdec
		Fto/Sb/Sdec	
Upland Moist Tussock Meadow	Moist Tussock Tundra	Esi/Phh/Hgmt	Ltic/Pm/Hgmt
		Esi/Phl/Hgmt	Ltic/Tm/Hgmt
		Esi/Tm/Hgmt	Ltim/Phh/Hgmt
		Fdob/Tm/Hgmt	Ltim/Phl/Hgmt
		Fmob/Phh/Hgmt	Ltim/Tm/Hgmt
		Fmob/Phl/Hgmt	Ltip/Phh/Hgmt
		Fmob/Tm/Hgmt	Ltip/Phl/Hgmt
		Fto/Phh/Hgmt	Ltip/Tm/Hgmt
		Fto/Phl/Hgmt	Mp/Phh/Hgmt
		Fto/Tm/Hgmt	Mp/Phl/Hgmt
		Ltic/Phh/Hgmt	Mp/Tm/Hgmt
		Ltic/Phl/Hgmt	
Upland Dry Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Esa/Ek/Bpv	Esi/Sb/Bpv
		Esa/Es/Bpv	
Lowland Moist Low Willow Shrub	Moist Sedge–Shrub Meadow	Esi/Phl/Slow	Ltic/Pm/Slow
		Fmob/Phh/Slow	Ltim/Phl/Slow
		Fmob/Phl/Slow	Ltim/Pm/Slow
		Fto/Dt/Slow	Mp/Dt/Slow
		Fto/Phl/Slow	Mp/Phh/Slow
		Ltic/Phh/Slow	Mp/Phl/Slow
		Ltic/Phl/Slow	Mp/Pm/Slow
Lowland Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Meadow	Cs/Mg/Hgmss	Fto/Tm/Hgmss
		Cs/Phl/Hgmss	Ltic/Dt/Hgmss
		Esi/Es/Hgmss	Ltic/Phh/Hgmss
		Esi/Phh/Hgmss	Ltic/Phl/Hgmss
		Esi/Phl/Hgmss	Ltic/Pm/Hgmss
		Esi/Pm/Hgmss	Ltic/Tm/Hgmss
		Esi/Tm/Hgmss	Ltim/Dt/Hgmss
		Fdob/Pm/Hgmss	Ltim/Phh/Hgmss
		Fdob/Tm/Hgmss	Ltim/Phl/Hgmss
		Fmob/Phh/Hgmss	Ltim/Plll/Hgmss
		Fmob/Phl/Hgmss	Ltim/Pm/Hgmss

Appendix Table 4. (Continued).

ECOTYPE	HABITAT CLASS	ITU CODE	
		Fmob/Plhh/Hgmss	Ltim/Tm/Hgmss
		Fmob/Pm/Hgmss	Mp/Dt/Hgmss
		Fmob/Tm/Hgmss	Mp/Phl/Hgmss
		Fto/Dt/Hgmss	Mp/Pm/Hgmss
		Fto/Phh/Hgmss	Mp/Sb/Hgmss
		Fto/Phl/Hgmss	Mp/Tm/Hgmss
		Fto/Pm/Hgmss	
Lowland Wet Sedge Meadow	Nonpatterned Wet Meadow	Esi/Pd/Hgwst	Ltim/N/Hgwst
		Ltic/N/Hgwst	Ltim/Pd/Hgwst
		Ltic/Pd/Hgwst	Mp/Pd/Hgwst
	Patterned Wet Meadow	Esi/Dt/Hgwst	Ltic/Plhh/Hgwst
		Esi/Plll/Hgwst	Ltic/Plhl/Hgwst
		Fdob/Plhh/Hgwst	Ltic/Pllh/Hgwst
		Fdob/Pllh/Hgwst	Ltic/Plll/Hgwst
		Fdob/Plll/Hgwst	Ltim/Dt/Hgwst
		Fmob/Plhh/Hgwst	Ltim/Ms/Hgwst
		Fmob/Pllh/Hgwst	Ltim/Plhl/Hgwst
		Fmob/Plll/Hgwst	Ltim/Pllh/Hgwst
		Fto/Dt/Hgwst	Ltim/Plll/Hgwst
		Fto/Pllh/Hgwst	Ltiu/Plll/Hgwst
		Fto/Plll/Hgwst	Mp/Dt/Hgwst
		Ltic/Dt/Hgwst	Mp/Pllh/Hgwst
		Ltic/Ms/Hgwst	Mp/Plll/Hgwst
Lowland Sedge Marsh	Aquatic Sedge Marsh	Esi/Pd/Hgwfs	Ltim/Pd/Hgwfs
		Fdob/Pd/Hgwfs	Ltim/Pllh/Hgwfs
		Fto/Pd/Hgwfs	Ltiu/Pd/Hgwfs
		Ltic/Pd/Hgwfs	Mp/N/Hgwfs
		Ltim/N/Hgwfs	Mp/Pd/Hgwfs
Lowland Lake	Deep Open Water without Islands	Wldit/W/W	
	Deep Open Water with Islands or Polygonized Margins	Wldit/Lp/W Wldit/Wi/W	Wlsit/Wi/W
	Shallow Open Water without Islands	Wlsit/W/W	
	Shallow Open Water with Islands or Polygonized Margin	Wlsit/Lp/W	
Lowland Basin Complex	Old Basin Wetland Complex (Ice-rich)	Ltic/Xb/Xbo Ltim/Xb/Xbo	Ltiu/Xb/Xbo
Lowland Deep-polygon Complex	Aquatic Sedge with Deep Polygons	Fdob/Plhh/Xp	
Lacustrine Moist Low Willow Shrub	Moist Sedge–Shrub Meadow	Ltnc/N/Slow	Ltnm/N/Slow
Lacustrine Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Meadow	Ltnc/N/Hgmss	Ltnm/Pd/Hgmss
		Ltnc/Pm/Hgmss	Ltnm/Pm/Hgmss
		Ltnm/N/Hgmss	
Lacustrine Wet Sedge Meadow	Nonpatterned Wet Meadow	Ltdn/Pd/Hgwst	Ltnm/N/Hgwst
		Ltnc/N/Hgwst	Ltnm/Pd/Hgwst
		Ltnc/Pd/Hgwst	
	Patterned Wet Meadow	Ltnc/Ms/Hgwst	Ltnm/Ms/Hgwst
Lacustrine Sedge Marsh	Aquatic Sedge Marsh	Ltnc/N/Hgwfs	Ltnm/Pd/Hgwfs
		Ltnc/Pd/Hgwfs	Wlsit/W/Hgwfs
		Ltnm/N/Hgwfs	Wlsit/Wi/Hgwfs
Lacustrine Grass Marsh	Aquatic Grass Marsh	Ltnc/N/Hgwfg	Wlsct/W/Hgwfg

