AN ECOLOGICAL LAND SURVEY FOR THE COLVILLE RIVER DELTA, ALASKA, 1996

Final Report

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EXECUTIVE SUMMARY

The Colville River drains ~29% of the North Slope of Alaska and its delta is the largest in arctic Alaska. The interaction of geomorphic, hyrdrologic, and ecological processes produces a dynamic landscape that is noted for large concentrations of birds, mammals, and fish. These populations, in turn provide important subsistence resources for the residents of the Inupiaq village of Nuiqsut and the Helmericks' homestead. The delta's physical and biological complexity and its importance for the local subsistence economy, all provide significant challenges as how to best minimize potential ecological impacts of oil development.

ARCO Alaska, Inc. (ARCO) and the Kuukpik Unit Owners currently are formulating plans for the Alpine Development Project on the delta. In preparation for oil development, ARCO initiated a broad range of studies in 1992 to inventory and evaluate the physical, chemical, biological, and cultural resources of the delta. This report presents the results of an ecological land survey (ELS) that was conducted during 1992–1996 as part of a broader study of wildlife and habitat use (Johnson et al. 1996, 1997) and as a companion study to investigations on geomorphology and hydrology (Jorgenson et al. 1996, 1997). Because an ELS seeks to relate many features of the landscape, the resulting database is a very powerful tool. It contains information about physical and biological properties that can be combined to provide information, or to create models, for specific engineering and land management applications (e.g., ice contents, flooding regimes, wildlife habitat, fish habitat).

In this study, we used an ELS approach that inventoried terrain units (surficial geology, waterbodies), surface forms (primarily ice-related features), and vegetation characteristics on the delta and adjacent coastal plain (117,142 ha; 289,464 acres). This information was used to map integrated terrain units (ITUs) that incorporated the three components into one classification. Nineteen terrestrial terrain units, 19 waterbodies, 16 surface forms, and 17 vegetation classes were identified for mapping and combined into 178 ITUs. For the purposes of ecosystem analysis, we aggregated the ITUs into a more general classification of 36 ecosystem classes (Ecosites 1:50000) that preserved both geomorphic and vegetative characteristics. We also classified and mapped the area on a smaller scale (Ecodistricts 1:200,000). The classification of Ecodistricts (7 classes, e.g. Colville River Delta) and Ecosubdistricts (17 classes, e.g., Outer Colville River Delta) is based on landscapes with similar geology, geomorphology, and hydrology.

Large differences were found between the delta and the adjacent coastal plain. Within the delta, the most common ecosystems included Tidal Rivers, Coastal Barrens, Coastal Wet Meadows, Coastal Salt-killed Wet Meadow, Riverine Deep Lakes, Riverine Wet Meadows, and Riverine Low Scrub. In contrast, the most common ecosystems on the adjacent coastal plain were associated with the thaw-lake cycle and included Lowland Deep and Shallow Lakes, Lacustrine Wet Meadows, Lacustrine Thaw Complex (ice-poor), Lowland Thaw Complex (ice-rich), Lowland Wet Meadows, Lowland Moist Meadows, and Upland Tussock Meadows. Overall map accuracy was 60% for the 36 ecosystem classes and 71% for a set of 24 wildlife habitat classes that were derived from the same ITU database.

Multiple environmental factors contributed to the distribution of ecosystems and their associated plant species. Of eight physical and chemical characteristics examined (elevation ratio, water depth, drainage index, pH, EC, surface organic-horizon thickness, cumulative organic-horizon thickness, and thaw depths), all except pH and surface organic-horizon thickness, were found to have significant effects on ecosystem distribution based on ordination analysis. Significant environmental factors were related to ecosystem productivity and successional stage, though many plant species showed broad ecological tolerances, and all ecosystem classes had considerable overlap in the ordination analysis. The broad overlap in species and ecosystem distributions, and in their environmental characteristics, made accurate classification and mapping of ecosystems difficult.

In the delta, ecosystem distribution and evolution are affected by numerous geomorphic factors including marine, fluvial, eolian, permafrost, and thaw-lake processes. Coastal Barrens, which are associated with marine processes and 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, Elymus arenarius,* and *Puccinellia phryganodes.* Saline areas affected by tidal flooding and storm surges include Coastal Wet Meadows, dominated by *Carex subspathacea*, *C. ursina*, *Puccinellia phryganodes,* and *Dupontia fisheri*, and Coastal Salt-killed Wet Meadows, which are being colonized by

Puccinellia phryganodes, *P. andersonii*, and *Stellaria humifusa*. Salt becomes less important on slightly higher areas that are affected only by freshwater flooding events. Riverine marshes occur in high-water channels and small ponds created by channel meandering and frequently are colonized by *Arctophila fulva* and *Carex aquatilis*. Riverine Tall and Low Scrub, which occur as narrow strips slightly higher on the floodplain, are subject to less flooding and sedimentation, have well-drained soils, and are dominated by *Salix alaxensis, Salix lanata, Bromus pumpellianus, Equisetum* spp., and legumes. Riverine Wet 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 *Salix lanata*. Lowland Wet Meadows occur on abandoned floodplains that represent the oldest portions of the landscape, have saturated soils underlain by extremely ice-rich permafrost that has contributed to raising of the floodplain surface, and are dominated by plants similar to those on Riverine Wet Meadows but include more *Dryas integrifolia* and other dwarf shrubs. At this stage, the ice contents are sufficiently high that the permafrost becomes susceptible to thermokarst and Deep-polygon Complexes and Deep Riverine Lakes develop. These lakes may become tapped by channel migration, drain, and once again become Coastal Barrens. Finally, eolian sand frequently is deposited in large dunes downwind of large, barren sandbars, which contributes to the development of Upland Sandy Barrens, Upland Sandy Low Scrub, Upland Sandy Dwarf Scrub, and Upland Sandy Moist Meadows.

On the adjacent coastal plain, ice aggradation and thermokarst are the primary geomorphic processes that modify the landscape, although fluvial processes are evident along small rivers and streams. Deep Open Lakes form from the development and coalescing of thermokarst pits and ponds, and later expand by degrading permafrost along steep cutbanks. Breaching and drainage of these lakes creates Lowland Shallow Ponds and Lacustrine Barrens depending on how much of the basin is drained. Lacustrine Wet and Moist Meadows develop on the newly colonized areas and usually are dominated by *Carex aquatilis, Eriophorum angustifolium, Salix ovalifolia,* and *Dryas integrifolia*, depending on drainage conditions. Lowland Wet Meadows evolve from Lacustrine Wet Meadows after ice aggradation causes development of polygonal rims and raises the ground surface. Further raising of the surface by ice aggradation creates broad, gently rolling surfaces that become dissected by erosion and mass wasting, thereby providing modest topographic relief. Upland Tussock Tundra is dominated by *Eriophorum vaginatum* and generally occurs on moderately drained portions of slopes, whereas Upland Loamy Dwarf Scrub is dominated by *Dryas integrifolia* and occurs on exposed ridges. These ice-rich areas then are susceptible to thermokarst and renewal of the thaw-lake cycle.

We also present two applications of the ELS that illustrate how the spatial database was used to address specific land management or engineering applications. First, a habitat classification (24 classes) was derived from the original ITUs to differentiate characteristics important to wildlife (Johnson et al. 1996). Because the ITU database preserves detailed information, the habitat classification could be designed to reflect the characteristics important to the species being studied. Analyses revealed there were large differences in habitat selection among species and selection frequently changed during the year. Second, the ELS was used to provide an initial assessment of the flooding frequency within the delta to help locate facilities away from more flood-prone areas (Jorgenson et al. 1996). A simple spatial model of the distribution of five flood-frequency classes was developed based on differences in relative heights of the terrain units, distribution of flood waters observed from 1992 to 1995, and differences in soil stratigraphy (Figure 46, from Jorgenson et al. 1996). Frequency of flooding ranged from 1–2 yr (Class 1) to non-flooded (>~150 yr return, Class 5).

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INTRODUCTION

The Colville River drains ~29% of the North Slope of Alaska and its delta is the largest in arctic Alaska. The river's volume, sediment load, and interaction with coastal processes produce a dynamic deltaic system with diverse geomorphic, hydrologic, and ecological systems that are noted for their large concentrations of birds, mammals, and fish. The abundant fish and wildlife resources, in turn provide important subsistence resources for the residents of two permanent settlements, the Inupiaq village of Nuiqsut and the Helmericks' homestead. The delta's dynamic physical processes, its diverse and abundant biological resources, and its importance for the local subsistence economy, all provide significant challenges as how to best minimize potential ecological impacts of oil development.

Although oil exploration on the Colville River Delta and the adjacent coastal plain has been ongoing for decades, only recently have sufficient oil reserves been found to warrant commercial development. ARCO Alaska, Inc. (ARCO) and the Kuukpik Unit Owners currently are formulating plans for the Alpine Development Project on the delta. In recognition of the complexity of the deltaic environment and in preparation for oil development, ARCO initiated a broad range of studies in 1992 to inventory and evaluate the physical, chemical, biological, and cultural resources of the delta. This report presents the results of an ecological land survey (ELS) that was conducted during 1992–1996 as part of a broader study of wildlife and habitat use (Johnson et al. 1996, 1997) and as a companion study to investigations on geomorphology and hydrology (Jorgenson et al. 1996, 1997). Some of the information included in this report has been reported previously in the wildlife and geomorphology reports (e.g., habitat and terrain unit classifications) but has been synthesized in this report to provide a more integrated analysis of the ecological characteristics of the area.

The specific objectives of the ELS were to:

1) conduct a field survey of ecosystem compo nents, including surficial geology, topography, hydrology, and vegetation within the study area,

2) classify and map ecological components through an integrated-terrain-unit approach,

3) aggregate ecological components into a reduced set of ecosystems, at three scales,

4) evaluate the relationships among ecosystem com ponents, and

5) illustrate how the ecological information can be used to evaluate land capabilities (e.g., wildlife habitat and flooding regime).

The remarkable environment of the delta has been the subject of numerous studies conducted over the last four decades. Important studies on the geomorphology of the delta and nearby coast have been done by Walker 1976, Walker 1983, Carter and Galloway (1982, 1985), Reimnitz et al. (1985), and Rawlinson (1993). In addition, several major multidisciplinary research efforts have been conducted, including a study of nearshore aquatic and marine environments by the University of Alaska Fairbanks (UAF 1972), an investigation of the coast and shelf of the Beaufort Sea by numerous organizations during the early 1970s (Reed and Sater 1974), and numerous studies conducted under the Outer Continental Shelf Environmental Assessment Program of the National Oceanic and Atmospheric Administration.

To provide the broad range of information required to assess the engineering feasibility of the Alpine project and to analyze the potential ecological impacts of oil development, we utilized an ELS approach that views landscapes not just as aggregations of separate biological and earth resources, but as ecological systems with functionally related components (Rowe 1961; Bailey 1980, 1996; Wiken and Ironside 1977, Swanson et al. 1988). While thematic maps of individual ecosystem components (e.g., surficial geology, vegetation) have their particular uses, the linking and aggregating of components into ecosystems with co-varying climate, terrain, surface forms, hydrology, and biota can provide a spatial stratification and conceptual framework that conveys a much broader range of information required for modeling, analyzing, interpreting, and applying ecological knowledge. An ELS involves three types of effort: (1) an ecological land survey that inventories 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. Our emphasis in this report is on the ecological land survey and classification efforts, and we only briefly discuss some of the potential land evaluation applications.

In our ELS, we inventoried information on terrain units (surficial geology, geomorphology), surface forms (primarily ice-related features), and vegetation and used this information to map integrated terrain units (ITU) that incorporate all three components. This approach provides great flexibility for extracting information or developing classifications for specific engineering and ecological applications (e.g., ice contents, flooding regimes, wildlife habitat, fish habitat). To reduce the complexity resulting from the large number of possible ITU combinations, we aggregated the ITU's into more general ecosystem classes. These classes, which were designed to account for the variability of physical, chemical, and biological characteristics across the landscape, represent more information than does a single component map (e.g., vegetation). There are several benefits of this approach: it recognizes the importance that geomorphic processes have 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.

An ecological land classification (ELC) also involves a hierarchical organization of ecosystems at multiple spatial scales by using various landscape components (i.e., surficial geology, soils, surface forms, vegetation) to differentiate successive levels of organization (Wilken 1981, O'Neil et al. 1986, Bailey 1996, ECOMAP 1993, Klijn and Udo de Haes 1994). In this report, we evaluate and present three levels of ecosystem organization, ecosites (1:18,000 scale), ecosections (1:100,000), and ecodistricts (1:200,000). Ecosites (e.g., Coastal Wet Meadow, also referred to in other classification systems as ecotopes, or landscape type) delineate areas with homogenous topography, terrain, soil, surface form, hydrology, and vegetation. Ecosections (e.g., Alluvial-Marine Terrace, landtype associations, terrain unit, geomorphic sections) are homogeneous with respect to geomorphic features and water regime, and have recurring patterns of soils and vegetation that are related through a successional sequence. Although we do not explicitly present ecosections, the terrain units incorporated in the ITU's form the basis for organizing ecosection units. Ecodistricts (e.g., Colville River Delta, subregions, physiographic districts) are broader areas with similar geology, geomorphology, and hydrology and are more synonymous with physiographic units used at a landscape level of organization. Ecoregions (e.g., Arctic Coastal Plain), which differentiate areas based on their climatic regimes and gross physiography, have recently been mapped for Alaska by Gallant et al. (1995). In this report, we use the more familiar term 'ecosystem' primarily when referring to the ecosite level of organization, while maintaining the use of 'ecodistrict' when discussing larger areas of the landscape.

As an aid in developing the ecological land classification, we analyzed the relationships among ecological components by comparing the distribution of components across topographic sequences, by comparing the vegetation composition among the ecosystems (ecosite level), and by evaluating the environmental characteristics associated with individual plant species and ecosystems. Results from these analyses then were integrated into conceptual models of the response of ecosystems to geomorphic processes associated with landscape evolution. These models improve our ability to predict the response of ecosystems to disturbance and ensure greater consistency during classification and mapping.

In this report, we also present two applications of the ELS to illustrate how the spatial database can be used to assess specific land management or engineering applications. First, a habitat classification was developed to differentiate habitat characteristics important to wildlife with a particular emphasis on waterbirds (Johnson et al. 1996). Second, the ELS was used to provide an initial assessment of the flooding frequency within the delta to help locate facilities away from more flood-prone areas (Jorgenson et al. 1996).

STUDY AREA

This study focuses on the Colville River Delta and the proposed Transportation Corridor (hereafter referred to as the Transportation Corridor) on the adjacent coastal plain (Figure 1). Current plans for oil development on the delta include a road and two drill sites within the proposed Development Area (hereafter referred to as the Development Area) and a pipeline to the Kuparuk Oilfield. Various alternative development scenarios also are being considered, although only the preferred ARCO alternative is depicted and discussed here (AAI 1996). The village of Nuiqsut, established in 1971, is near the head of the delta.

The delta study area has a typical arctic maritime climate. Winters are cold and windy and last about eight months. Summers are cool, with temperatures ranging from -10° C in mid-May to 15° C in July and August (Simpson et al. 1982); summers also are characterized by low precipitation, overcast skies, fog, and persistent winds from the northeast. Occasional northwesterly winds usually bring storms, with high, wind-driven tides and rain (Walker and Morgan 1964).

The Colville River is the largest river on Alaska's North Slope and is one of eight major rivers with significant freshwater input to the Arctic Ocean (Walker 1983). The Colville enters the Beaufort Sea just west of the Kuparuk Oilfield and midway between Barrow and Kaktovik. It drains about 29% (53,600 km^2, 20,700 mi^2) of the North Slope of Alaska, with most of the watershed in the foothills (64%) and smaller areas in the Brooks Range (26%) and coastal plain (10%; Walker 1976). The head of the delta is located about 3 km upstream from the mouth of the Itkillik River (Arnborg et al. 1966). Below the Itkillik River, the area encompassed by the floodplain of the delta and water within the fringe of the delta covers 666 km^2 (257 mi^2).

The delta is bounded on both sides by old alluvial terraces that are traceable from the coast to above the Itkillik River (Carter and Galloway 1982). Fossil wood collected at the base of exposures yielded ages of 48,000–50,600 years before present (ybp), suggesting that the terraces and underlying deposits of gravelly sand were formed during the last interglacial period (Carter and Galloway 1982). These deposits are part of the Gubik Formation (Black 1964, Carter et al. 1977), a series of unconsolidated deposits that record a complex marine and alluvial history spanning ~3.5 million years (Carter et al. 1986). Modern sandy deltaic sediments in the delta generally range from 5–10 m below sea level and are underlain by 6–12 m of gravelly riverbed material (glaciofluvial outwash) and 20 or more meters of interbedded silts, clays, and organics indicative of marine or deltaic sediments associated with the Gubik Formation (Miller and Phillips 1996). The surficial geology of the central Arctic Coastal Plain has been mapped (1:63,360 scale) by Cater and Galloway (1985) and Rawlinson (1993).

The delta has two main distributaries, the Nechelik (western) Channel and the Colville East Channel (Figure 1). These two channels carry about 90% of the water through the delta during flooding and 99% during low water (Walker 1983). Smaller channels branching from the East Channel include the Sakoonang, Tamayayak, and Elaktoveach channels. The delta also is characterized by numerous lakes and ponds, sandbars, mud flats, sand dunes, and low- and high-centered polygons (Walker 1976, 1978). Most water bodies are shallow (< 2 m deep) ponds that freeze to the bottom in winter and thaw by June. Larger lakes typically are deeper (up to 10 m) and freeze only in the upper 2 m.

Both stabilized and active dunes, which are composed mainly of fine sand, are present in the delta (Walker 1976, Walker and Matsukura 1979). Stabilized dunes generally are long, narrow, vegetated ridges with smooth, rounded surfaces and few wind-eroded areas. Most of the stabilized dunes are oriented parallel to and on the west side of former river courses. Active dunes, in contrast, generally form on the western and southwestern sides of river channel bars and along the inner edge of tidal flats in response to the prevailing winds from the northeast. Large areas of stabilized sandy material deposited during the Pleistocene also are located just west of the delta (Carter 1981).