Appendix Table 4. (Continued)

ECOTYPE	HABITAT CLASS	ITU CODE	
		Ltnc/Pd/Hgwfg	Wlsit/W/Hgwfg
		Ltnm/N/Hgwfg	Wlsit/Wi/Hgwfg
Lacustrine Moist Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Ltnc/N/Bpv	Ltnm/N/Bpv
Lacustrine Basin Complex	Young Basin Wetland Complex (Ice-poor)	Ltnm/Xb/Xby	
Riverine Moist Tall Willow Shrub	Riverine Low and Tall Shrub	Fdoa/Mu/Stow	Fmoa/Mu/Stow
		Fdoa/N/Stow	Fmoa/N/Stow
		Fmoa/Mu/Stcw	
Riverine Moist Low Willow Shrub	Riverine Low and Tall Shrub	Fdoa/N/Slcw	Fmoi/N/Slcw
		Fdoa/N/Slow	Fmoi/N/Slow
		Fdoi/N/Slow	Fmoi/Pd/Slow
		Fdoi/Pd/Slow	Fmoi/Phh/Slow
		Fdoi/Phl/Slow	Fmoi/Phl/Slow
		Fdri/N/Slow	Fmoi/Plll/Slow
		Fhl/N/Slcw	Fmoi/Pm/Slow
		Fhl/N/Slow	Fmrif/N/Slow
		Fmoa/N/Slow	
Riverine Dry Dryas Dwarf Shrub	Upland and Riverine Dwarf Shrub	Fdoi/N/Sddt	Fmoi/N/Sddt
		Fdoi/Phl/Sddt	
Riverine Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Meadow	Fdoi/N/Hgmss	Fmoi/N/Hgmss
		Fdoi/Phl/Hgmss	Fmoi/Phh/Hgmss
		Fdoi/Pm/Hgmss	Fmoi/Phl/Hgmss
		Fdri/N/Hgmss	Fmoi/Pm/Hgmss
		Fhl/N/Hgmss	Fmoi/Tm/Hgmss
		Fhl/Phl/Hgmss	Fmrif/N/Hgmss
		Fhl/Pm/Hgmss	Fmrif/Pm/Hgmss
		Fhl/Tm/Hgmss	
Riverine Wet Sedge Meadow	Nonpatterned Wet Meadow	Fdoi/N/Hgwst	Fmoa/Pd/Hgwst
		Fdoi/Pd/Hgwst	Fmoi/N/Hgwst
		Fdri/N/Hgwst	Fmoi/Pd/Hgwst
		Fhl/N/Hgwst	Fmrif/N/Hgwst
		Fhl/Tb/Hgwst	Fmrif/Pd/Hgwst
		Fmoa/N/Hgwst	
	Patterned Wet Meadow	Fdoi/Plhl/Hgwst	Fmoi/Pllh/Hgwst
		Fdoi/Plll/Hgwst	Fmoi/Plll/Hgwst
		Fhl/Plll/Hgwst	Fmrif/Plll/Hgwst
		Fmoi/Plhh/Hgwst	
Riverine Sedge Marsh	Aquatic Sedge Marsh	Fdoi/Pd/Hgwfs	Fmrif/Pd/Hgwfs
		Fdra/N/Hgwfs	Wlsir/W/Hgwfs
		Fdri/N/Hgwfs	Wlsir/Wi/Hgwfs
		Fhl/N/Hgwfs	Wlsirt/Lp/Hgwfs
		Fmoi/N/Hgwfs	Wlsirt/W/Hgwfs
		Fmoi/Pd/Hgwfs	Wlsirt/Wi/Hgwfs
		Fmrif/N/Hgwfs	
Riverine Grass Marsh	Aquatic Grass Marsh	Wlscr/W/Hgwfg	Wlsir/Wi/Hgwfg
		Wlscr/Wi/Hgwfg	Wlsirt/W/Hgwfg
		Wlscrh/W/Hgwfg	Wlsirt/Wi/Hgwfg
		Wlsir/W/Hgwfg	

Appendix Table 4. (Continued).

ECOTYPE	HABITAT CLASS	ITU CODE	
Riverine Lake	Deep Open Water without Islands	Wldcr/W/W	Wldir/W/W
		Wldcrt/W/W	Wldirt/W/W
	Deep Open Water with Islands or Polygonized Margins	Wldcr/Wi/W	Wldir/Wi/W
		Wldcrt/Lp/W	Wldirt/Lp/W
		Wldcrt/Wi/W	Wldirt/Wi/W
		Wldir/Lp/W	
	Shallow Open Water without Islands	Wlscr/W/W	Wlsirt/W/W
		Wlsir/W/W	
	Shallow Open Water with Islands or Polygonized Margin	Wlsir/Lp/W	Wlsirt/Lp/W
		Wlsir/Wi/W	Wlsirt/Wi/W
	Tapped Lake with High-water Connection	Wldcrh/W/W	Wlscrh/W/W
Riverine Moist Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Fmraf/N/Bbg	Fmraf/N/Bpv
Riverine Complex	Riverine Complex	Fhl/Tb/Xr	Fhl/Xr/Xr
Riverine Dune Complex	Dune Complex	Esi/Xd/Xd	
Riverine Deep-polygon Complex	Aquatic Sedge with Deep Polygons	Fdoi/Plhl/Xp	
Coastal Moist Willow Dwarf Shrub	Salt Marsh	Fdoa/N/Sdwh	
Coastal Wet Sedge Meadow	Salt Marsh	Ltdn/N/Hgwhs	Mti/Pd/Hgwhs
		Ltdn/Pd/Hgwhs	Mti/Plhh/Hgwhs
		Mti/N/Hgwhs	Mti/Plll/Hgwhs
Coastal Salt-killed Wet Meadow	Salt-killed Tundra	Ltdn/Pd/Hgwhk	
Coastal Lake	Brackish Water (tidal ponds)	Welt/Lp/W	Welt/Wi/W
		Welt/W/W	
	Tapped Lake with Low-water Connection	Weldl/W/W	Welsl/W/W
		Weldl/Wi/W	
Coastal Moist Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Fdra/N/Bbg	Ltdn/N/Bpv
		Fdra/N/Bpv	
	Tidal Flat	Mta/N/Bbg	Mta/N/Bpv
Tidal River	River or Stream	Wert/W/W	
Nearshore Water	Nearshore Water	Wmn/W/W	
Lower Perennial River	River or Stream	Wrln/W/W	
Headwater Stream	River or Stream	Wrhl/Tb/W	Wrhl/W/W

Appendix Table 5. List of vascular plant species found in the Northeastern Planning Area of the NPRA, 2002. Nomenclature follows Viereck and Little (1972) for shrubs and Hulten (1968) for all other vascular species. Common Synonymies are listed parenthetically.

Betulaceae
- *Betula nana* L..

Caryophyllaceae
- *Melandrium apetalum* (L.) Fenzl.
- *Minuartia* sp.
- *Silene acaulis* L.
- *Stellaria crassifolia* Ehrh.
- *Stellaria humifusa* Rottb.
- *Stellaria longipes* Goldie
- *Stellaria monantha* Hult.
- *Wilhelmsia physodes* (Fisch.) McNeill

Compositae (Asteraceae)
- *Artemisia borealis* Pall.
- *Aster sibiricus* L.
- *Chrysanthemum bipinnatum*
- *Erigeron eriocephalus*
- *Petasites frigidus* (L.) Franchet
- *Saussurea angustifolia*
- *Senecio atropurpureus*

Crassulaceae
- *Sedum rosea* (L.) Scop. ssp. *integrifolia* (Raf.) Hult. (*=Rhodiola integrifolia* Raf.)