Marine processes are active primarily during the short ice-free period and contribute to the build-up of tidal flats along the fringe of the delta (Walker 1974). The nearly flat, barren mud or sand undergoes periodic inundations by tidal waters, but most of the material in the tidal flats accumulates during spring breakup. Because river flooding and breakup is initiated prior to the breakup of sea ice, floodwater from the river deposits sediment as it progresses over the sea ice.

In addition to these depositional processes, the accumulation of peat has contributed substantially to deltaic deposits, thus raising the surface of the floodplain. At selected sampling sites along the Arctic Coastal Plain, Schell and Ziemann (1983) measured depths of peat accumulation of 0.5–3 m with the thick-

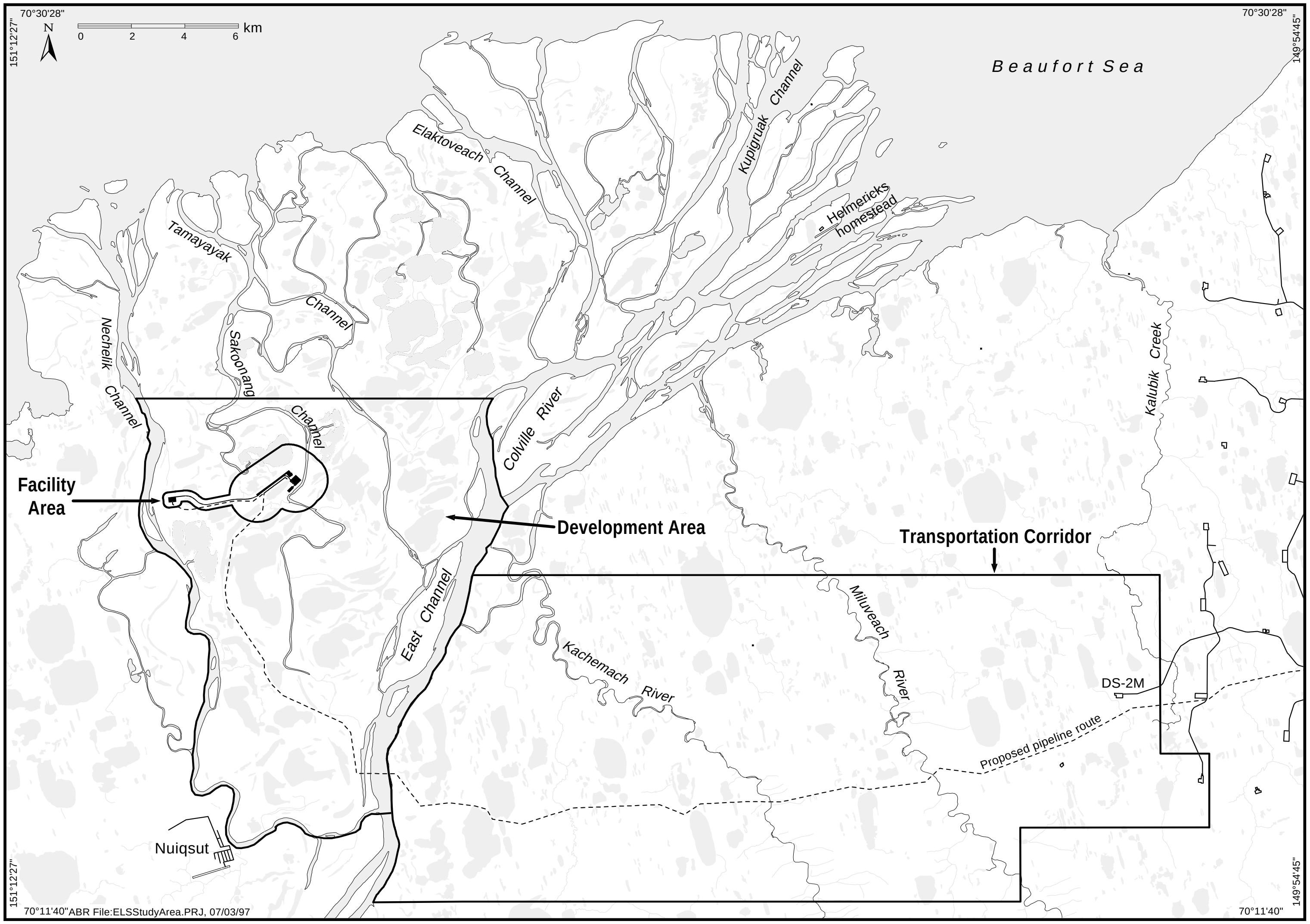

Figure 1. Map of study area for the ecological land survey on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992-1996

est deposit having a basal peat age of 12,610 ybp. Although formation of ice wedges and development of polygons can alter and erode the peat mat, the ubiquitous layer of peat throughout the coastal plain has contributed to the development of the arctic landscape.

Along with sediment deposition, hydraulic and thermal erosion have contributed to the evolution of the deltaic landscape. Although breakup may normally be the largest annual flooding event, the frozen active layer limits the erosional effect of the flood. However, water during both the breakup flood and at lower stages contributes to thermal erosion of the banks. Thermal erosion of material at and below the water surface often leads to the collapse of large blocks, which may be the predominant cause of bank erosion within this area (Walker and Morgan 1964, Walker 1976, Ritchie and Walker 1974).

Strong relationships among landforms, surface forms, and vegetation have been found in permafrost-dominated tundra ecosystems and have formed the basis for many classification and mapping schemes (Walker et al. 1980, Walker 1985, Walker and Acevedo 1987, Walker et al. 1989, Jorgenson 1986). Some relationships among landforms, surface forms, and vegetation within the delta have been described by Rothe et al. (1983). Similar relationships have been found on the floodplain of the Meade River (Peterson and Billings 1978, 1980) and the delta of the Sagavanirktok River (Walker et al. 1980).

Integrated-terrain-unit maps (based on 1:18,000-scale photography) that classified and delineated terrain units, surface forms, and vegetation components of the landscape initially were produced for the delta in 1992 (Jorgenson et al. 1993) and revised in 1995 (Jorgenson et al. 1996). In addition, land-cover maps (1:30,000 scale) of the delta have been generated by the U. S. Fish and Wildlife Service (USFWS) (Rothe et al. 1983). Other land-cover maps for the North Slope have been produced for the Prudhoe Bay area (Walker and Acevedo 1987), NPRA (Morrisey and Enis 1981, Markon and Derksen 1994, Kempka et al. 1995, Arctic National Wildlife Refuge (Walker et al. 1982, Markon 1986, Jorgenson et al. 1996), and Canada (Russel et al. 1992). Wetlands (1:63,360 scale) classified under the National Wetlands Inventory system also have been mapped by the USFWS. The North Slope Borough has mapped the vegetation, surface form, and landforms on the North Slope (1:250,000 scale). Vegetation-soil-landform associations have been described and mapped for the Prudhoe Bay region by Walker et al. (1980).

The delta has long been recognized as one of the most productive deltas for fish and wildlife on the arctic coast of Alaska (Gilliam and Lent 1982, Divoky 1983). The area is important for Tundra Swans (*Cygnus columbianus*), Brant (*Branta bernicla*), Yellow-billed Loons (*Gavia adamsii*), and Greater White-fronted Geese (*Anser albifrons*) and a variety of other migratory birds (Rothe et al. 1983, Johnson et al. 1996, 1997). Arctic (*Coregonus autumnalis*) and least cisco (*Coregonus sardinella*) overwinter in the delta and support the only commercial fishery on the North Slope (NOAA/OCSEAP 1983, Moulton 1996). Caribou (*Rangifer tarandus*) from both the Central Arctic Herd and the Teshekpuk Herd use the delta (Gilliam and Lent 1982). Finally, the area's resources are important to the subsistence economy of the Nuiqsut villagers.

METHODS

FIELD SURVEYS

Field surveys were conducted on the delta and adjacent coastal plain on 8 July–3 August 1992, 28 July–8 August 1995, and 28 July–14 August 1996. Data were collected at plots (uniform patches ~50 x 50 m) located along 28 transects (~1 km long), or toposequences, and at 85 additional sites (ground reference plots) that had ecosystem characteristics underrepresented along the transects (Figure 2).

TOPOSEQUENCES AND GROUND REFERENCE PLOTS

Locations for transects were selected to represent a cross section of ecosystems (ecosite level) within each ecosubdistrict (a subdivision of ecodistricts; e.g., Outer Colville River Delta, Miluveach Floodplain) and in areas marked for potential development (drill sites, river crossings). Each transect was established in an area that maximized the range of typical vegetation and terrain unit types over a short distance. Sampling stations for ecosystem descriptions (6–10 per transect) were located along each transect in distinct vegetation types (identifiable on aerial photographs) or vegetation types within terrain units of interest. At each station, measurements were made of topography, soil stratigraphy, hydrology, and vegetation cover.

Topographic relief was measured at frequent intervals along each transect. Elevations were obtained 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). When possible, surveys were referenced to a geodetic control network established to provide elevations above mean sea level for hydrologic monitoring (Jorgenson et al. 1996).

Near-surface soil stratigraphy was described from a soil core or soil pit at each plot. Most soil profiles were limited to the active (thawed) layer (~50–100 cm) and these samples were obtained from soil plugs dug with a shovel. Deeper soil cores (up to 2.5 m deep) 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 for each profile included the texture of each horizon, the depth of organic matter, depth of thaw, and ice volume and structure. In the field, soil texture was classified according to Soil Conservation Service system (SSDS 1993). Cryogenic structure (forms, distribution, and volumes of ice) was classified in the field according to a modified system based on systems developed by Katasonov (1969) and Murton and French (1994). The soil profiles were subdivided into lithofacies (Appendix Table 1) using criteria similar to those described by (Miall 1985).

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

Plant cover at most plots was measured using the point-intercept method (Mueller-Dombois and Ellenberg 1974) and at the remaining plots by visual estimation. For point sampling, a 50-m long vegetation-sampling transect was oriented approximately perpendicular to the elevation transect or through the center of the point location; the functional criteria for placement of the vegetation sampling transect was that it be entirely contained within a single terrain unit, surface form, and vegetation type. At 1-m intervals, the plant species (or other ground cover) present was determined by aligning the cross-hairs on a sighting tube or by sighting along a meter tape (n = 50 points per vegetation transect). If more than one layer of plants overlapped at a point, each occurrence was recorded, thereby generating a repetitive cover index that could exceed 100%. Bare soil was recorded only when plants, litter or water was absent. Similarly, litter was recorded only when vegetation was absent or the litter was embedded within vegetation layers (standing dead); only the first occurrence of litter was recorded even if there were multiple layers of litter. For qualitative descriptions of plant cover, percent cover of dominant plant species was estimated visually. At all sampling locations (transect stations and point locations) a summary list was compiled of all plant species observed (whether or not they were sampled by the point-intercept method). Taxonomic nomenclature followed Hulten (1968) for vascular plants, Ireland (1982) and Nyholm (1975) for bryophytes, and Thomson (1984) for lichens. Identification of mosses and lichens during field sampling was limited to a few

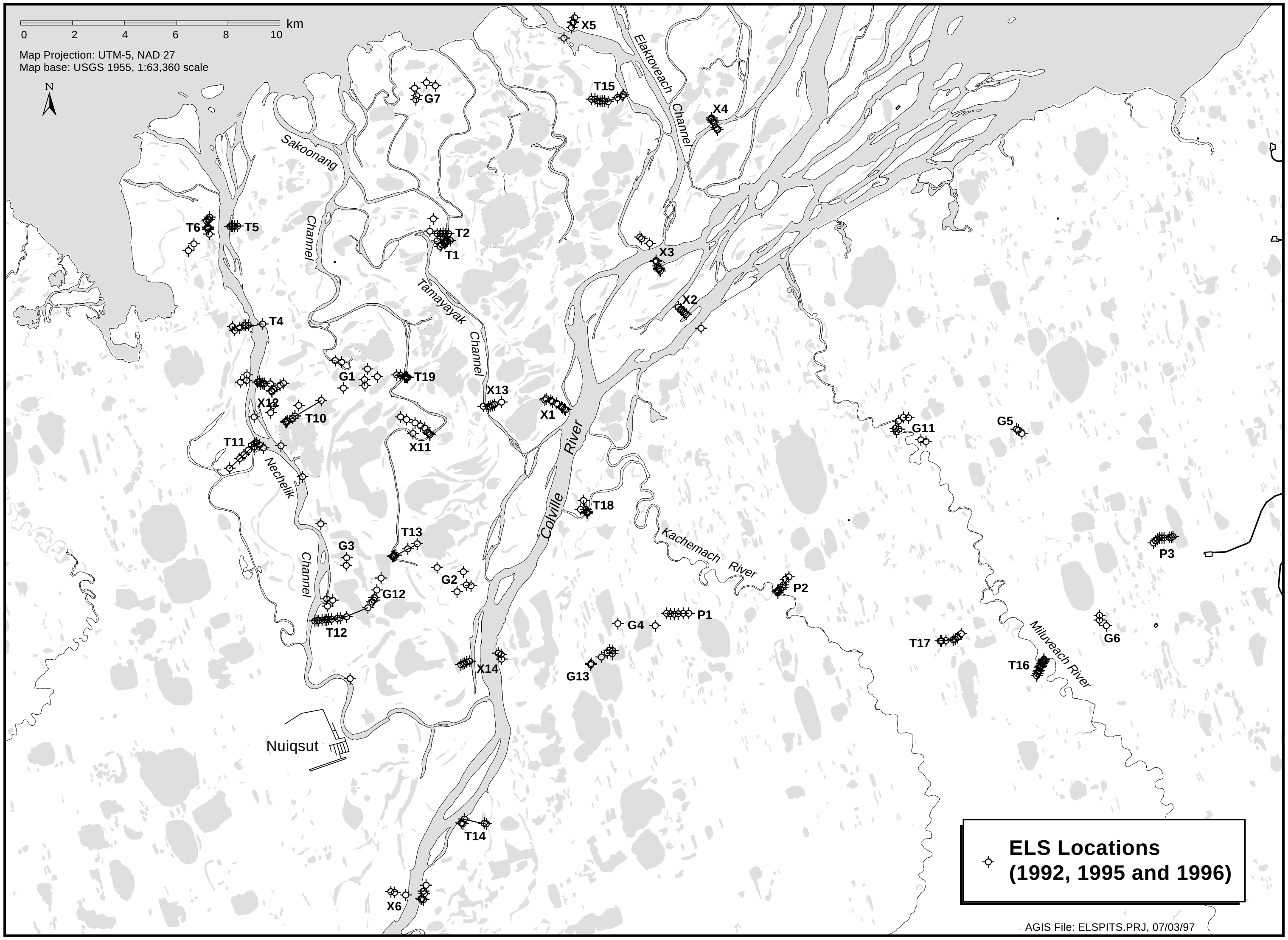

Figure 2. Sampling locations for the ecological land survey on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992-1996. Label denotes general location for series of plots.

species; most species were collected and then identified in the lab. Voucher specimens were collected for all taxa identified and are archived at ABR.

ACCURACY ASSESSMENT

As part of the field survey in 1996, data were collected for an accuracy assessment of the ecological land classification and derived wildlife habitat map produced in 1995. Sampling was done according to a stratified random design (Congalton 1991) that included 20 mapped areas over 2 ha for each common habitat type and 10 areas each for less common habitat types. Two ground observers visited 134 of these selected areas. Photographs were taken at each site and observers (Pullman and Burgess) recorded vegetation, surface form, and terrain data. In the office, ground data and photographs collected by the field observers were compared by a third observer (Jorgenson), who determined a consensus classification for the site. Waterbodies were not included in the original set of stratified samples; these were evaluated from the air ($n = 32$) in the course of traveling to and from sample sites during the 1996 field survey. Additionally, 76 sites from the 1996 field data were included to increase sample size and supplement underrepresented habitat types. Of the 242 possible sites, 15 were excluded from the final accuracy assessment because of location errors or because the data were collected from areas that were smaller than the minimum mapping unit. The final data set used for map accuracy assessment consisted of 227 points in 21 habitat types. The integrated terrain units described in the field were converted to ecosystem and habitat classes according to our standard matrices for aggregating ITU's. Omission and commission errors then were tabulated for ecosystems (ecosite level) and habitats by comparing ground identifications with map polygon identifications (Congalton 1991).

CLASSIFICATION AND MAPPING

The development of an ecological land classification (ELC) at the ecosite scale (1:18,000) from field data involved three phases: (1) terrain units, surface forms, and vegetation components of each plot were classified from field data using standard classification systems, (2) the terrain units, surface forms, and vegetation classes were combined into integrated terrain units (ITU), and (3) a reduced set of ecosystem classes (ecosite level) were derived by aggregating similar terrain units and similar vegetation classes (Figure 3). The ecosystem classification presented here was built upon the land classification effort initiated in 1992 (Jorgenson et al. 1993).

Integrated terrain units were based on three components: terrain unit (surficial geology and waterbody type), microtopographic surface form (related to ice content), and vegetation type, with each using a standard classification system developed for Alaska (Table 1). The terrain unit classification system was developed by Kreig and Reger (1982) and has been adopted by the Alaska Division of Geological and Geophysical Surveys for their engineering-geology mapping scheme. This classification system was modified slightly to incorporate surficial geology units in the Transportation Corridor that have been identified by Rawlinson (1993) and our study and to better differentiate deltaic sediments that are related to flooding regimes. Within the terrain unit classification, we also classified waterbodies based on their depth, connectivity, salinity, and genesis (Appendix Table 2). The surface-form classification was based on the system developed by Washburn (1973), but was modified to include surface forms described by Walker et al. (1980) and the National Wetlands Working Group (1988). Vegetation was classified primarily using the Alaska Vegetation Classification (AVC) developed by Viereck et al. (1992), but also includes information from Walker and Acevedo (1987). We also included additional salt-affected classes and classes for two complex types representing stages of thaw-lake basins. The basin wetland complexes were developed for areas where at least three vegetation types were present, the dominant cover type described was less than 70% of the polygon being mapped and inclusions were below the minimum mapping size.