Cruciferae (Brassicaceae)
- *Arabis arenicola*
- *Cardamine hyperborea*
- *Cardamine pratensis*
- *Cochlearia officinalis*
- *Parrya nudicaulis*

Cyperaceae
- *Carex aquatilis* Wahlenb. ssp. *aquatilis*
- *Carex atrofusca* Schkuhr
- *Carex bigelowii* Torr.
- *Carex capillaris* L..
- *Carex chordorrhiza* Ehrh.
- *Carex concinna* R. Br.
- *Carex glareosa Wahlenb.* ssp. *amphigena* (Fern.) Hult.
- *Carex holostoma* Drej.
- *Carex krausei* Boeck.
- *Carex maritima* Gunn.
- *Carex membranacea* Hook.
- *Carex misandra* R. Br.
- *Carex nardina* E. Fries
- *Carex rariflora* (Wahlenb.) Smith
- *Carex rotundata* Wahlenb.
- *Carex rupestris* All.
- *Carex saxatilis* L.ssp. *laxa* (Trautv.) Kalela
- *Carex scirpoidea* Michx.
- *Carex subspathacea* Wormsk.
- *Carex vaginata* Tausch
- *Carex Williamsii* Britt.
- *Eriophorum angustifolium* Honck. ssp. *subarcticum* (V. Vassiljev) Hult.
- *Eriophorum russeolum* Fries
- *Eriophorum scheuchzeri* Hoppe
- *Eriophorum vaginatum* L.
- *Kobresia myosuroides* (Vill.) Fiori & Paol.

Empetraceae
- *Empetrum nigrum* L.

Equisetaceae
- *Equisetum arvense* L..
- *Equisetum scirpoides* Michx.
- *Equisetum variegatum* Schleich.

Ericaceae
- *Andromeda polifolia* L.
- *Arctostphylos rubra* (Rehd. & Wilson) Fern. (*=Arctous rubra* (Rehd. & Wilson) Nakai *)*
- *Cassiope tetragona* (L.) D. Don
- *Ledum decumbens* (Ait.) Lodd.
- *Vaccinium uliginosum* L.
- *Vaccinium vitis-idaea* L.

Gentianaceae
- *Gentianella propinqua* (Richards.) Gillet var. *propinqua* (*=Gentiana propinqua* Richards. ssp. *Propinqua)*

Graminae (Poaceae)
- *Agropyron boreale* (Turcz.) Drobov subs. *alaskanum* (Scribn. & Merr.) Melderis *(=Elymus alaskanus)*
- *Agrostis scabra* Willd.
- *Alopecuris alpinus* Sm. ssp. *alpinus*
- *Arctagrostis latifolia* (R. Br.) Griseb.
- *Arctophila fulva* (Trin.) Anderss.
- *Calamagrostis deschampsioides* Trin.
- *Calamagrostis purpurascens* R. Br. ssp. *purpurascens*
- *Deschampsia brevifolia* R. Br.
- *Deschampsia caespitosa* (L.) P. Beauv. ssp. *caespitosa*
- *Dupontia fischeri* R. Br.
- *Festuca rubra* L.
- *Festuca* sp.
- *Festuca vivipara* (L.) Smith
- *Hierchloe alpina* (Sw.) Roem. & Schult.
- *Koeleria asiatica* Domin
- *Poa arctica* R. Br.
- *Poa glauca* M. Vahl.
- *Poa hartzii* R. Br. var. *alaskana* R.J. Soreng.
- *Poa lanata* Scribn. & Merr.
- *Puccinellia langeana* (Berl.) Sorens.
- *Trisetum spicatum* (L.) Richter

Haloragaceae
- *Hippuris vulgaris* L..
- *Myriophyllum spicatum* L.

Juncaceae
- *Juncus arcticus* Willd.
- *Juncus biglumis* L.
- *Juncus castaneus* Smith
- *Juncus stygius* L. ssp. *americanus* (Buchenau) Hult.
- *Luzula arctica* Blytt.
- *Luzula confusa* Lindeb.
- *Luzula multiflora* (Retz.) Lej. var. *frigida* (Buchenau) Hult.
- *Luzula tundricola* Gorodk.

Leguminosae

Appendix Table 5. (Continued).

Astragalus alpinus L..
Astragalus eucosmus Hornem. ssp. *Sealie* (LePage) Hult.
Astragalus umbellatus Bunge
Hedysarum alpinum L.
Hedysarum mackenzii Richards.
Oxytropis arctica R. Br.
Oxytropis campestris (L.) DC.
Oxytropis deflexa (Pall.) DC.
Oxytropis nigrescens (Pall.) Fisch.
Oxytropis viscida Nutt.
Lentibulariaceae
Utricularia intermedia Hayne
Utricularia vulgaris L. ssp. *macrorhiza* (Le Conte) Clausen *(=Utricularia macrorhiza)*
Liliaceae
Tofieldia coccinea Richards.
Tofieldia pusilla (Michx.) Pers.
Onagraceae
Epilobium latifolium L.
Papaveraceae
Papaver lapponicum (Tolm.) Nordh.
Papaver macounii Greene
Papaver sp.
Plumbaginaceae
Armeria maritima (Mill.) Willd. ssp. *arctica* (Cham.) Hult.
Polemoniaceae
Polemonium acutiflorum Willd.
Polygonaceae
Polygonum bistorta L. ssp. *plumosum* (Small) Hult. *(=Bistorta plumosa* Greene*)*
Polygonum viviparum L.
Rumex arcticus Trautv.
Potamogetonaceae
Potamogeton filiformis Pers.
Potamogeton gramineus L..
Pyrolaceae
Pyrola grandiflora Radius
Pyrola secunda L. *(=Orthilia secunda)*
Ranunculaceae
Anemone narcissiflora L.. ssp. *villosissima* (DC.) Hult.
Anemone parviflora Michx.
Caltha palustris L. ssp. *asarifolia* (DC.) Hult.
Ranunculus hyperboreus Rottb.
Ranunculus pallasii Schlect.
Rosaceae
Dryas integrifolia Vahl.
Potentilla palustris (L.) Scop. *(=Comarum palustre* L.*)*
Rubus chamaemorus L..
Salicaceae
Salix alaxensis (Anderss.) Cov.
Salix arctica Pall.
Salix fuscescens Anderss.
Salix glauca L.
Salix lanata L. ssp. *Richardsonii* (Hook)
Salix ovalifolia Trautv.
Salix phlebophylla Anderss.
Salix planifolia Pursch. ssp. *pulchra* (Cham.) Argus
Salix polaris Wahlenb. ssp. *pseudopolaris* (Flod.) Hult.
Salix reticulata L.
Saxifragaceae
Parnassia palustris L.
Saxifraga bronchialis L.
Saxifraga cernua L.
Saxifraga hieracifolia Waldst. & Kit.
Saxifraga hirculis L..
Saxifraga punctata L.
Scrophulariaceae
Castilleja caudata (Pennell) Rebr.
Pedicularis capitata Adams
Pedicularis kanei Durand ssp. *Kanei* *(=Pedicularis lanata* ssp. *Kanei* (Durand)*)*
Pedicularis labradorica Wirsing
Pedicularis langsdorffii Fisch. ssp. *arctica* (R. Br.) Pennell
Pedicularis sudetica Willd.
Pedicularis verticillata L.
Valerianaceae
Valeriana capitata Pall.

Appendix Table 6. List of mosses, liverworts, and lichens found in the Northeastern Planning Area of the NPRA, 2002[1].

Mosses and Liverworts

Aongstroemia longipes (Somm.) B.S.G.
Aulacomnium acuminatum
Aulacomnium palustre (Hedw.) Schwaegr.
Aulacomnium turgidum (Wahlenb.) Schwaegr.
Bartramia pomiformis Hedw.
Blepharostoma trichophyllum (L.) Dum.
Brachythecium mildeanum (Schimp.) Schimp. ex Milde
Brachythecium turgidum (Hartm.) Kindb.
Bryobrittonia longipes (Mitt.) Horton
Bryum aeneum Blytt ex B. S. G.
Bryum pseudotriquetrum (Hedw.) Gaertn. et al.
Bryum subneodamense Kindb.
Calliergon giganteum (Schimp.) Kindb.
Calliergon richardsonii (Mitt.) Kindb. in Warnst.
Campylium arcticum Williams
Campylium polygamum (B.S.G.) C.Jens.
Campylium stellatum (Hedw.) C.Jens.
Catoscopium nigritum (Hedw.) Brid.
Ceratodon purpureus (Hedw.) Brid.
Dicranum acutifolium (Lindb. et H.Arnell) C.Jens.
Dicranum elongatum Schleich. ex Schwaegr.
Dicranum groenlandicum Brid.
Dicranum laevidens Williams
Dicranum spadiceum Zett.
Distichium capillaceum (Hedw.) B.S.G.
Ditrichum flexicaule (Schwaegr.) Hampe
Drepanocladus brevifolius (Lindb.) Warnst.
Drepanocladus polycarpus (Bland. ex Voit) Warnst.
Hylocomium splendens (Hedw.) B.S.G.
Hypnum bambergeri Schimp.
Hypnum lindbergii Mitt.
Hypnum pratense Koch ex Spruce
Leptobryum pyriforme (Hedw.) Wils.
Limprichtia revolvens (Sw.) Loeske
  (=Drepanocladus revolvens)
Meesia triquetra (Richter) Aongstr.
Oncophorus wahlenbergii Brid.
Orthothecium chryseon (Schwaegr. ex Schultes) Schimp.
Philonotis tomentella Molendo
Plagiomnium ellipticum (Brid.) T.Kop.
Platydictya jungermannioides (Brid.) Crum
Pleurozium schreberi (Brid.) Mitt.
Pohlia cruda (Hedw.) Lindb.
Pohlia nutans (Hedw.) Lindb.
Polytrichum juniperinum Hedw.[2]
Polytrichum strictum Brid.
Pseudocalliergon turgescens (T.Jens.) Loeske
Ptilidium ciliare (L.) Hampe
Racomitrium lanuginosum (Hedw.) Brid.

Mosses and Liverworts (cont.)