Classification, mapping and mensuration involved the following methods. Integrated terrain units were delineated on acetate overlays of 1:18,000 scale color-infrared (CIR) or true-color photographs (8 July 1992 and 5 July 1983, respectively). CIR coverage was not available for the entire study area. All aerial photographs were obtained from AeroMap, Inc., Anchorage, AK. The minimal mapping size for polygons was 0.25 ha for waterbodies, 2.0 ha for wetland complexes, and 0.5 ha for other classes. A mirror stereoscope was used for photo-interpretation. Acetates then were digitized and encoded with Atlas GIS software (Strategic Mapping, Inc., Santa Clara, CA). To control accuracy, photos and acetates were registered to UTM coordinates of prominent features (control points, typically waterbody shorelines or shoreline features) identified on a controlled base map developed from SPOT imagery. The digitized map of each

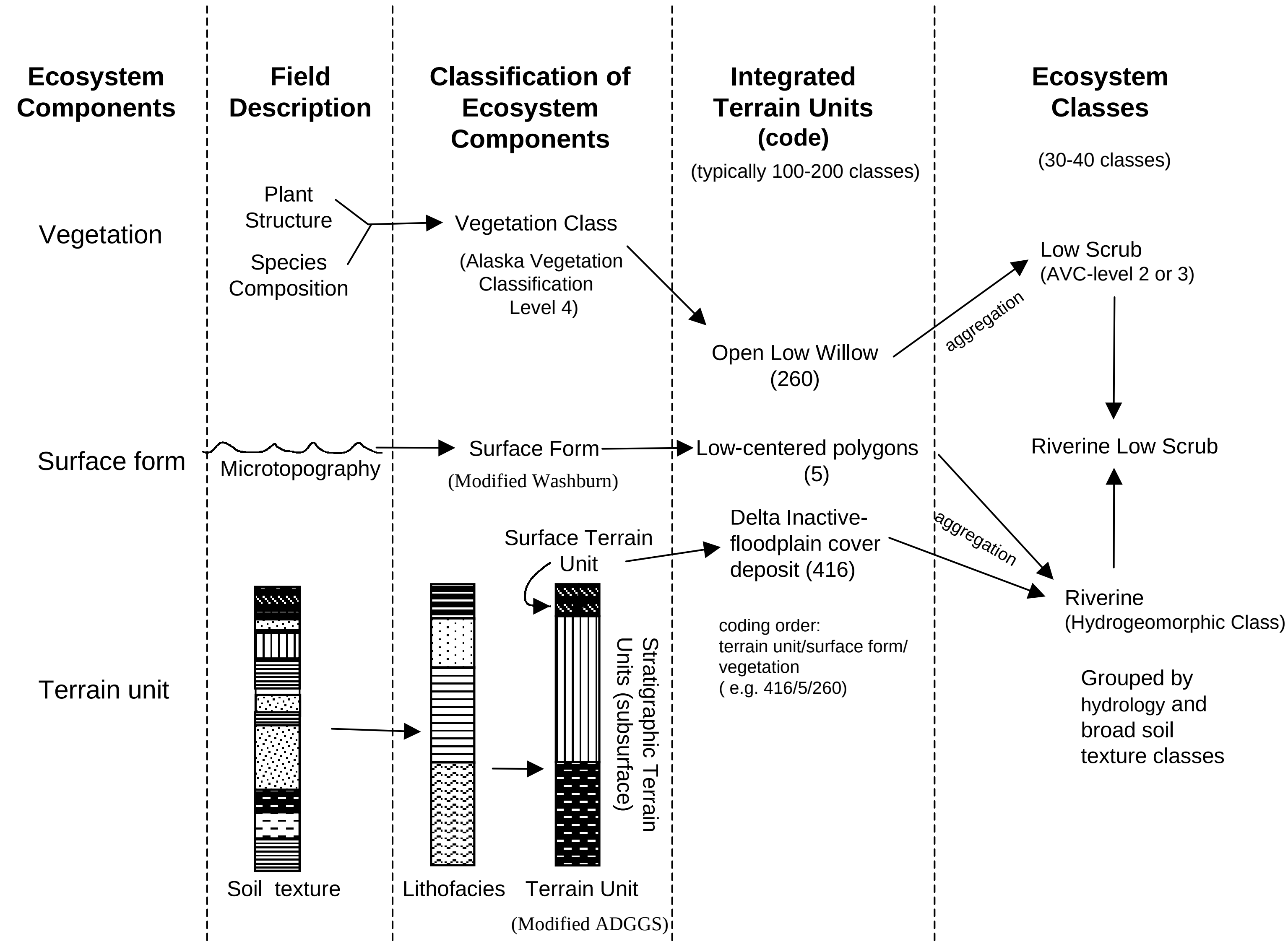

Figure 3. System for integrating vegetation, surface form and terrain units into Integrated Terrain Units (ITU) and then grouping ITU's into ecosystem classes

Table 1. Coding system for classifying and mapping terrain units, surface forms, and vegetation on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Code		Class
TERRAIN UNIT		
DEPOSITS		
330	Cs	Solifluction Deposit (not mapped)
380	Es	Eolian Sand Dunes
412	Fdrl	Delta, Riverbed/Riverbars (411 field code)
413	Fdrh	Delta, High-water Channel
415	Fdca	Delta, Active-floodplain Cover Deposit
416	Fdci	Delta, Inactive-floodplain Cover Deposit
417	Fda	Delta, Abandoned-floodplain Cover Deposit
441	Fpr	Floodplain, Riverbed Deposit
443	Fpca	Floodplain, Active-floodplain Cover Deposit
444	Fpci	Floodplain, Inactive-floodplain Cover Deposit
452	Fpa	Floodplain, Abandoned-floodplain Cover Dep.
545	Fto	Alluvial Terrace (ancient floodplain)
595	Fgp	Alluvial Plain Deposit (undifferentiated fluvial)
816	Ltn	Thaw Basin, Ice-poor
817	Lti	Thaw Basin, Ice-rich
818	Ltdn	Delta Thaw Basin, Ice-poor
819	Ltdi	Delta Thaw Basin, Ice-rich
860	Mp	Alluvial-Marine Terrace
862	Mt	Tidal Flat
872	Hfg	Fill, Gravel
874	Hfp	Fill, Peat (peat roads)
WATERBODIES		
905	Rt	River, Tidal
910	Rl	River, Lower Perennial
918	Rb	River, Thermokarst (beaded stream)
922	Ldi	Deep Isolated Lake
925	Ldir	Deep Isolated Lake, Riverine
930	Ldc	Deep Connected Lake
941	Lsi	Shallow Isolated Pond
943	Lsir	Shallow Isolated Pond, Riverine
948	Lsid	Shallow Isolated Pond, Dune Depression
950	Lsc	Shallow Connected Pond
963	En	Nearshore Water
983	Etdl	Deep Tapped Lk. w/ Low-water Connection
984	Etdh	Deep Tapped Lk. w/ High-water Conn.
986	Etsl	Shallow Tapped Lk. w/ Low-wat. Conn.
987	Etsh	Shallow Tapped Lk. w/ High-water Conn.
989	Ep	Brackish Ponds (tidal affected)
995	Hid	Drainage Impoundment
996	Hl	Sewage Lagoon
997	Hr	Reserve Pit

Code		Class
SURFACE FORM		
0	N	Nonpatterned
2	Pd	Polygons, Disjunct
3	Pf	Polygons, Flat-centered (not mapped)
5	Plll	Polygons, Low-cent., Low-relief, Low-dens.
6	Pllh	Polygons, Low-cent., Low-relf, High-dens.
7	Plhl	Polygons, Low-cent., High-relf, Low-dens.
8	Plhh	Polygons, Low-cent., High-relf., High-dens
9	Pm	Polygons, Mixed High and Low (not mapped)
11	Phl	Polygons, High-centered, Low-relief
12	Phh	Polygons, High-centered. High-relief
17	Tm	Mixed Pits and Polygons
21	Fh	Hummocks (not mapped)
23	Ff	Frost Scars (not mapped)
31	Mud	Mounds, Undifferentiated
35	Mpi	Pingos
39	Ms	Strang (not mapped)
54	Mg	Gelifluction Lobes (not mapped)
62	Ek	Dunes, Streaked
81	Dw	Water Tracks (not mapped)
85	Db	Streambank (not mapped)
96	Si	Islands Present
97	Sm	Water with Highly Polygonized Margin
98	L	Cliff or Bluff
99	W	Water
101	Cb	Basin Complex
VEGETATION		
0	B	Barren (<5% vegetated)
10	P	Partially Vegetated (*Deschampsia*, *Elymus*)
221	Stcw	Closed Tall Willow (not mapped)
231	Stow	Open Tall Willow
242	Slcw	Closed Low Willow
260	Slow	Open Low Willow (can include sedges)
270	Sdd	*Dryas* Tundra (also w/ sedges or lichens)
295	Sdwh	Halophytic Dwarf Willow (coastal)
314	Hmt	Tussock Tundra
320	Hmss	Moist Sedge–Shrub Tundra (*Dryas* or willow
334	Hwsw	Wet Sedge–Willow Meadow (also w/o willov
336	Has	Fresh Sedge Marsh
337	Hag	Fresh Grass Marsh
345	Hwhg	Halophytic Grass Wet Meadow
346	Hwhs	Halophytic Sedge Wet Meadow
348	Hwhk	Salt-killed Wet Meadow
411	Cby	Basin Wetland Complex, Young
412	Cbo	Basin Wetland Complex, Old

EXAMPLE OF ITU CODING SYSTEM
Terrain Unit, Surface Form, Vegetation
412/6/331 or 941/96/337

photo was geometrically rectified by performing a three-point transformation ("rubber-sheeting") to match control point UTMs, thus compensating for distortion caused by camera tilt. After rectification, features on adjacent photos were joined to create a seamless map of the entire area. Area measurements for each polygon were obtained with the GIS.

To simplify map presentation and ecological analysis, we aggregated the 178 ITU's into a reduced set of 36 ecosystem classes at the ecosite level (corresponding to the microscale level in Appendix Table 3). First, the terrain unit/ surface form combinations were aggregated into major physiographic units (e.g., coastal, riverine, lowland, etc.) based on similarity of geomorphic processes. For example, all fluvial terrain units (e.g., Riverbed/Riverbar, Active-floodplain Cover Deposits, and Inactive-floodplain Cover Deposits) were aggregated into the Riverine class. Second, vegetation classes were aggregated into simplified physiognomic classes (e.g., wet meadow, low scrub, barrens similar to Level II and III in the AVC) depending on growth form and cover classes. For example, low and tall shrub and open and closed canopy cover classes were combined into the Scrub class. Third, the physiographic units and the vegetation physiognomic classes were combined to form ecosystem classes (ecosite level) (Appendix Table 4). This approach preserved characteristics related to both geomorphic processes and vegetation development and allowed us to reduce the number of classes in a systematic way.

In addition to this large-scale mapping, ecodistricts (1:200,000 scale) were delineated based on recurring patterns of terrain units. The ecodistricts and ecosubdistricts (the same basic concept of ecodistricts but a subdivision at a slightly larger scale) were delineated on an acetate overlay on a 1:100,000 scale SPOT image.

DATA ANALYSIS

VEGETATION COMPOSITION

Plant cover data were analyzed three ways: (1) descriptive statistics were generated for plant cover of each species within each ecosystem class, (2) descriptive statistics were generated for each growth form within each ecosystem class, and (3) an objective sorting technique was used to evaluate the reliability of plant associations and to identify species that best differentiated among the associations. Descriptive statistics of species composition utilized both point-frame and visually estimated data and were presented in tabular format as means, standard deviations, and frequencies (occurrence in plots) for each ecosystem class. Ecosystem classes were grouped by vegetation type to facilitate comparison. Evaluations of percent cover of each growth-form used only the point-sampling data to allow a more quantitative comparison among ecosystems.

For objective vegetation classification, a computerized sorted-table routine that approximates the Braun-Blanquet Method of community classification (Mueller-Dombois and Ellenberg 1974) was performed using *Coenos* software (A. Ceska, Victoria, B.C.). Sorted-table analysis, which is based on species data alone, was used to objectively describe associations of species, the degree of overlap among species groups, and potential 'indicator' species. Indicator species, which are common only in specific plant communities, are valuable in areas where a few dominant species occur in many vegetation types. Species ($n = 316$) and plots ($n = 293$) were grouped by establishing inclusion and exclusion percentages. Species occurring in greater than 66% of plots were excluded from the analysis since they are too ubiquitous to discriminate types. The analysis also identifies species that can not be associated with any group. Both the point-sampling and visually estimated data were included in the analysis to maximize sample sizes.

ECOLOGICAL RELATIONSHIPS

Ecological relationships among plant species, ecosystem classes, and environmental parameters (elevation ratio, water depth, drainage index, pH, EC, organic-horizon thickness, cumulative organic-horizon thickness, and thaw depth) were evaluated by (1) generating descriptive statistics of environmental parameters by plant species, (2) generating descriptive statistics of environmental parameters by ecosystem, and (3) performing a multivariate ordination procedure (canonical correspondence analysis) that relates plant composition to environmental gradients. Mean and standard deviation of values for the eight parameters were plotted for 26 plant species and all ecosystem classes. Plant species were selected by frequency (20 most commonly occurring) and by indicator status. Six indicator species were chosen to describe plant associations that were ecologically significant (e.g., Salt-killed Meadow, Fresh Grass Marsh) but too uncommon to be represented in the frequency selection. Sample sites in which selected species occurred with low percent cover were excluded from the analysis. Elevation ratios were calculated for each sample site as an index of the relative elevation of an ecosystem along a toposequence. The relative elevation ratio describes the relationship of the elevation of each transect sample station to the elevation of the first occurrence of inactive cover deposit on that transect. Inactive-floodplain Cover Deposits were chosen as the reference value because the interbedded organic and mineral horizons indicated that the deposits occasionally are flooded and are in equilibrium with the current flooding regime.

Canonical correspondence analysis (CCA) using *PC-ORD* software (mjm Software, Gleneden Beach, OR) was conducted to identify the principal environmental factors affecting the distribution of plants. Only the detailed quantitative data derived from point sampling (229 sites) were used for CCA. CCA was used to ordinate the vegetation data and to identify significant environmental variables associated with the ordination. Because complete data sets of environmental variables could not be obtained for all 229 plots, three subset matrices of environmental data were constructed to maximize both number of plots and number of variables. All matrices contained data describing organic-horizon thickness, cumulative organic-horizon thickness, and a drainage index. Additionally, each subset matrix contained one of the following combinations: depth to water (above- or below-ground) and thaw depth (153 plots), pH and electrical conductivity (EC) (150 plots), or thaw depth and elevation ratio (132 plots).

EVALUATION AND MODELING

In this report, we present two uses of the integrated-terrain-unit map for evaluating the ecological capabilities of the land: wildlife habitat characterization and modeling of flood frequency. The wildlife habitat classification and analyses were conducted as part of intensive wildlife studies (Johnson et al. 1996, 1997) and the modeling of flood distribution was performed as part of studies on the geomorphology and hydrology of the delta (Jorgenson et al. 1996). They are summarized in this report to provide examples of the type of analyses that can be conducted with the ELS database.

The 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 breeding waterbirds and their use of waterbodies and wet and moist tundra types and on mammals and upland birds that use shrublands and dry tundra types.

We consolidated ITUs into an initial set of 49 wildlife habitat types from a hierarchical classification of wildlife habitats (Appendix Table 5) that has been used in several bird-habitat studies in the nearby Prudhoe and Kuparuk oilfields (Jorgenson et al. 1989, Murphy et al. 1989, Johnson et al. 1990, Anderson et al. 1991, Murphy and Anderson 1993). Several new habitat types (i.e., Aquatic Sedge with Deep Polygons, Deep Open Water with Polygonized Margins, and various Tapped Lake classes) were added to the original system to recognize habitats unique to the Colville Delta region. The initial 49 wildlife habitat types were further reduced by eliminating types with very small areas (<0.5% of the area and low levels of wildlife use) and combining similar types with apparently similar levels of use. The combining of habitat types was subjective and incorporated information from previous wildlife investigations in the region (Bergman et al. 1977, Kessel 1979, Martin and Moitoret 1981, Seaman et al. 1981, Troy et al. 1983, Spindler et al. 1984, Meehan 1986, Nickles et al. 1987, Meehan and Jennings 1988, Murphy et al. 1989, Murphy and Anderson 1993) and our knowledge of factors important to the wildlife species under consideration.

The development of a simple model for predicting flood distribution and frequency across the delta involved five steps: (1) ranking the relative elevations of terrain units, (2) ranking the percentage of areas flooded at various flood stages using flood distribution maps from a limited number of years, (3) analyzing sediment deposition and driftwood occurrence, (4) comparing stage-discharge and flood-frequency relationships at the head of the delta with relative elevations of terrain units, and (5) minor adjustment of flood-frequency classes within three flooding regions. A flood-frequency class then was assigned to each terrain unit within each flooding region, and these were used to create a map of flood distribution.

RESULTS AND DISCUSSION

CLASSIFICATION AND MAPPING

ECOSYSTEM COMPONENTS

Terrain Units

Twenty-one terrestrial terrain units were identified within the delta and the adjacent coastal plain (Table 2). Two of these units (Solifluction Deposits and Loess) were too small in extent to map. A map of terrain units (terrain units at the surface) revealed large differences in the distribution of terrain units between the delta and the adjacent coastal plain (Figures 4a, 4b and Table 3). Terrain units that were common on the delta included: Delta Riverbed/Riverbar Deposits, High-water Channels, Delta Active-floodplain Cover Deposits, Delta Inactive-floodplain Cover Deposits, Abandoned-floodplain Cover Deposits, Tidal Flat Deposits, Eolian Sand Deposits, and Delta Ice-rich and Ice-poor Thaw Basin Deposits. In contrast, terrain units on the adjacent coastal plain include Floodplain Riverbed Deposits, Active-floodplain Cover Deposits, Inactive-floodplain Cover Deposits, Alluvial and Alluvial-Marine Terraces, Alluvial Plain, and Gravel and Peat Fill Deposits. Brackish water in nearshore and tidal river areas was differentiated from freshwater in lower perennial rivers, lakes, and ponds, and these units are described in more detail in the Waterbodies section below.

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

Waterbodies

Nineteen classes of waterbody were identified within the delta and the adjacent coastal plain (Figure 5, Table 4). Waterbodies that were common on the delta included: Tidal Rivers, Brackish Ponds, Shallow and Deep Tapped Lakes, and Shallow and Deep Isolated Ponds (Table 3). In contrast, waterbodies that were common on the coastal plain included: Lower Perennial Rivers (Kachemach and Miluveach Rivers), Thermokarst rivers (beaded streams), Deep Isolated Lakes, Shallow Isolated Ponds, and Shallow Connected Ponds.