Rhytidium rugosum (Hedw.) Kindb.
Sanionia uncinata (Hedw.) Loeske
  (=Drepanocladus unciatus (Hedw.) Warnst.)
Scorpidium scorpioides (Hedw.) Limpr.
Sphagnum imbricatum Hornsch. ex Russ.
Sphagnum rubellum Wils.
Sphagnum squarrosum Crome
Sphenolobus minutus (Schreb.) Berggr.
Syntrichia ruralis (Hedw.) Web. et Mohr
Timmia austriaca Hedw.
Tomentypnum nitens (Hedw.) Loeske
  (=Tomenthypnum nitens[2]*)*
Tortella tortuosa (Hedw.) Limpr.
Warnstorfia pseudostraminea (C. Muell.) Tuom. et T. Kop.

Lichens

Alectoria nigricans (Ach.) Nyl.
Alectoria ochroleuca (Hoffm.) A. Massal.
Bryocaulon divergens (Ach.) Kärnefelt
Cetraria islandica (L.) Ach.
Cetrariella delisei (Bory ex Schaerer) Kärnefelt & Thell *(=Cetraria deliseii)*
Cladina arbuscula (Wallr.) Hale & Culb.
Cladina rangiferina (L.) Nyl.
Cladonia gracilis (L.) Willd.
Cladonia pyxidata (L.) Hoffm.
Dactylina arctica (Richardson) Nyl.
Flavocetraria cucullata (Bellardi) Kärnefelt & Thell
  (=Cetraria cucullata (Bell.) Ach.
Flavocetraria nivalis (L.) Kämefelt & Thell
  (=Cetraria nivalis (L.) Ach.)
Japewia tornoënsis (Nyl.) Tønsberg
Masonhalea richardsonii
Nephroma arcticum L. Torss.
Ochrolechia androgyna (Hoffm.) Arnold
Ochrolechia frigida (Sw.) Lynge
Ochrolechia inaequatula (Nyl.) Zahlbr.
Peltigera aphthosa (L.) Willd.
Peltigera malacea (Ach.) Funck[2]
Pertusaria sp.
Physconia muscigena[2]
Rinodina turfacea (Wahlenb.) Körber
Sphaerophorus globosus (Hudson) Vainio
Stereocaulon sp.
Thamnolia vermicularis (Sw.) Ach. ex Schaerer

[1] Nomenclature follows National Plants Database (NRCS 2001) except as noted.
[2] Nomenclature follows Vitt, et al. (1988).

Appendix Table 7. Habitat classification system for the Arctic Coastal Plain of Alaska (modified from Jorgenson et al. 1989).

Class	Codes
MARINE WATERS	**100 O**
Inshore Waters	110 On
Offshore Waters	120 Oo
Sea Ice	130 Oi
COASTAL ZONE	**200 C**
Nearshore Water	201 Cn
Open Nearshore Water	205 Cno
Brackish Ponds (Deep or Shallow)	210 Cnp
Deep	211 Cnpd
without Islands	212 Cnpdw
with Islands	213 Cnpdi
with Polygonized Margins	214 Cnpdp
Shallow	221 Cnps
Tapped Lakes (deltas only)	230 Cnt
Deep	231 Cntd
Low-water Connection	232 Cntdl
High-water Connection	235 Cntdh
Shallow	241 Cnts
Low-water Connection	242 Cntsl
High-water Connection	245 Cntsh
Coastal Wetland Complex	250 Cw
Salt Marsh	251 Cwm
Halophytic Sedge	252 Cwms
Halophytic Grass	253 Cwmg
Halophytic Herb	254 Cwmh
Halophytic Dwarf Willow Scrub	257 Cws
Barren	260 Cb
Coastal Islands	261 Cbi
Coastal Beaches	271 Cbb
Cobble-Gravel	272 Cbbc
Sand	273 Cbbs
Coastal Rocky Shores	275 Cbr
Low	276 Cbrl
Cliffs	277 Cbrc
Tidal Flats	280 Cbt
Salt-killed Tundra	285 Cbk
Causeway	291 Cbc
FRESH WATERS	**300 W**
Open Water	305 Wo
Deep Open Lakes	310 Wod
Isolated	311 Wodi
without Islands	312 Wodiw
with Islands	313 Wodii
with Polygonized Margins	314 Wodip
Connected	315 Wodc
Shallow Open Water (Isolated or Connected)	320 Wos
without Islands	322 Wosw
with Islands	323 Wosi
with Polygonized Margins	324 Wosp
Rivers and Streams	330 Wr
Tidal	331 Wrt
Lower Perennial	341 Wrl
Upper Perennial	351 Wru
Deep Pools	352 Wrud
Shallow	353 Wrup
Riffles	354 Wrur
Falls	355 Wruf
Intermittent	356 Wri
Water with Emergents (Shallow, Isol. or Conn.)	360 We
Aquatic Sedge	361 Wes
without Islands	362 Wesw
with Islands	363 Wesi
Deep Polygon Centers	364 Wesp
Aquatic Grass	371 Weg
without Islands	372 Wegw
with Islands	373 Wegi
Aquatic Herb	381 Weh
without Islands	382 Wehw
with Islands	383 Wehi
Impoundment	390 Wi
Drainage Impoundment	391 Wid
Effluent Reservoir	395 Wie
BASIN WETLAND COMPLEXES	**400 B**
Young (non-ice rich)	401 By
Old (ice-rich)	405 Bo
RIVERINE COMPLEX	**410 R**
RIVERINE DUNE COMPLEX	**420 Dx**
MEADOWS	**500 M**
Wet Meadows	510 Mw
Nonpatterned	511 Mwn
Sedge (*Carex, Erioph.*)	512 Mwns
Sedge-Grass (*Carex, Dupontia*)	516 Mwng
Low Relief	521 Mwl
Sedge	522 Mwls
High Relief (Sedge-Willow)	531 Mwh
Sedge	532 Mwhs
Moist Meadows	540 Mm
Low Relief	541 Mml

Appendix Table 7. (Continued).

Class	Codes	Class	Codes
Sedge-Dwarf Shrub Tundra	542 Mmls	Partially Vegetated	815 Pfp
Tussock Tundra	546 Mmlt	Eolian Barrens	820 Pe
Herb	548 Mmlh	Barren	821 Peb
High Relief	551 Mmh	Partially Vegetated	825 Pep
Sedge-Dwarf Shrub Tundra	552 Mmhd	Upland Barrens (talus, ridges, etc.)	830 Pu
Tussock Tundra	556 Mmht	Barren	831 Pub
Dry Meadows	560 Md	Partially Vegetated	835 Pup
Grass	561 Mdg	Lacustrine Barrens (shore bottoms, margins)	840 Pl
Herb	566 Mdh	Barren	841 Plb
SHRUBLANDS	**600 S**	Partially Vegetated	845 Plp
Riverine Shrub	605 Sr	Alpine	860 Pa
Riverine Tall Shrub	610 Srt	Cliffs (Rocky)	871 Pc
Riverine Low Shrub	611 Srl	Bluffs (Unconsolidated)	875 Pb
Willow	612 Srlw	Barren (Unstable)	876 Pbb
Birch	615 Srlb	Partially Vegetated (Stable)	877 Pbv
Alder	618 Srla	Burned Areas (Barren)	880 Pr
Riverine Dwarf Shrub	621 Srd		
Dryas	622 Srdd	**ARTIFICIAL**	**900 A**
Upland Shrub	630 Su	Fill	910 Af
Upland Low Shrub	631 Sul	Gravel	911 Afg
Mixed Shrub Tundra	632 Sulm	Barren or Partially Vegetated	912 Afgb
Willow	635 Sulw	Vegetated	913 Afgv
Alder	638 Sula	Medium-grained	920 Afm
Upland Dwarf Shrub	641 Sud	Barren or Partially Vegetated	921 Afmb
Dryas	642 Sudd	Vegetated	925 Afmv
Ericaceous	645 Sude	Sod (Organic-Mineral)	930 Afs
Lowland Shrub (including bogs)	650 Sl	Barren or Partially Vegetated	931 Afsb
Lowland Low Shrub Bog	651 Sll	Vegetated	935 Afsv
Mixed Shrub	652 Sllm	Excavations	940 Ae
Lowland Dwarf Shrub	661 Sld	Gravel	941 Aeg
Ericaceous	662 Slle	Barren or Partially Vegetated	942 Aegb
Willow	663 Sllw	Vegetated	945 Aegv
		Structure and Debris	950 As
PARTIALLY VEGETATED	**800 P**		
Riverine Barrens (including deltas)	810 Pf		
Barren	811 Pfb		

Appendix Table 8. Comparison of ecotype, wildlife habitat, vegetation, and NPRA landcover classes in the Northeastern Planning Area of the NPRA, 2002