The waterbody classification differentiated numerous characteristics that are ecologically important to 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. Many of these characteristics were incorporated into the ecosystem classification (see Ecosystem Classification section).

Surface Forms

Twenty surface forms were identified within the delta and the adjacent coastal plain, although four (Hummocks, Frost Scars, Strang, and Gelifluction Lobes) did not occur in large or distinct enough areas to map (Table 5). A map of surface forms also revealed large differences in distribution of surface forms between the delta and the adjacent coastal plain (Figure 6, Table 6). Surface forms that were common on the delta included: Nonpatterned; Disjunct Polygons; Low-centered, Low-relief, Low-density Polygons; Low-centered, Low-relief, High-density Polygons; and Streaked Dunes. In contrast, common surface forms on the coastal plain included: Nonpatterned; Disjunct Polygons; High-centered, Low-relief Polygons, and Basin Complexes.

Surface forms are good indicators of the extent of subsurface ice, and they greatly influence drainage patterns. The volume of ice contributed by wedge ice increases from 0% in Nonpatterned areas to 20% in High-density, Low-centered Polygons, within the delta (Jorgenson et al. 1997). The amount of polygonization also impedes surface and subsurface water flow. Nonpatterned areas appear to be more productive, presumably because subsurface movement of water and nutrients is not impeded by polygonal rims.

Vegetation

Thirty one vegetation classes (Level IV, Alaska Vegetation Classification [AVC]) were recognized within the study area, although only 17 were mappable after aggregation of similar types (Figure 7, Table 7). Vegetation classes were chosen for mapping based on reliability of identification on aerial photography and dissimilarity of species composition. Common veg-

Table 2. Classification and description of terrestrial terrain units on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Unit	Description
Solifluction Deposit	Unconsolidated fine-grained material, or rocky or gravelly fines, resulting from mass movement of saturated materials. Surface has lobe pattern from downslope movement (not mapped).
Eolian Sand Deposit (Dunes)	Unconsolidated, wind-deposited accumulations of primarily very fine and fine sand. Surficial patterns associated with ice-aggradation generally are absent. The sand dunes are being built by deposition of sand from adjacent sandbars and are prone to wind erosion, giving them distinctive, highly dissected patterns. Active dunes occur at the inner edge of extensive mudflats, the outer delta, and along the western and southwestern sides of river channel bars. Only distinct dunes were mapped, whereas smooth sand sheets overlying other deposits were not.
Eolian Loess	Unconsolidated, wind-deposited accumulations of silt and very fine sand that form a blanket over other terrain units in the delta, such as abandoned floodplains and old terraces (not mapped).
Delta, Riverbed/ Riverbar Deposit	Silty and sandy riverbed or lateral accretion deposits laid down from the bed load of a river in areas of channeled flow. This unit includes point bars, lateral bars, mid-channel bars, unvegetated high-water channels, and broad riverbed/sandbars exposed during low water. In general, texture of the sediments becomes finer in a seaward direction along the distributaries and in a bankward direction from the deepest portion of the channel (thalweg). Organic matter, including driftwood (mostly small willows), peat shreds, and other plant remains, usually is interbedded with the sediments. Only those riverbed deposits that are exposed at low water were mapped. Frequent flooding (every 1–2 yr.) prevents the establishment of permanent vegetation.
Delta, High-water Channel	Riverbed deposits in channels that are only flooded during periods of high flow. Because of river meandering, these channels are no longer active during low-flow conditions. High-water Channel deposits are similar to those described for Delta Riverbeds. 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-floodplain Cover Deposit	Thin (10-50 cm) fine-grained cover deposits (primarily silt) that are laid down over sandier riverbed deposits during flood stages. Relatively frequent (every 3–4 yr.) 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-floodplain Cover Deposit	Fine-grained cover or vertical accretion deposits laid down over coarser riverbed 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 (0.3-2 m thick) of silty cover deposits overlying riverbed 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.
Floodplain, Riverbed Deposit	Sandy gravel, and occasionally sand, deposited as lateral accretion deposits in channels of active floodplains by fluvial processes. Subrounded to rounded pebbles and cobbles are common in the sandy gravel. Frequent deposition and scouring from flooding prevents the establishment of vegetation. The channel has a meandering configuration.

Table 2 (cont.)

Unit	Description
Floodplain, Active-Floodplain Cover Deposit	Thin (20-60 cm), fine-grained cover deposits (primarily silt) laid down over sandy or gravelly riverbed deposits during flood stages. Relatively frequent (every 3–4 yr.) deposition prevents the development of a surface organic horizon. This unit usually occurs on the upper portions of point and lateral bars and supports low and tall willow vegetation.
Floodplain, Inactive-floodplain Cover Deposit	Interbedded layers of peat and silty very fine sand material (20-60 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 gravelly riverbed deposits. This unit has substantial segregated and massive ice, as indicated by the occurrence of ice-wedge polygons.
Floodplain, Abandoned Cover Deposit	These deposits are similar to Delta, Abandoned-floodplain Cover Deposits, they generally consist of an accumulation of peat (20-60 cm) overlying cover deposits and riverbed alluvium. Fines at the surface typically are eolian, as flooding is rare. The thick organic layer promotes ice development and thaw depths are shallow.
Thaw Basin Deposit, Ice-poor	Thaw basin deposits, which are caused by the thawing of ground ice, typically are fine-grained and organic-rich, and the stratigraphy of the original sediments has been deformed by the subsidence. On the terraces and coastal plain east of the delta, pebbly silt or fine sand is more common. 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	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.
Delta Thaw Basin Deposit, Ice-poor	Deposits in thaw lakes connected to a river or to nearshore water (tapped lake); they occur only in deltaic environments. 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.
Delta Thaw Basin Deposit, Ice-rich	Similar to the above unit, except that sediments are ice-rich, as indicated by the development of ice-wedge polygons. Typically, the sediments contain a sequence of a thick (20-60 cm) layer of interbedded silt and peat, fine-grained cover deposits, and silty clay lacustrine deposits. They still are subject to flooding.
Alluvial Terrace	Fluvial gravelly sand, sand, silty sand, and peat. These terraces are ancient and are not subject to flooding under the current regime. Deposits usually are overlain by eolian silt and sand and organic-rich thaw basin deposits. This unit has a high content of segregated and massive ice, as indicated by the presence of ice-wedge polygons and the abundance of thaw ponds. Soils generally are slightly acidic (pH 5.5-6.5) due to lack of marine influence.
Alluvial-Marine Terrace	A sequence of alluvial and marine terraces (A, B, and C of Rawlinson 1993). Composition is variable but generally consists of undifferentiated gravelly sand overlain by fluvial gravelly sand, silty sand, and organic silt. Stratified layers of marine gravelly sand, silty sand, silt and minor clay occur in some locations beneath the fluvial deposits. The deposits generally are overlain by pebbly eolian sand and silt and organic-rich lacustrine deposits. This unit is not subject to river flooding. Soils generally are neutral to slightly alkaline (pH 6.5-8) due to influence of underlying marine sediments.
Alluvial Plain Deposit	Peat, eolian loess and sand, lacustrine sediments, and sandy gravel deposited by braided river processes on an alluvial plain. A typical sequence consists of 20-60 cm of peat or mixed sand and peat typical of lacustrine material, 1–2 m of sand and pebbly fine sand (Beechey Sand), and thick beds (below 2–4 m) of sandy gravel and gravel (Ugnuravik Gravel). The surface is ice-rich, as indicated by polygonal development and the prevalence of thaw lakes. Water depths in thaw lakes generally are 1–2 m, indicating that ice contents are high and sediments are not thaw stable.
Tidal Flat Deposit	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. 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.
Fill, Gravel	Gravel and sandy gravel that has been placed as fill for roads and pads in the village of Nuiqsut and the Kuparuk Oilfield. The gravel is obtained from deep riverbed deposits or gravelly coastal plain deposits.
Fill, Peat	Peat fill ("peat road") includes a mixture of organic and fine-grained sediments that has been obtained by taking peat material from the active layer and piling it into a roadbed.

Table 3. Areal extent of terrestrial terrain units and waterbodies on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Class	Area		Percentage of Area
	Acres	Hectares	
Terrestrial Terrain Unit			
Eolian Sand Dunes	4,246	1,718	1.5
Delta Riverbed/Riverbars, Lateral Deposits	19,213	7,775	6.6
Delta, High-water Channel	4,351	1,761	1.5
Delta, Active-floodplain Cover Deposit	2,956	1,196	1.0
Delta, Inactive-floodplain Cover Deposit	42,680	17,272	14.7
Delta, Abandoned-floodplain Cover Deposit	8,552	3,461	3.0
Floodplain, Riverbed Deposit	357	145	0.1
Floodplain, Active-floodplain Cover Deposit	445	180	0.2
Floodplain, Inactive-floodplain Cover Deposit	2,424	981	0.8
Alluvial Terrace	17,075	6,910	5.9
Alluvial Plain Deposit	451	182	0.2
Thaw Basin, Ice-poor	15,341	6,208	5.3
Thaw Basin, Ice-rich	19,741	7,989	6.8
Delta Thaw Basin, Ice-poor	8,054	3,259	2.8
Delta Thaw Basin, Ice-rich	2,207	893	0.8
Alluvial-Marine Terrace	32,410	13,116	11.2
Tidal Flat	22,076	8,934	7.6
Fill, Gravel	262	106	0.1
Fill, Peat	85	34	0.0
Total Mapped Terrestrial Terrain Unit Area	202,926	82,121	70.1
Waterbodies			
Shallow Isolated Ponds with Deep Polygon Centers	3,125	1,265	1.1
River, Tidal	24,658	9,979	8.5
River, Lower Perennial	345	140	0.1
River, Thermokarst	123	50	< 0.1
Deep Isolated Lake	14,848	6,009	5.1
Deep Isolated Lake, Riverine	835	338	0.3
Deep Connected Lake	5,308	2,148	1.8
Shallow Isolated Pond	5,957	2,411	2.1
Shallow Isolated Pond, Riverine	451	183	0.2
Shallow Isolated Pond, Dune Depression	5	2	< 0.1
Shallow Connected Pond	560	227	0.2
Nearshore Water	17,741	7,179	6.1
Deep Tapped Lake with Low-water Connection	5,346	2,164	1.8
Deep Tapped Lake with High-water Connection	5,022	2,033	1.7
Shallow Tapped Lake with Low-water Connection	9	4	< 0.1
Shallow Tapped Lake with High-water Connection	301	122	0.1
Brackish Ponds	1,889	764	0.7
Drainage Impoundment	4	2	< 0.1
Sewage Lagoon	2	1	< 0.1
Reserve Pit	6	2	< 0.1
Total Mapped Waterbody Area	86,538	35,021	29.9
Total Area	289,464	117,142	

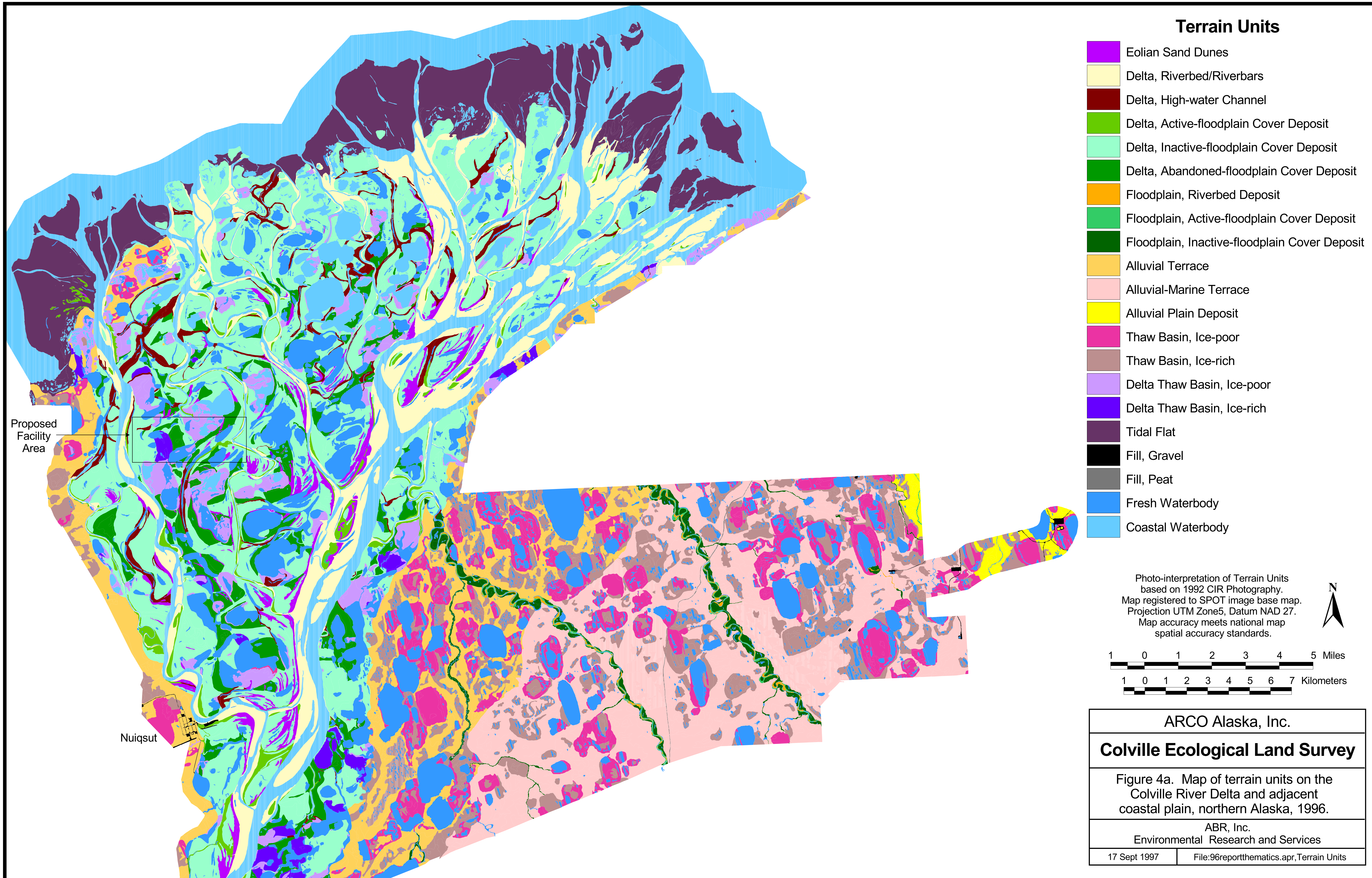

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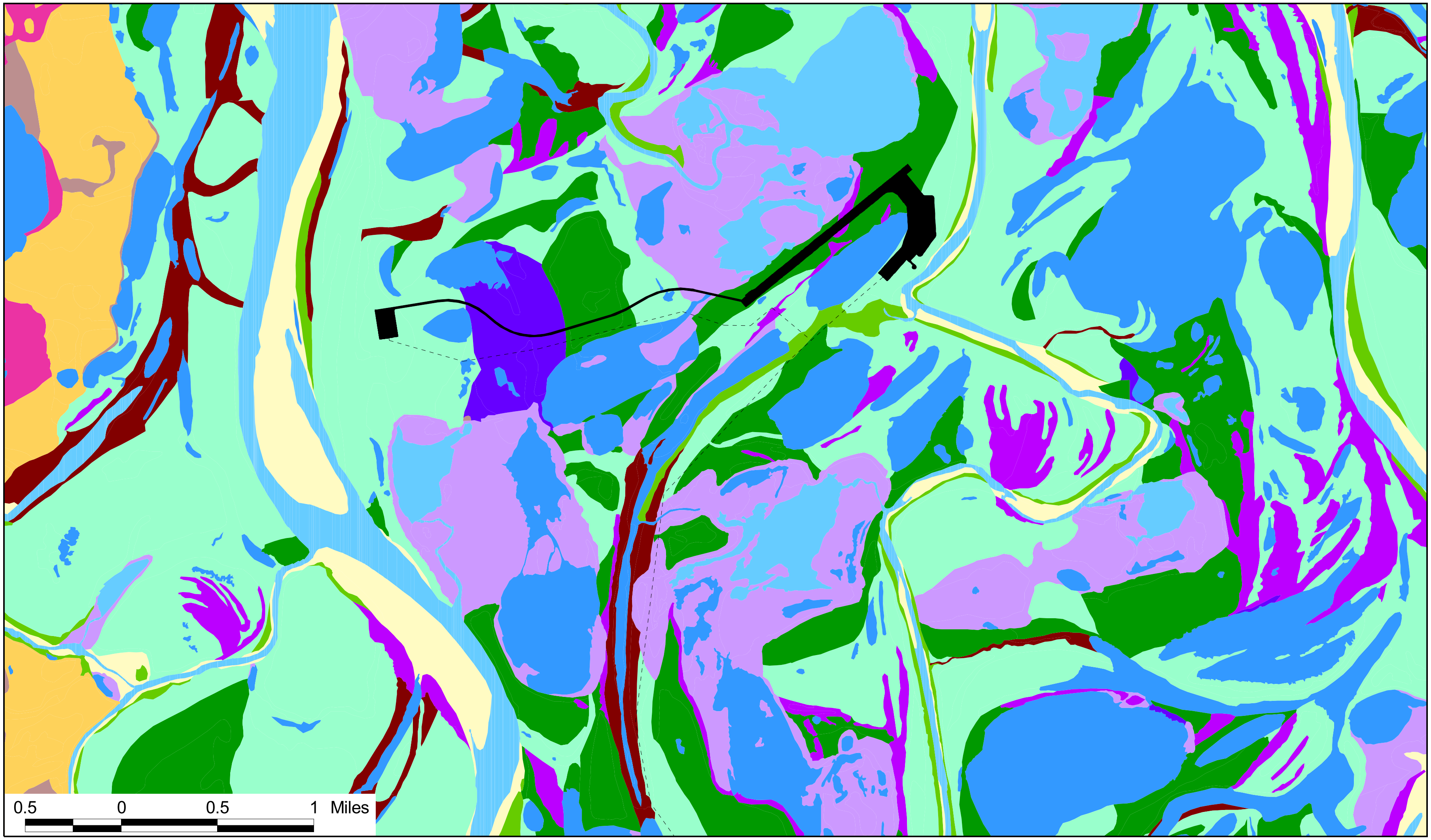
Figure 4a. Map of terrain units on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

ABR, Inc.
Environmental Research and Services

17 Sept 1997 | File:96reportthematics.apr,Terrain Units



Eolian Sand Dunes
Delta, Riverbed/Riverbars
Delta, High-water Channel
Delta, Active-floodplain Cover Deposit
Delta, Inactive-floodplain Cover Deposit
Delta, Abandoned-floodplain Cover Deposit
Alluvial Terrace
Thaw Basin, Ice-poor
Thaw Basin, Ice-rich
Delta Thaw Basin, Ice-poor
Delta Thaw Basin, Ice-rich
Fill, Gravel
Fresh Waterbody
Coastal Waterbody

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Colville Ecological Land Survey

Figure 4b. Map of terrain units in the vicinity of the proposed Facility Area, Colville River Delta, 1996.

ABR, Inc.
Environmental Research and Services

3 Sept 1997	File: ELS_Infield_Views.apr, Terrain

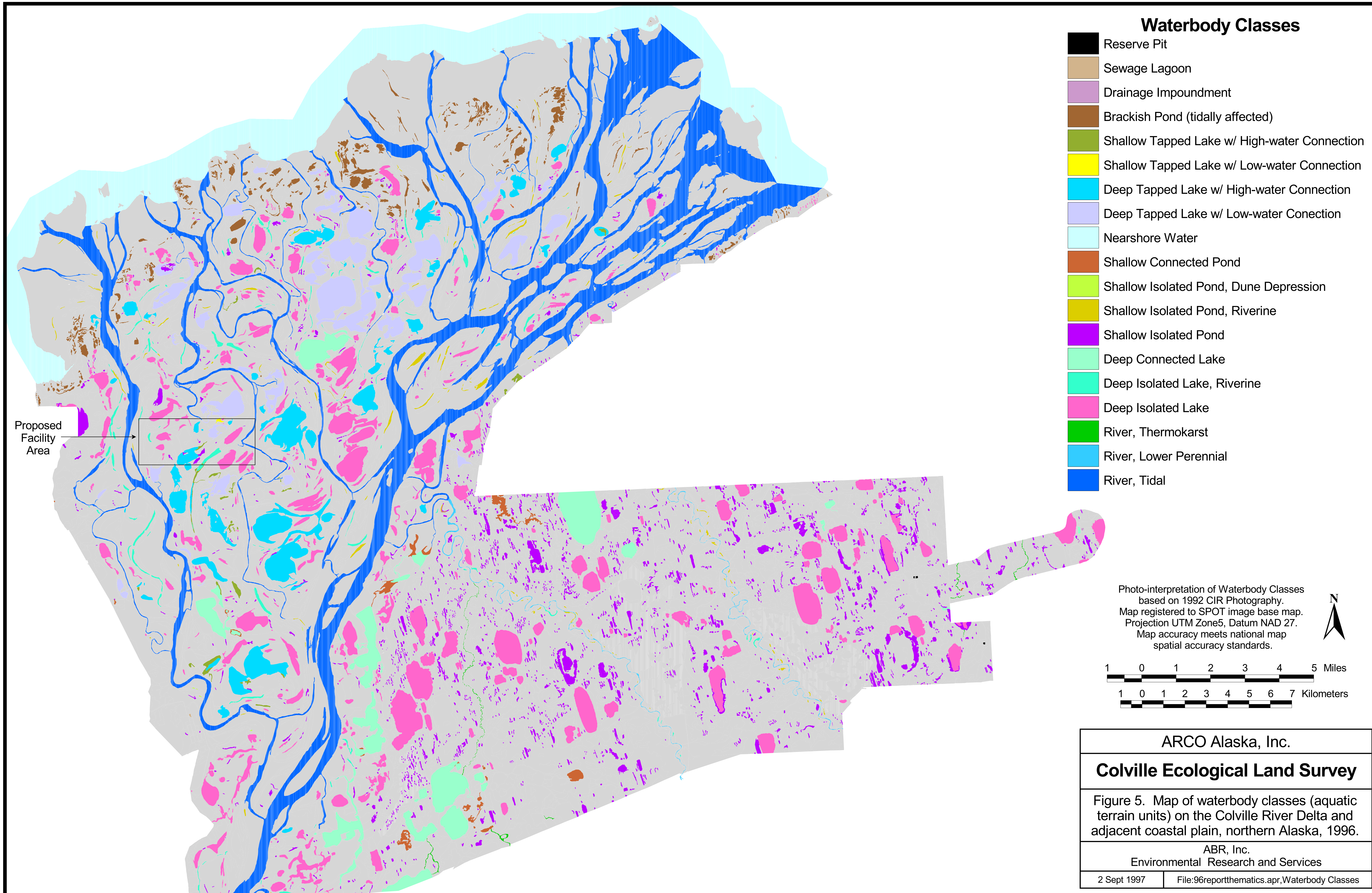


Figure 5. Map of waterbody classes (aquatic terrain units) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

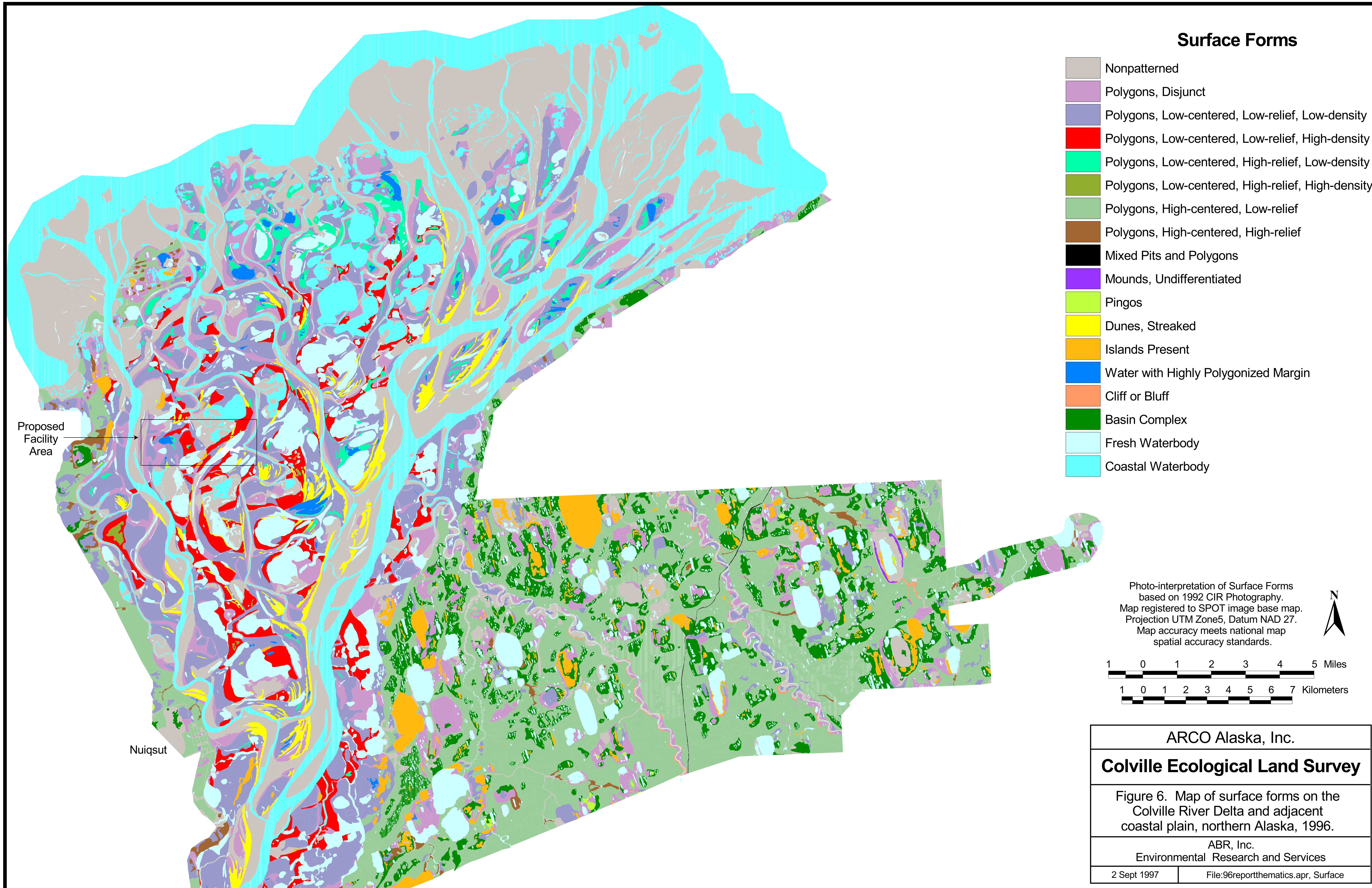

Surface Forms
Nonpatterned
Polygons, Disjunct
Polygons, Low-centered, Low-relief, Low-density
Polygons, Low-centered, Low-relief, High-density
Polygons, Low-centered, High-relief, Low-density
Polygons, Low-centered, High-relief, High-density
Polygons, High-centered, Low-relief
Polygons, High-centered, High-relief
Mixed Pits and Polygons
Mounds, Undifferentiated
Pingos
Dunes, Streaked
Islands Present
Water with Highly Polygonized Margin
Cliff or Bluff
Basin Complex
Fresh Waterbody
Coastal Waterbody
Proposed Facility Area
Nuiqsut
Photo-interpretation of Surface Forms based on 1992 CIR Photography. Map registered to SPOT image base map. Projection UTM Zone5, Datum NAD 27. Map accuracy meets national map spatial accuracy standards.
N
1 0 1 2 3 4 5 Miles
1 0 1 2 3 4 5 6 7 Kilometers
ARCO Alaska, Inc.
Colville Ecological Land Survey
Figure 6. Map of surface forms on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.
ABR, Inc.
Environmental Research and Services
2 Sept 1997
File:96reportthematics.apr, Surface

Table 4. Classification and description of waterbodies (aquatic terrain units) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Class	**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.
Brackish Pond (tidal affected)	Coastal 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.
River, Tidal	Permanently flooded channels of 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.
River, Lower Perennial	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.
River, Thermokarst (beaded stream)	A stream flowing through ice-rich soils, that has thawed ice lenses along its course. The stream channel consists of small linked ponds, resembling beads on a string. These rivers flow throughout the summer, but freeze completely during the winter.
Deep Isolated Lake	Deep (≥1.5 m) waterbodies which 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 Lake, Riverine	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 Connected Lake	Deep (≥1.5 m) waterbodies that do not freeze to the bottom during winter. These lakes have distinct outlets with water present throughout the summer.
Shallow Isolated Pond	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. A special type, consisting of small isolated ponds occurring in deep low-centered polygons on Delta Inactive-floodplain Cover Deposits or Delta Abandoned-floodplains, was not included in the waterbody mapping. They form part of a thermokarst complex, and were included in the terrain unit mapping.
Shallow Isolated Pond, Riverine	Shallow (< 1.5 m) ponds or small lakes associated with old river channels. Water freezes to the bottom during winter and thaws by early to mid-June. Sediments are fine-grained silt and clay.

Table 4 (cont.)

Class	**Description**
Shallow Isolated Pond, Dune Depression	Shallow (<1.5 m) waterbodies, with no distinct outlet, that form in depressions among sand dunes. They freeze to the bottom during winter.
Shallow Connected Pond	Shallow (<1.5 m) waterbody with a distinct outlet containing water throughout the year. Freezes to the bottom during winter.
Deep Tapped Lake with Low-water Connection	Deep (>1.5 m) 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 shorelines. These lakes do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand.
Deep Tapped Lake with High-water Connection	Similar to preceding type, but 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 channels due to deposition during seasonal flooding.
Shallow Tapped Lake with Low-water Connection	Shallow (<1.5 m) 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 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.
Shallow Tapped Lake with High-water Connection	Similar to preceding type, 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 channels due to deposition during seasonal flooding.
Drainage Impoundment	A shallow waterbody created by impoundment of water above a man-made structure such as a road. The water is permanent, but water levels fluctuate substantially, peaking during spring breakup.
Sewage Lagoon	Man-made waterbody created to hold the effluent from a sewage treatment system.
Reserve Pit	Man-made waterbody created to hold the effluent of a well-drilling operation.

Table 5. Classification and description of surface forms on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Class	Description
Nonpatterned	These flat, nonpatterned 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, abandoned river channels, and exposed riverbanks. However, it also includes old upland surfaces composed of high-centered polygons with indistinct rims that may be masked by tussock tundra vegetation.
Disjunct Polygon Rims	In areas with disjunct polygon rims, polygon rims resulting from ice-wedge development are evident but not sufficiently developed to create closed polygons. Also prevalent on young landforms such as low river terraces, drained lake basins, and high-water channels.
Polygons, Low-centered, Low relief, Low-density	Well-developed ice-wedge polygons with a central low "basin," a raised "rim," and (frequently) a "trough" between polygons. Typically, polygons range from 15 to 30 m across. Larger polygons are often partially bisected by newly forming rims.
Polygons, Low-centered, Low-relief, High-density	The most advanced stage of polygon development, where polygons are small (8–15 m across) and relief between the polygon center and rim remains small (<0.5 m). Many polygon basins contain shallow standing water throughout the summer. In the last stages of development, the polygons are so dense and the rims so large that little area is left for polygon basins. The newly developing rims bisecting larger polygons, which are evident in low-density polygon units, are absent. This unit delineates areas with high ice content and generally is found on high or old terraces.
Polygons; Low-centered, High-relief, Low-density	A form of polygonal development caused by extensive accumulation of material along rims or by thaw settlement of the central basin. The polygons are relatively large (15–30 m across) and the relief between the basins and rims is >0.5 m. This form is common along the outer delta.
Polygons; Low-centered, High-relief, High-density	A form of polygonal development caused by extensive accumulation of material along rims or by thaw settlement of the central basin. The polygons are relatively small (8-15 m across). This form is common along the outer delta.
Polygons; High-centered, Low-relief	High-centered polygons are composed of a raised "center" and a relatively low "trough" between centers of adjacent polygons. 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 low-centered polygons. The centers are only slightly raised (<0.5 m) 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.
Polygons; High-centered, High-relief	These units are comprised of high-centered polygons in which progressive thawing of the ice wedge causes subsidence, resulting in the development of deep (>0.5 m) troughs. This thermokarst process frequently is related to changes in drainage adjacent to river and lake banks or surface disturbance.
Mixed Pits and Polygons	This unit 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.

Table 5. (cont.)

Class	Description
Mounds, Undifferentiated, Dense	Undifferentiated mounds that cannot be related to a specific geomorphic process. This class was used for mounds that were infrequently found in recently drained thaw basins. The mounds presumably are related to ice-wedge polygons modified by wave action.
Hummocks	Small mounds composed of organic-rich, fine-grained mineral soil, usually <0.5 m in height. This unit typically occurs on the slopes of moderately stable river bluffs and on the steep slopes of pingos. Hummocks are thought to be caused by runoff due to melting of the snow pack combined with thermal erosion. Hummocks could not be discerned on aerial photography and were not mapped.
Frost-Scar	Frost scars are roughly circular and slightly convex. They are composed of fine-grained mineral soil that, under the proper moisture and freezing conditions, undergoes heaving. This process of frost churning recurs frequently enough to prevent the development of an organic mat. Frost scars may occupy 30% or more of a given surface and at higher densities may have a center spacing of 2-3 m. These units often were indistinct and therefore were not mapped.
Strang	Small hummocky ridges (<0.5 m), or strings, formed by ice development and oriented perpendicular to direction of slope. The areas between strang often have standing water. Areas covered by Strang were rare and the type was not mapped.
Gelifluction Lobes	Imbricate lobes or sheets on slopes formed by the slow downslope flow of soil and vegetation masses saturated with water. Frequently form on steep slopes where there is a ready source of meltwater and an impermeable frozen sublayer.
Pingos	Pingos are small, ice-cored hills that commonly form in recently drained thaw lake basins. Sediments beneath lakes remain thawed during the winter in lakes deeper than about 2 m. When the lake drains, these unfrozen sediments freeze, and cryogenic forces cause doming of the surface to form a pingo.
Dunes, Streaked	A form of dune surface characterized by thin, elongate strips or stringers.
Islands Present	Used as a modifier for waterbodies when one or more islands are present. Islands are defined as at least 1 m across and 3 m from the shore.
Water with Highly Polygonized Margin	Waterbodies with highly irregular shorelines caused by the degradation of low-centered polygons. The remnant portions of rims protrude into the water forming small islands and peninsulas.
Cliff or Bluff	A steep slope in hilly areas or along riverbanks. Cliff is used to denote areas with bedrock; Bluff is used for areas with more moderate slopes composed of unconsolidated material.
Basin Complex	Complex microrelief within large depressions 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 old, Ice-rich Thaw Basins, the complex usually consists of Ponds, Nonpatterned Ground, Low-centered Polygons, and High-Centered Polygons.
Water	Areas covered by permanent water.