Ecotype	Habitat Class	Vegetation Class	Landcover Class
Upland Dry Tall Willow Shrub	Upland Low and Tall Shrub	Open and Closed Tall Willow Shrub	Tall Shrub, Low Shrub
Upland Moist Low Willow Shrub	Upland Low and Tall Shrub	Open and Closed Low Willow Shrub	Low Shrub, Dwarf Shrub
Upland Dry Dryas Dwarf Shrub	Upland and Riverine Dwarf Shrub	Dryas Dwarf Shrub Tundra	Dwarf Shrub, Moss/Lichen Tundra
Upland Moist Cassiope Dwarf Shrub	Upland and Riverine Dwarf Shrub	Cassiope Dwarf Shrub Tundra	Dwarf Shrub
Upland Moist Tussock Meadow	Moist Tussock Tundra	Tussock Tundra	Tussock Tundra, Dwarf Shrub
Upland Dry Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Barren and Partially Vegetated	Dunes/Dry Sand Barrens, Moss/Lichen Tundra, Sparsely Vegetated
Lowland Moist Low Willow Shrub	Moist Sedge–Shrub Meadow	Open and Closed Low Willow Shrub	Low Shrub, Dwarf Shrub
Lowland Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Tundra	Moist Sedge/Grass Meadow
Lowland Wet Sedge Meadow	Nonpatterned Wet Meadow	Wet Sedge Meadow Tundra	Flooded Tundra (Nonpattern), Wet Tundra
	Patterned Wet Meadow		Flooded Tundra (Low-centered Polygons)
Lowland Sedge Marsh	Aquatic Sedge Marsh	Fresh Sedge Marsh	Flooded Tundra (Nonpattern), Aquatic-Carex
Lowland Lake	Deep Open Water without Islands	Water	Clear Water (Deep)
	Deep Open Water with Islands or Polygonized Margin		Clear Water (Deep)
	Shallow Open Water without Islands		Turbid and Shallow Water
	Shallow Open Water with Islands or Polygonized Margin		Turbid and Shallow Water
Lowland Basin Complex	Old Basin Wetland Complex (Ice-rich)	Old Basin Complex	na
Lowland Deep-polygon Complex	Aquatic Sedge with Deep Polygons	Deep Polygon Complex	na
Lacustrine Moist Low Willow Shrub	Moist Sedge–Shrub Meadow	Open and Closed Low Willow Shrub	Low Shrub, Dwarf Shrub
Lacustrine Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Tundra	Moist Sedge/Grass Meadow
Lacustrine Wet Sedge Meadow	Nonpatterned Wet Meadow	Wet Sedge Meadow Tundra	Flooded Tundra (Nonpattern), Wet Tundra
	Patterned Wet Meadow		Flooded Tundra (Low-centered Polygons)
Lacustrine Sedge Marsh	Aquatic Sedge Marsh	Fresh Sedge Marsh	Flooded Tundra (Nonpattern), Aquatic-Carex
Lacustrine Grass Marsh	Aquatic Grass Marsh	Fresh Grass Marsh	Aquatic-Arctophilla
Lacustrine Moist Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Barren and Partially Vegetated	Mud Barrens, Sparsely Vegetated, Moss/Lichen Tundra
Lacustrine Basin Complex	Young Basin Wetland Complex (Ice-poor)	Young Basin Complex	na
Riverine Moist Tall Willow Shrub	Riverine Low and Tall Shrub	Open and Closed Tall Willow Shrub	Tall Shrub, Low Shrub
Riverine Moist Low Willow Shrub	Riverine Low and Tall Shrub	Open and Closed Low Willow Shrub	Low Shrub, Dwarf Shrub
Riverine Dry Dryas Dwarf Shrub	Upland and Riverine Dwarf Shrub	Dryas Dwarf Shrub Tundra	Dwarf Shrub
Riverine Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Meadow	Moist Sedge–Shrub Tundra	Moist Sedge/Grass Meadow
Riverine Wet Sedge Meadow	Nonpatterned Wet Meadow	Wet Sedge Meadow Tundra	Flooded Tundra (Nonpattern), Wet Tundra
	Patterned Wet Meadow		Flooded Tundra (Low-centered Polygons)
Riverine Sedge Marsh	Aquatic Sedge Marsh	Fresh Sedge Marsh	Flooded Tundra (Nonpattern), Aquatic-Carex
Riverine Grass Marsh	Aquatic Grass Marsh	Fresh Grass Marsh	Aquatic-Arctophilla
Riverine Lake	Deep Open Water without Islands	Water	Clear Water (Deep)
	Deep Open Water with Islands or Polygonized Margin		Clear Water (Deep)
	Shallow Open Water without Islands		Turbid and Shallow Water
	Shallow Open Water with Islands or Polygonized Margin		Turbid and Shallow Water
	Tapped Lake with High-water Connection		Clear Water (Deep)
Riverine Moist Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Barren and Partially Vegetated	Mud Barrens, Dunes/Dry Sand Barrens, Sparsely Vegetated
Riverine Complex	Riverine Complex	Riverine Complex	na
Riverine Dune Complex	Dune Complex	Dune Complex	na
Riverine Deep-polygon Complex	Aquatic Sedge with Deep Polygons	Deep Polygon Complex	na
Coastal Moist Willow Dwarf Shrub	Salt Marsh	Halophytic Willow Dwarf Shrub Tundra	na (probably mapped as Dwarf Shrub, Dunes/Dry Sand Barrens)
Coastal Wet Sedge Meadow	Salt Marsh	Halophytic Sedge Wet Meadow	na (probably mapped as Flooded Tundra (Nonpattern), Wet Tundra)
Coastal Salt-killed Wet Meadow	Salt-killed Tundra	Salt-killed Wet Meadow	na (probably mapped as Sparsely Vegetated)
Coastal Lake	Brackish Water (tidal ponds)	Water	na (mapped as Turbid and Shallow Water)
	Tapped Lake with Low-water Connection		Clear Water (Deep)
Coastal Moist Barrens	Barrens (Riverine, Eolian, or Lacustrine)	Barren and Partially Vegetated	Mud Barrens, Dunes/Dry Sand Barrens, Sparsely Vegetated
	Tidal Flat		na (pbobably mapped as Mud Barrens, Sparsely Vegetated)
Tidal River	River or Stream	Water	Clear Water (Deep)
Nearshore Water	Nearshore Water	Water	Clear Water (Deep)
Lower Perennial River	River or Stream	Water	Clear Water (Deep)
Headwater Stream	River or Stream	Water	Clear Water (Deep)