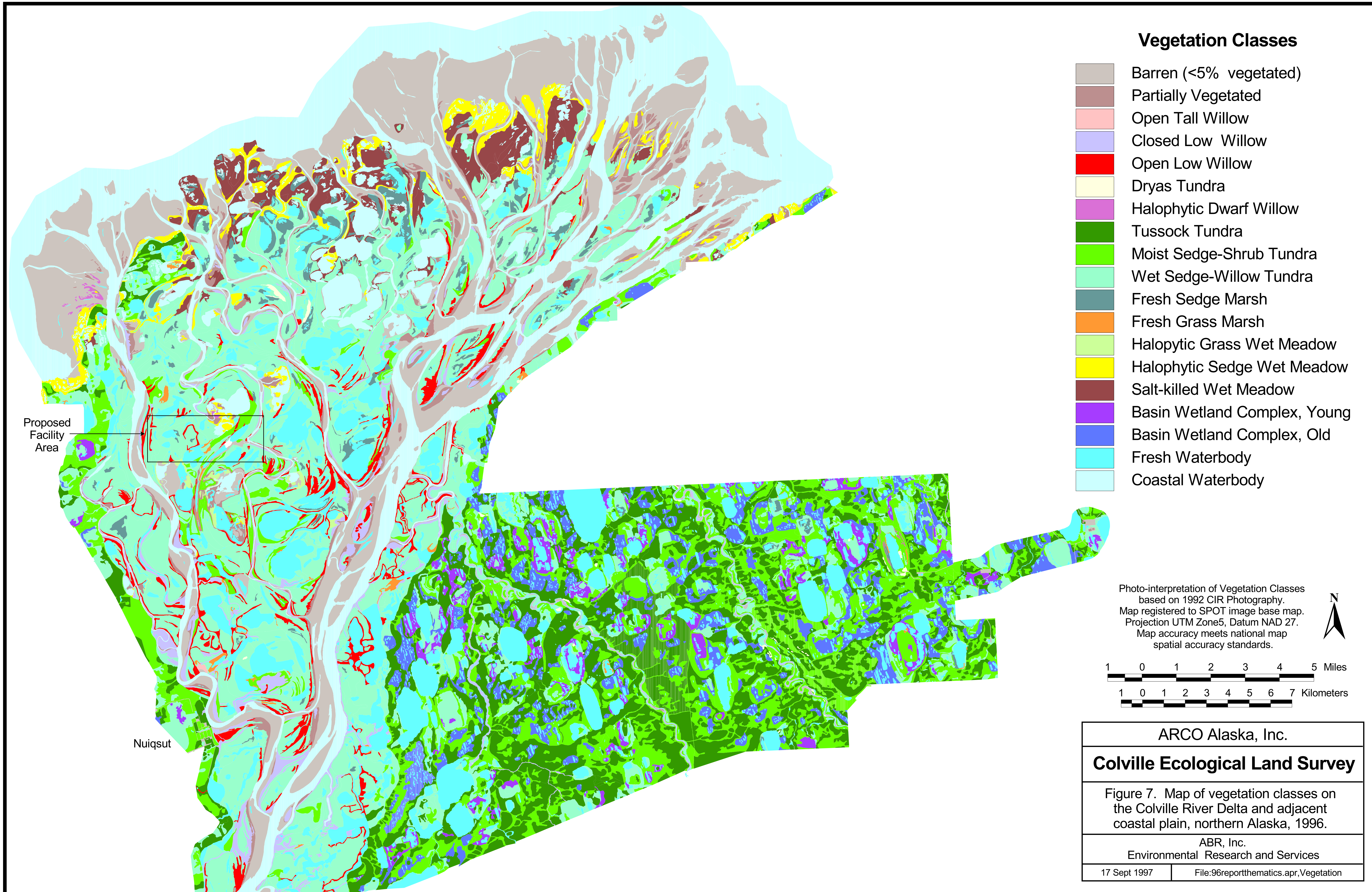


Figure 7. Map of vegetation classes on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Table 6. Areal extent of surface forms and vegetation types on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Class	Area		Percentage of Area
	Acres	Hectares	
Surface Form			
Nonpatterned	62,462	25,278	21.6
Polygons, Disjunct	20,577	8,327	7.1
Polygons, Low-centered, Low-relief, Low-density	38,579	15,612	13.3
Polygons, Low-centered, Low-relief, High-density	8,283	3,352	2.9
Polygons, Low-centered, High-relief, Low-density	3,275	1,325	1.1
Polygons, Low-centered, High-relief, High-density	132	53	< 0.1
Polygons, High-centered, Low-Relief	51,953	21,025	17.9
Polygons, High-centered, High-Relief	1,425	577	0.5
Mixed Pits and Polygons	85	34	< 0.1
Mound, Undifferentiated, Dense	85	34	< 0.1
Pingos	192	78	0.1
Dunes, Streaked	4,239	1,716	1.5
Islands Present	6,080	2,460	2.1
Water with Highly Polygonized Margin	1,955	791	0.7
Cliff or Bluff	260	105	0.1
Basin Complex	14,985	6,064	5.2
Water	74,897	30,310	25.9
Vegetation			
Barren	36,833	14,906	12.7
Partially Vegetated	5,576	2,256	1.9
Open Tall Willow	29	12	< 0.1
Closed Low and Tall Willow	5,493	2,223	1.9
Open Low Willow	5,358	2,168	1.9
Dryas Tundra	265	107	0.1
Halophytic Dwarf Willow	145	59	0.1
Tussock Tundra	30,989	12,541	10.7
Moist Sedge-Shrub Tundra	31,712	12,833	11.0
Wet Sedge-Willow Meadow	59,914	24,246	20.7
Fresh Sedge Marsh	3,651	1,478	1.3
Fresh Grass Marsh	563	228	0.2
Halophytic Grass Wet Meadow	466	189	0.2
Halophytic Sedge Wet Meadow	4,458	1,804	1.5
Salt-killed Wet Meadow	6,417	2,597	2.2
Basin Wetland Complex, Young	4,343	1,758	1.5
Basin Wetland Complex, Old	10,642	4,306	3.7
Water, No Emergents	82,610	33,431	28.5
Total Area	289,464	117,142	

Table 7. Classification and description of vegetation types on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Class	Description
Barren	Barren flats on river floodplains, sand dunes, and recently drained lake bottoms that are recently exposed or too unstable to support more than a few pioneering plants (<5% cover). Typical pioneer plants include *Salix alaxensis*, *Elymus arenarius*, and *Deschamspia caespitosa*. Riverine Barrens include river flats and bars, primarily within the Colville River but also found within high-energy sections of tributaries. These areas are flooded seasonally and are underlain by fine-grained sediments (primarily silt) overlying sandy gravel. Lacustrine Barrens include newly drained lake basins as well as unvegetated margins of lakes and ponds in which water level fluctuations inhibit vegetation growth. These areas are flooded seasonally and are underlain by clay and silt. On the delta, sediments usually are slightly saline and are being colonized by salt-marsh plant species.
Partially Vegetated	Riverbanks, sand dunes, and recently drained lake basins that have 5-30% vegetative cover. Colonizers on riverbars include *Deschampsia caespitosa*, *Elymus arenarius*, *Alopecurus alpinus*, *Puccinellia phryganodes*, *Chrysanthemum bipinnatum*, *Stellaria humifusa* and *Equisetum arvense*. On sand dunes *Salix lanata, S. alaxensis*, *Deschampsia caespitosa*, and *Elymus arenarius* are important.
Closed Tall Willow	Riverine willows dominated by a closed canopy of *Salix alaxensis*. *Salix lanata* also can be and important component, forming a lower canopy. Common understory species include *Bromus pumpellianus*, *Equisetum arvense*, *Hedysarum alpinum*, and *Astragalus alpinus*. *Salix alaxensis* occasionally obtains heights of 2 m. This rare class usually was grouped with Closed Low Willow. Found on Active-floodplain Cover Deposits subject to flooding and sedimentation nearly every year.
Open Tall Willow	Similar to Closed Tall Willow except shrubs form an open canopy (25-75% cover). Forbs, particularly legumes, and grasses are more important in the open canopy.
Closed Low Willow	Riverine willows form a closed (>75% cover) low canopy. *Salix alaxensis* and *S. glauca* are more common on better-drained Active-floodplain Cover Deposits, whereas *S. lanata* is dominant on more organic, poorly-drained, Inactive-floodplain Cover Deposits. The understory commonly includes *Arctostaphylos rubra, Dryas integrifolia, S. reticulata, Lupinus arcticus*, and *Tomenthypnum nitens* and other mosses.
Open Low Willow	Riverine or upland willow community with an open canopy (25-75% cover). On better-drained stable sand dunes, *Salix glauca* is dominant. Common associates include *Dryas integrifolia, S. reticulata, Cassiope tetragona, Arctostaphylos rubra,* and *Astragalus umbellatus*. On wetter sites such as Inactive-floodplain Cover Deposits and drained lake basins, *Salix lanata* and *S. planifolia* are more common and sedges also are important. Associates include *Carex aquatilis, C. bigelowii, Eriophorum angustifolium, Dupontia fisheri*, *Arctagrostis latifolia, Dryas integrifolia, S. reticulata, Lupinus arcticus*, and mosses such as *Tomenthypnum nitens.*
Dryas Tundra	The dwarf shrub *Dryas integrifolia* forms an open to closed cover. Other common species include *Salix reticulata, S. phlebophylla, Carex bigelowii*; forbs are found on moister sites, and lichens on drier sites. *Tomenthypnum nitens* is a common moss in this class. *Dryas* Tundra is found on well drained sites, usually ridges, pingos and occassionally stream terraces.
Halophytic Dwarf Willow	The dwarf willow *Salix ovalifolia* forms an open to closed mat along margins of Tidal Flats and delta river bars. Other common species include *Deschampsia caespitosa, Puccinellia andersonii, Dupontia fisheri, Arctagrostis latifolia, Alopecurus alpinus, Chrysanthemum bipinnatum,* and *Petasites frigidus*. Usually found on Active-floodplain Cover Deposits subject to flooding and sedimentation nearly every year.

Table 7. (cont.)

Class	**Description**
Tussock Tundra	The vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum*; associated species include *Carex bigelowii*, *Dryas integrifolia*, *Cassiope tetragona*, and *Salix reticulata*. Many of the associated species are similar to those listed for Moist Sedge-Shrub Tundra. Found on broad upper slopes of ridges on coastal plain deposits and within ice-rich basins. Water generally is absent from the active layer during midsummer but occasionally can be found near the surface (>15 cm depth).
Moist Sedge–Shrub Tundra	Vegetation is dominated by *Carex aquatilis, C. bigelowii, Eriophorum angustifolium, Salix planifolia,* and *Dryas integrifolia*. Other common vascular species include *S. reticulata, Vaccinium vitis-idaea, Cassiope tetragona, Chrysanthemum integrifolia, Senecio atropurpureus, Pedicularis lanata, P. capitata, Polygonum viviparum,* and *Papaver macounii*. The ground surface is covered with a nearly continuous carpet of mosses usually including *Tomenthypnum nitens, Hylocomium splendens, Aulacomnium turgidum,* and *Dicranum* spp. This class combines Sedge–Willow and Sedge–*Dryas* Tundra. In high-relief areas (especially high-centered polygons) vegetation communities are more complex, including wet and aquatic sedge vegetation in flooded troughs. Up to 30% of the area can be Wet Sedge–Willow Meadow. Occurs on better-drained uplands between thaw basins, on riverbanks, lower slopes of pingos, thaw-lake plains, and foothill slopes. Usually is associated with high-centered polygons, Nonpatterned Ground, Frost Scars or mixed polygon areas. 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.
Wet Sedge–Willow Meadow	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*. Willows, including *Salix lanata, S. arctica,* and *S. planifolia*, are abundant at some sites and may be dominant on drier polygon ridges, however this class also includes wet sedge meadows without willows. Occurs in lowland areas within drained-lake basins, level floodplains and on swales. Usually associated with low-centered polygons, Disjunct Polygons, Strang, and Nonpatterned Ground. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but remains saturated within 15 cm of the surface throughout the growing season. Soils usually have a moderately thick (10-50 cm) organic layer over silt loam.
Fresh Sedge Marsh	Permanently flooded waterbodies and marshes dominated by *Carex aquatilis*. Typically, emergent sedges occur in water 10-30 cm deep. Water and bottom sediments of this shallow vegetation class freeze completely during winter, but the ice melts in early June. The sediments usually have a peat layer (10-50 cm deep) overlying silt loam.
Fresh Grass Marsh	Ponds and lake margins with emergent *Arctophila fulva.* Due to shallow water depths (0.3 - 1.0 m), the water freezes to the bottom in the winter and the ice melts by early June. *Arctophila* stem densities and annual productivity vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in the thaw-lake cycle and is more productive than Fresh Sedge Marshes.
Halophytic Grass Wet Meadow	Vegetation is dominated by *Dupontia fisheri,* and usually includes *Puccinellia phryganodes, P. andersonii, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.* This type occurs along the Beaufort Sea coast, delta margins, and shorelines of tapped lakes and is distributed patchily among brackish tidal pools and bare mudflats. Salinity levels and frequency of inundation usually are less than in Halophytic Sedge Wet Meadows. The soil is composed of marine or lacustrine silt and clay.

Table 7. (cont.)

Class	Description
Halophytic Sedge Wet Meadow	Similar to Halophytic Grass Wet Meadows, but is dominated by the sedges C*arex subspathacea*, and *C. ursina.* Associated species often include *Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea.*
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 *P. andersonii, D. fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, S. humifusa, Cerastium beeringianum,* and *Salix ovalifolia.* This habitat typically occurs either on low-lying areas that originally supported Wet Sedge-Willow Tundra and Basin Wetland Complexes, or, less commonly, along drier coastal bluffs that originally supported Moist Sedge-Shrub Meadows. 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.
Basin Wetland Complex, Young	Young Basin Wetland Complexes occur in portions of drained-lake basins and are characterized by a complex mosaic of open water, Fresh Sedge and Grass Marshes, and Wet and Moist Meadows in patches too small (<0.5 ha) to map individually. Young complexes occur in Ice-poor Thaw Basins and the variety of vegetation types reflects the many terrain units and surface forms found there. Ecological communities within younger basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating between these two types. To be mapped as a complex the area must have at least three vegetation types, with no single type covering more than 70% of the area. Minimum size for mapping polygon is 2 ha.
Basin Wetland Complex, Old	Similar to Young Basin Wetland Complexes but occuring in portions of Ice-rich Thaw Basins. This type is characterized by vegetation found in association with ice-wedge development and aggradation of segregated ice including Wet Sedge–Willow Meadow with low relief polygons, Moist Sedge–Shrub Meadows, and Tussock Tundra. Fresh Sedge and Grass Marshes are absent. Soils generally have a moderately thick (0.2-0.5 m) organic layer overlying fine-grained silt or sandy silt. This class has at least three vegetation types, although no single type dominates (>70% of the area). Minimum size for mapping polygon is 2 ha.

etation types in the delta included Barrens, Closed Low and Tall Willow, Open Low Willow, Wet Sedge–Willow Meadow, Halophytic Wet Sedge Meadow, and Salt-killed Wet Meadow. In contrast, the most common vegetation types on the adjacent coastal plain were Tussock Tundra, Moist Sedge–Shrub Tundra (Sedge–*Dryas* and Sedge–Willow combined), and Young and Old Basin Wetland Complexes (Table 6). A summary of the field data with both Level IV (AVC) and the 17 classes used for mapping is provided in Appendix Table 6.

For comparison with these subjectively identified vegetation types (using criteria defined in the AVC), we also used a quantitative approach to vegetation classification using an ordination technique (sorted-table analysis). The sorted-table analysis created 14 vegetation classes, and many of these corresponded with our vegetation classification (Appendix Table 7). For example, the *Salix alaxensis–Equisetum arvense–Bromus pumpiliamus–Aster siberica* group has the same composition as the riverine tall willow type, and the *Puccinellia phryganodes–Carex subspathacea–Stellaria humifusa–Carex ursina* group agrees well with the coastal halophytic wet meadow types. Generally, vegetation types that occur in well-defined habitats such as salt-affected areas and barrens were readily discerned by the sorted-table analysis. However, types that occur over a wide range of conditions did not separate well. For example, the species grouping defined by the sorted-table analysis as Litter–*Dryas integrifolia–Eripohorum angustifolium–Salix reticulata* overlaped with nearly all other groups in the table. This difficulty in discerning valid groupings from species-rich areas or from data sets with wide-ranging environmental gradients has been documented for other areas (Ceska and Roemer 1971). In some cases, the most stable species groups can be identified by using more restrictive cutpoints in the analysis than commonly employed. This technique, however, did not result in better separation of species groups for the Colville data, in fact species' groupings were very poorly defined and the number of species per group was reduced compared with the original analysis. In both the standard and the more restricted analysis, many plots were assigned to more than one possible species grouping. For these plots, other factors such as environmental and ecological associations need to be assessed before the plots can be classified. Although we found the sorted-table analysis unsatisfactory for classification of our data, it was useful for identifying plant species that differentiate among classes, particularly for those analytical classes that corresponded to AVC classes.

TOPOSEQUENCES

Topographic sequences, or toposequences, were established to document changes in elevation, terrain units, surface-forms, and vegetation at selected locations on the delta and adjacent coastal plain (Figures 8–16). The terms 'Transect' and 'Cross Section' both were used for naming the toposequences, and they are similar, except that Cross Sections were associated with the hydrologic studies and included measurements of the channel bottom (not included in these figures).

Three of the toposequences (Transects 12 and 10, Cross Section 11) are within the Inner Colville River Delta and one (Transect 15) is within the Outer Colville River Delta. Transect 12, located along the upper Nechelik Channel, includes a complete lateral-bar sequence with a High-water Channel associated with channel migration (Figure 9). It illustrates the accumulation of organic matter, changes in surface form from Nonpatterned to Low-centered, Low-relief, High-density Polygons, and vegetation succession from Barren, to tall and low willows, to Wet Sedge–Willow Meadows during floodplain development. Cross Section 11 (S9.80), near the proposed well sites adjacent to the Sakoonang Channel, represents a nearly complete sequence of delta evolution—from a barren Delta Riverbed/Riverbar Deposit to an Abandoned-floodplain Cover Deposit with Wet Sedge–Willow Meadows. It also includes an stabilized Eolian Sand Deposit with *Dryas* Tundra and ends at a thaw lake that is eroding into the ice-rich sediments (Figure 10). Transect 10 starts in a Delta Ice-poor Thaw Basin that was recently tapped by Nechelik Channel and has Halophytic Grass Wet Meadows, crosses a Delta Ice-rich Thaw Basin with Wet Sedge–Willow Meadows, and ends on an Abandoned-floodplain Cover Deposit with Moist Sedge–Shrub Meadows (Figure 11). Transect 15, in the Outer Colville Delta, crosses a variety of salt-affected ecosystems that include Halophytic Grass Wet Meadow and Halophytic Dwarf Willow vegetation on Delta Active and Inactive-floodplain Cover Deposits (Figure 12).

Situated along the Miluveach River, Transect 16 illustrates a sequence that starts at a Lower Perennial River, crosses Inactive- and Abandoned-floodplain Cover Deposits and an Alluvial-Marine Terrace with Moist Sedge–Shrub Tundra and *Dryas* Tundra, and ends at in an Ice-rich Thaw Basin with a Fresh Sedge Marsh (Figure 13). Similarly, Transect P2 on the

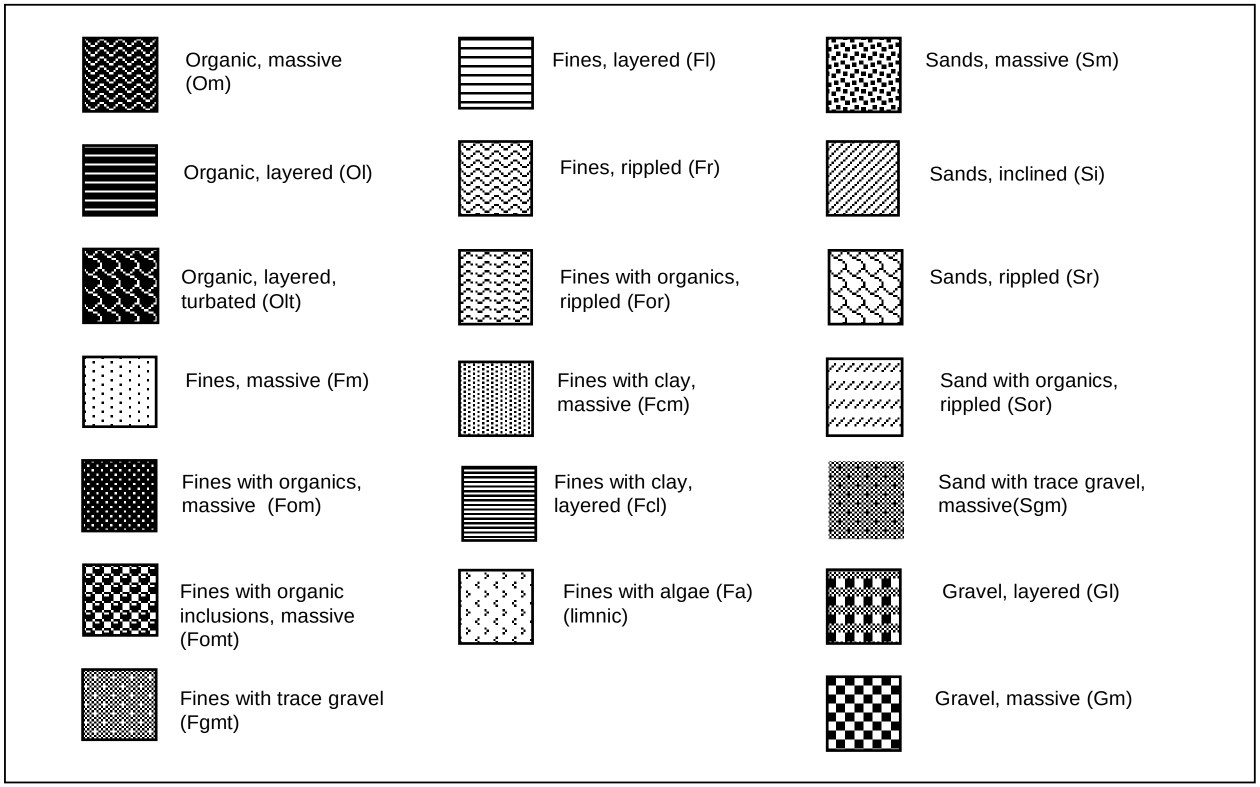


Figure 8. Classification and fill patterns of lithofacies used in characterizing soil stratigraphy along toposequences (Figure 9-16) sampled on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

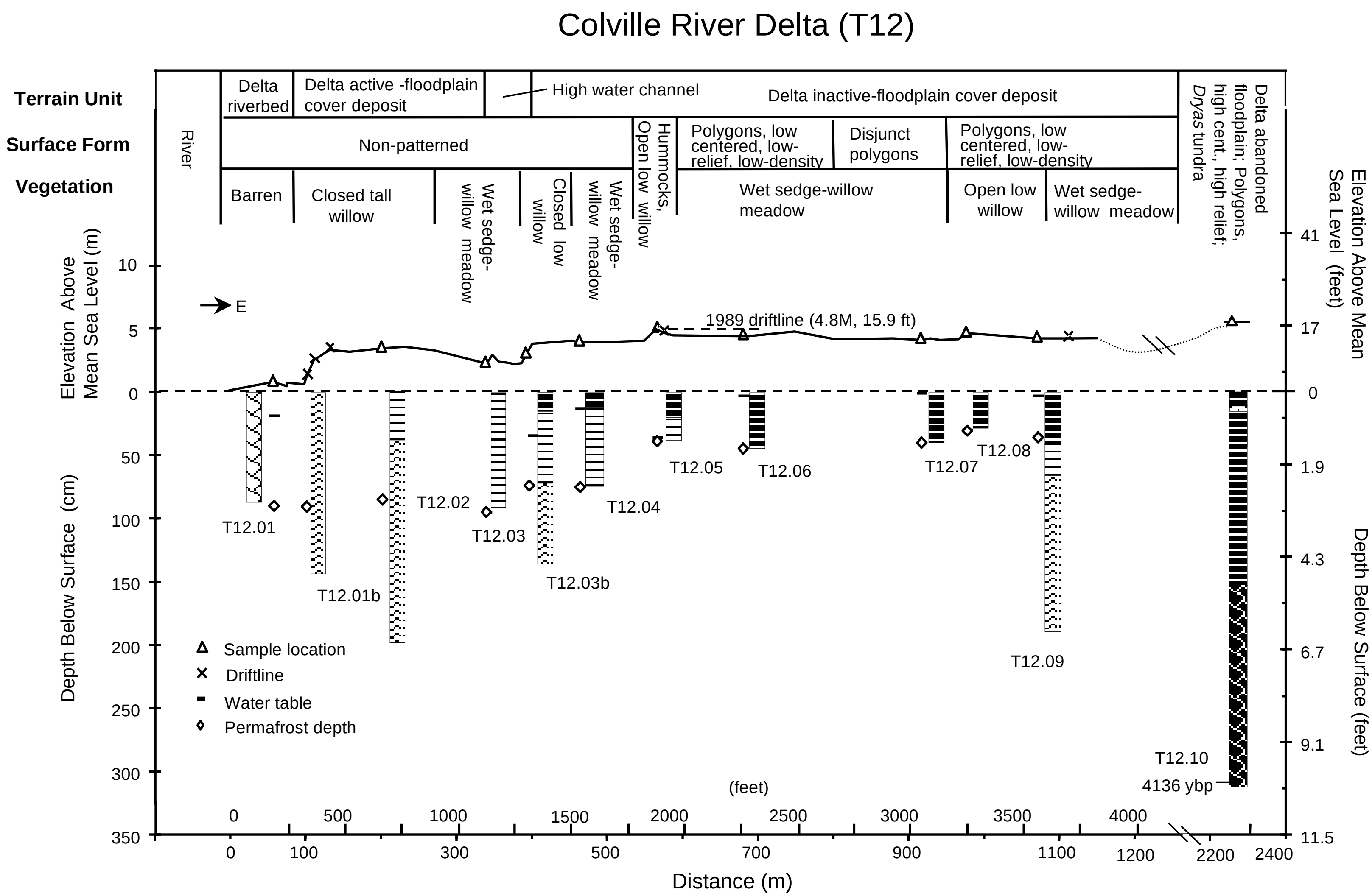


Figure 9. A representative terrain sequence (Transect 12) illustrating changes in terrain units, soils, hydrology, vegetation, and permafrost on the floodplain of the Colville River Delta, northern Alaska, 1996

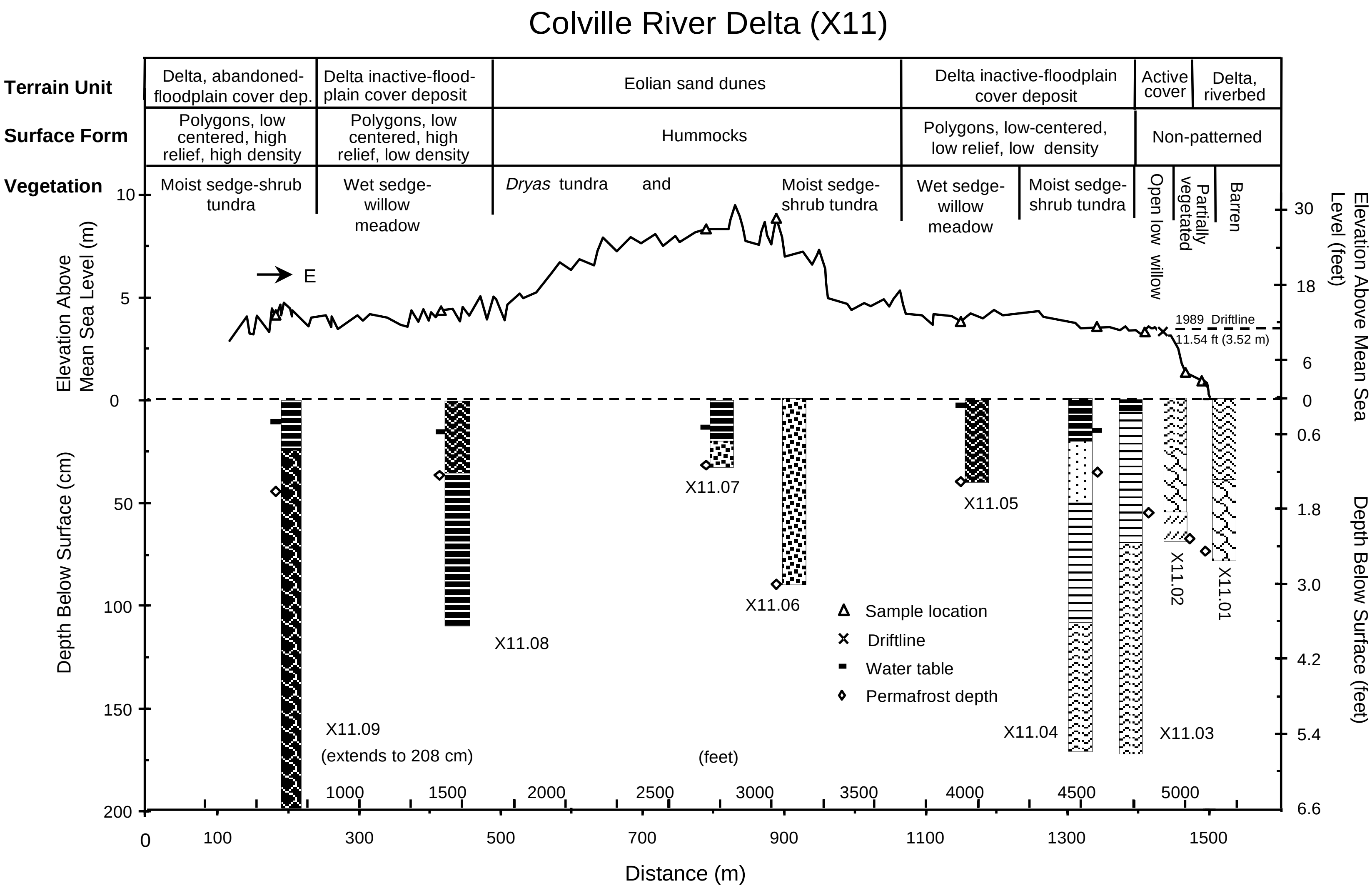


Figure 10. A representative toposequence (Cross section 11) illustrating changes in terrain units, soil, hydrology, vegetation, and permafrost on the floodplain and sand dunes on the Colville River Delta, northern Alaska 1996

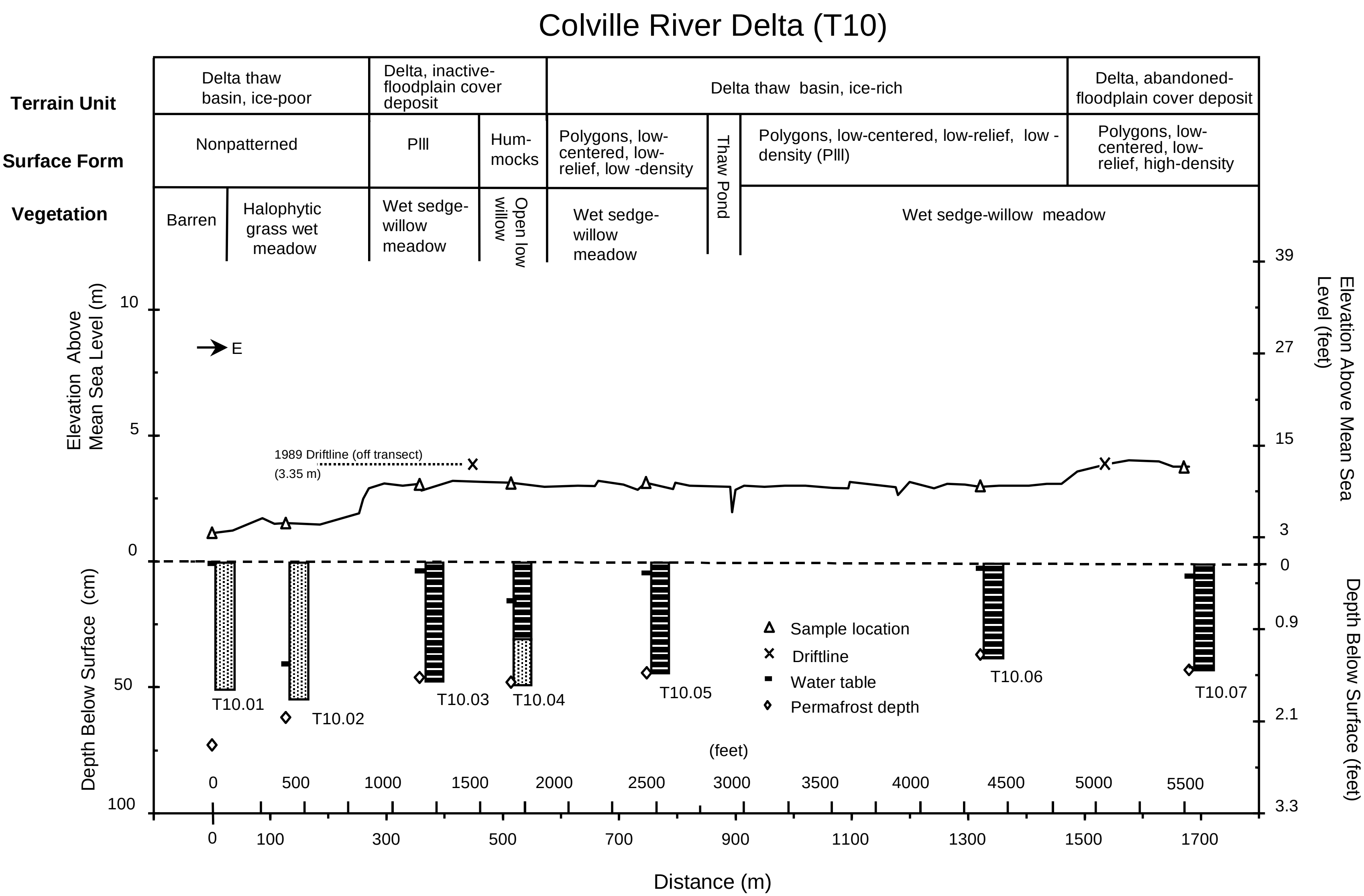


Figure 11. A representative toposequence (Transect 10) illustrating changes in terrain units, soils, hydrology, vegetation, and permafrost on the floodplain and sand dunes on the Colville River Delta, northern Alaska 1996

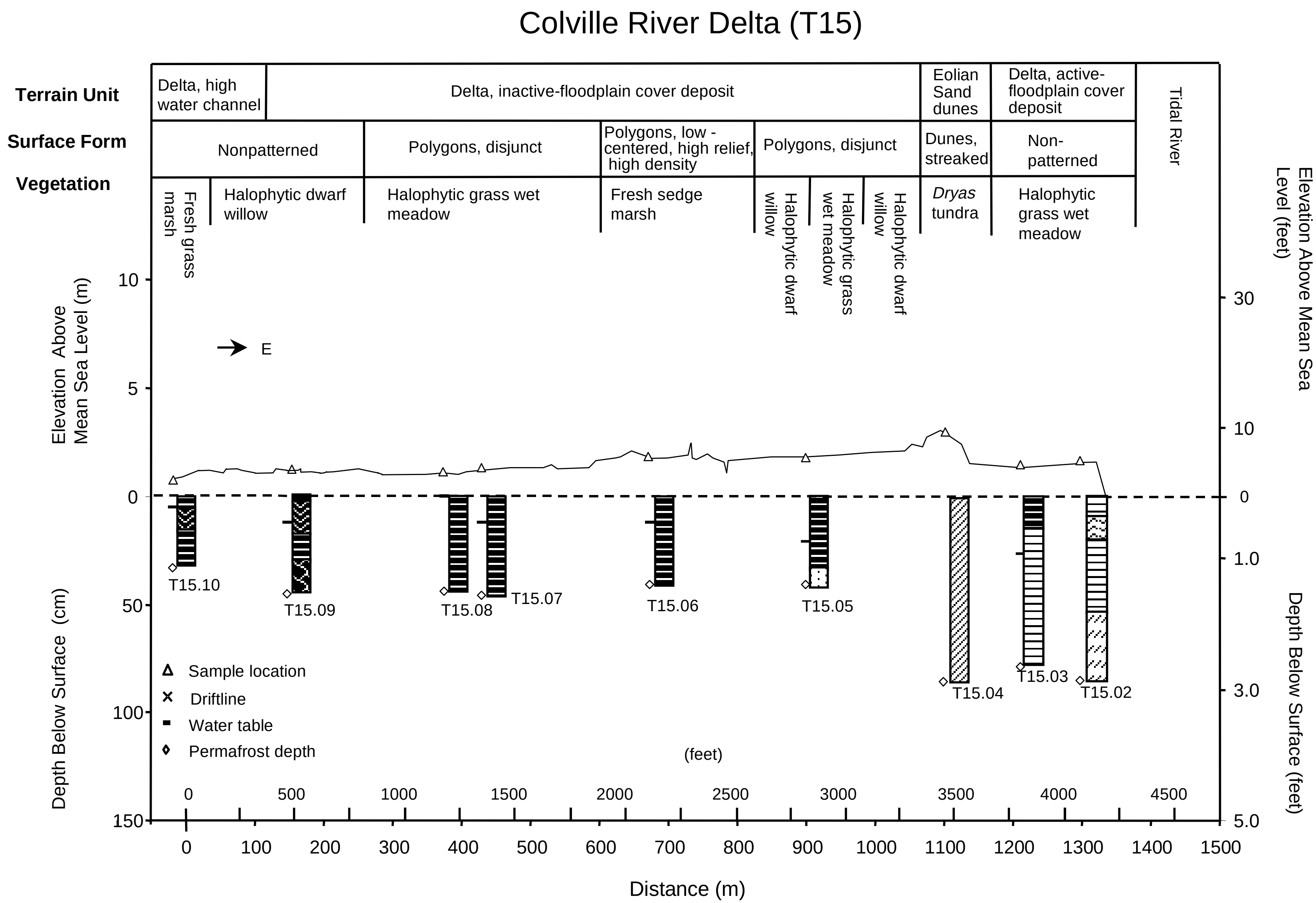


Figure 12. A representative toposequence (Transect 15) illustrating changes in terrain units, soils, hydrology, vegetation, and permafrost along the coastal fringe of the Colville River Delta, northern Alaska 1996

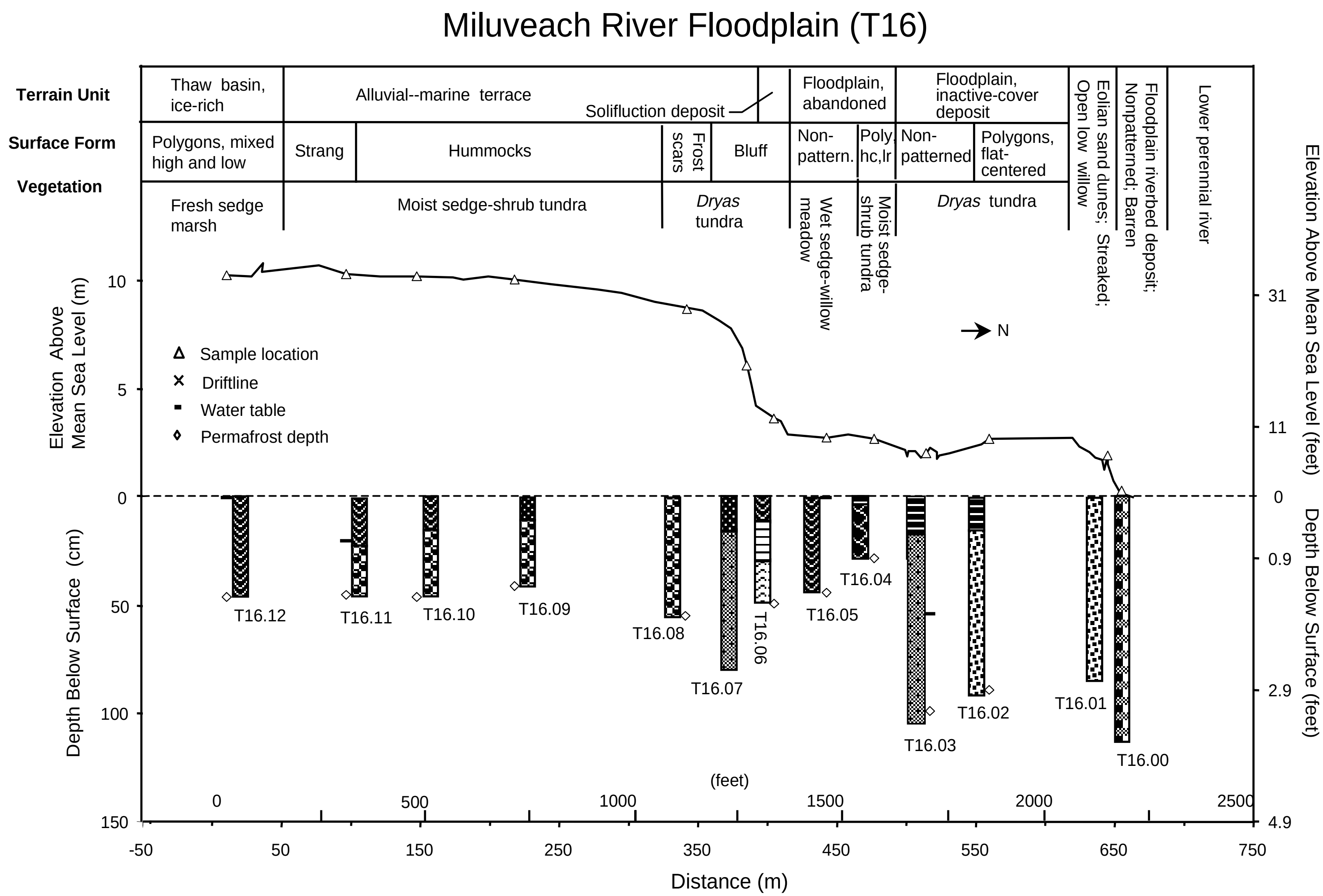


Figure 13. A representative toposequence (Transect 16) illustrating changes in terrain units, soils, hydrology, vegetation, and permafrost on the floodplain of the Miluveach River near the Colville River Delta, Alaska, 1996

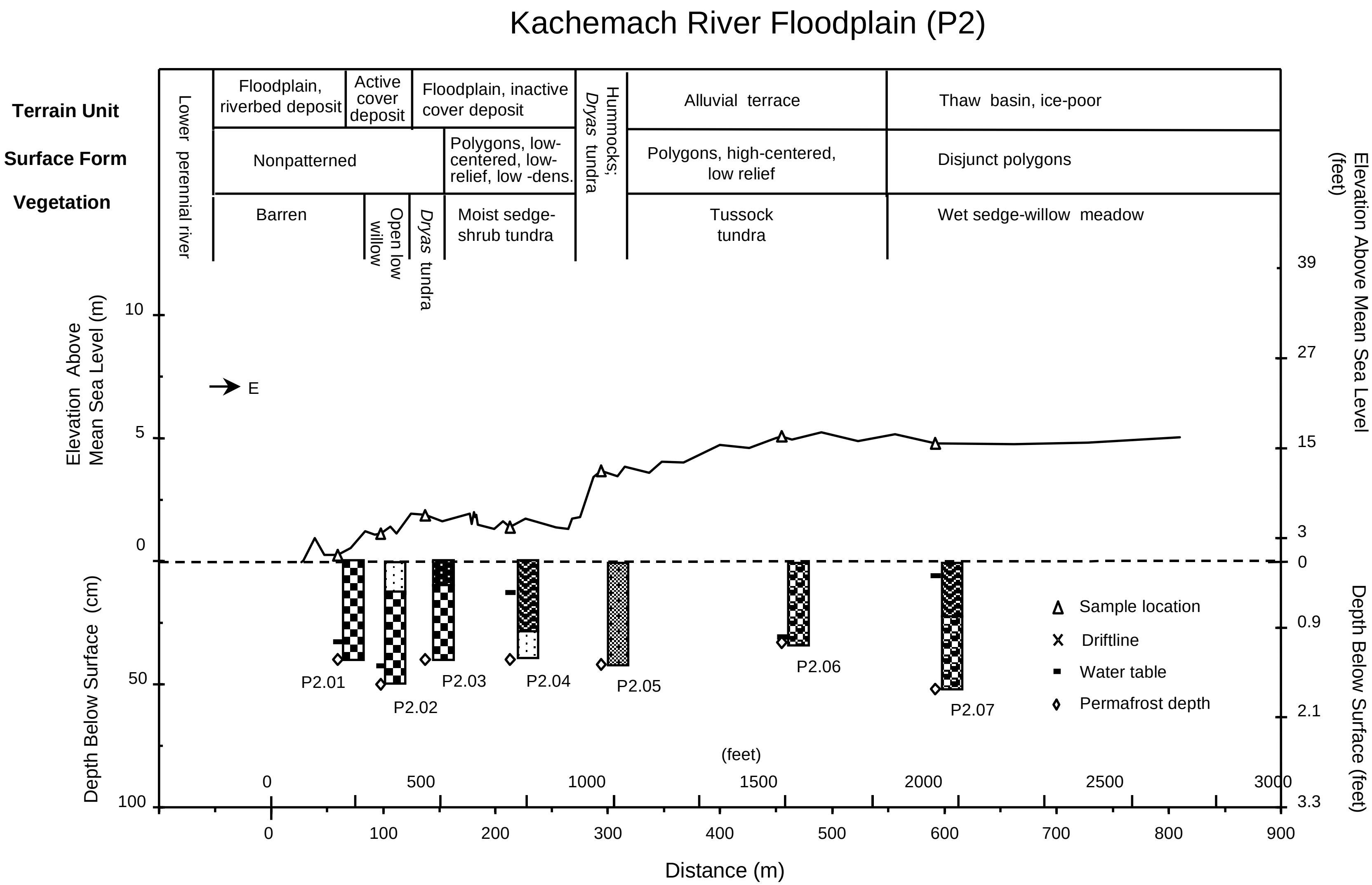


Figure 14. A representative toposequence (Transect P2) illustrating changes in terrain units, soils, hydrology, vegetation, and permafrost on the floodplain of the Kachemach River near the Colville River Delta, Alaska, 1996

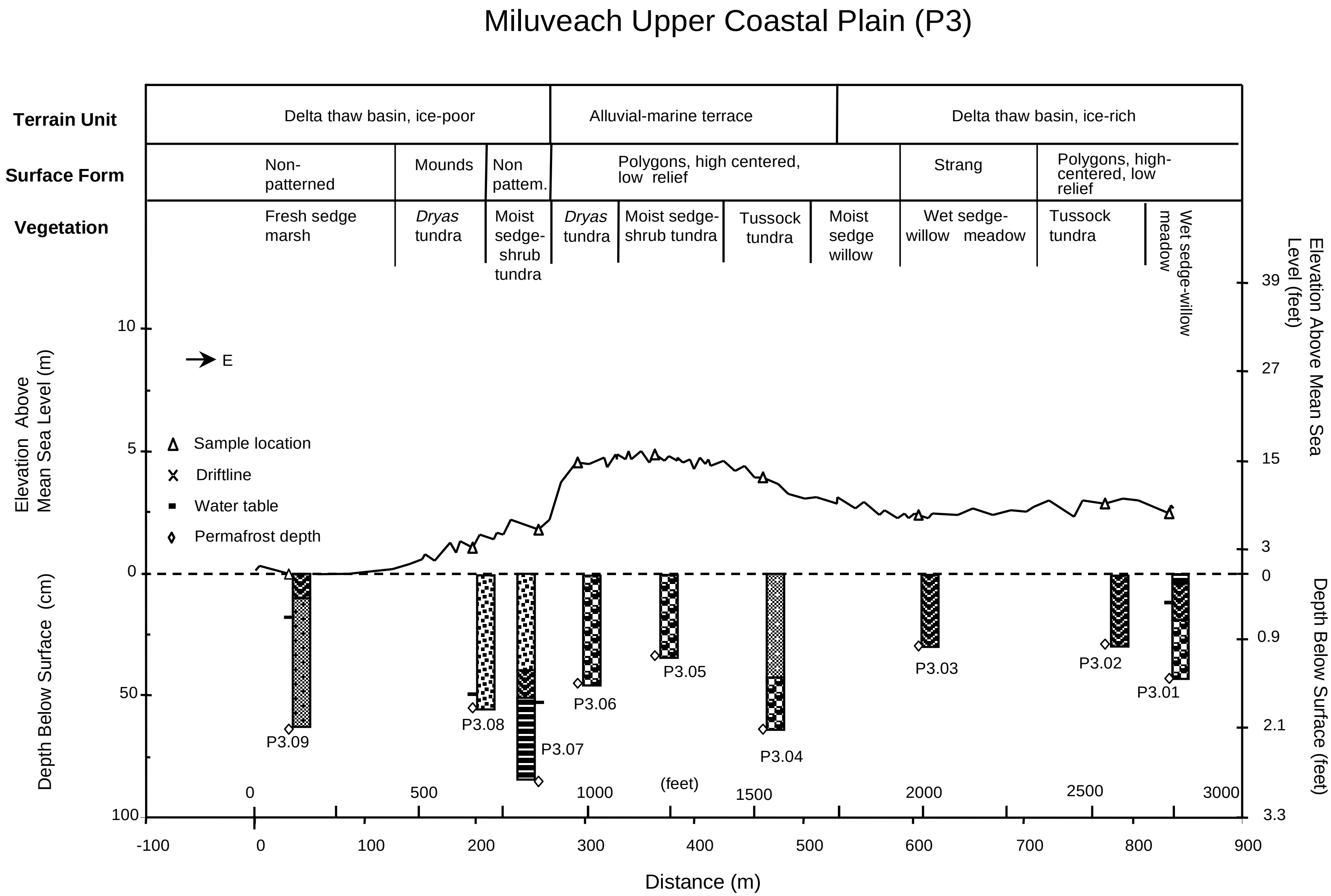


Figure 15. A representative terrain sequence (Transect P3) illustrating changes in terrain units, soils, hydrology, vegetation, and permafrost in a thaw basin on the coastal plain adjacent to the Colivlle River Delta, Alaska, 1996

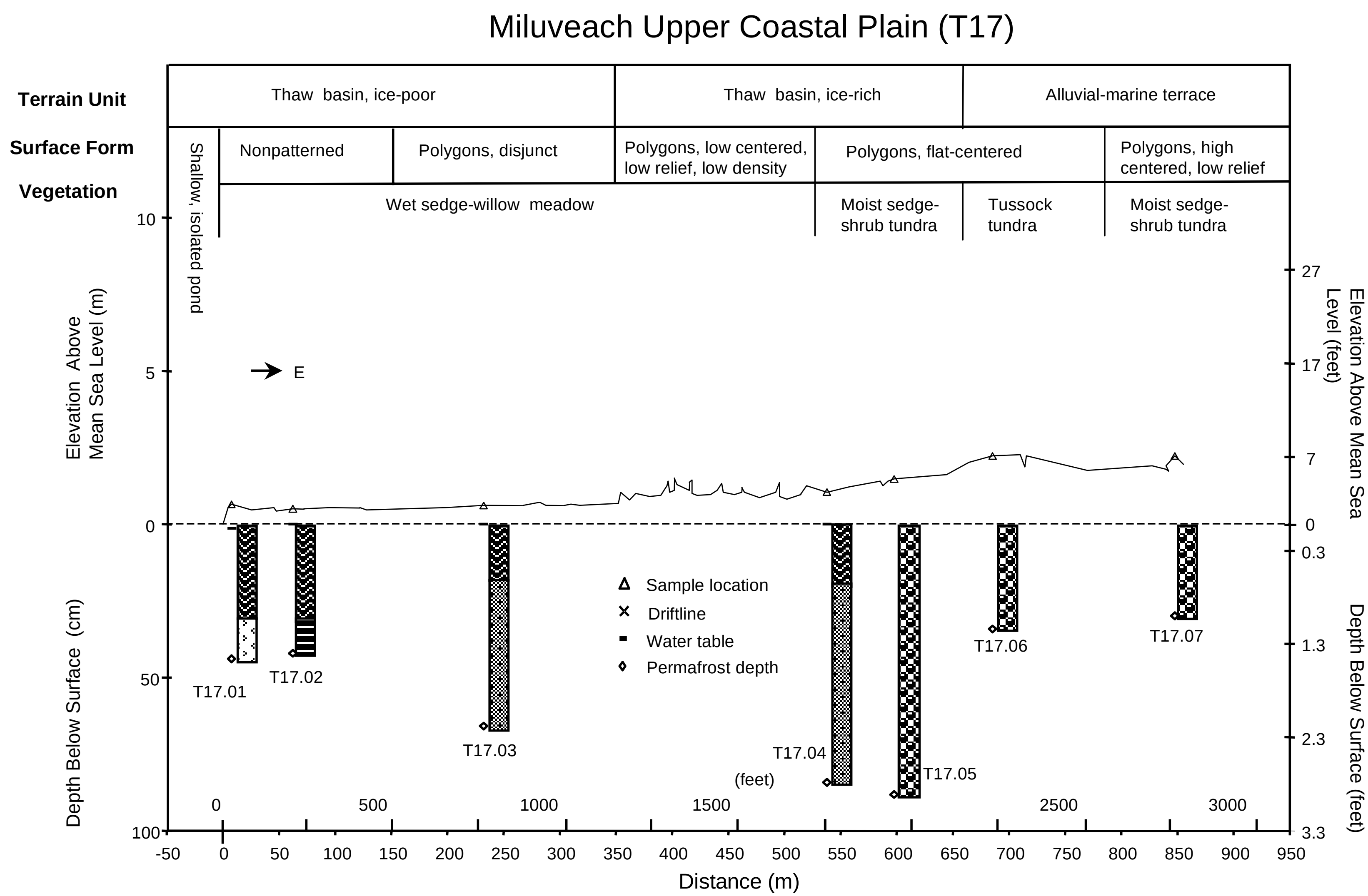


Figure 16. A representative terrain sequence (Transect 17) illustrating changes in terrain units, soils, hydrology, begetation, and permafrost on a thaw basin on the coastal plain adjacent to the Colville River Delta, Alaska, 1996

Kachemach River floodplain starts at a Lower Perennial River, crosses Active- and Inactive-floodplain Cover Deposits supporting Open Low Willow, *Dryas* Tundra, and Moist Sedge–Shrub Tundra, and ends on an Alluvial Terrace and Ice-poor Thaw Basin with Tussock Tundra and Wet Sedge–Willow Meadows (Figure 14).

Situated within the coastal plain, Transects P3 (Figure 15) and 17 (Figure 16), both illustrate changes in the evolutionary sequence from Ice-poor Thaw Basins, to Ice-rich Thaw Basins, to Alluvial-Marine Terraces. Along this gradient, the vegetation also changes from Fresh Sedge Marsh and Wet Sedge–Willow Meadows in basins, to Moist Sedge–Shrub Tundra on lower slopes, Tussock Tundra on upper slopes, and *Dryas* Tundra on well-drained ridges.

ECOSYSTEMS AND LANDSCAPES

To address the complexity and variation associated with the various ecosystem components, we developed a systematic approach to aggregating these components into a reduced set of ecosystem classes at the ecosite level (i.e., relatively homogenous patches of surficial geology, hydrology, soils, and vegetation). To do this, we first examined the associations among ecosystem components that occurred along the toposequences and hierarchically organized them using geomorphic processes as the primary organizing factor. Detailed descriptions and a distribution map of these ecosystem classes are provided below in the Ecosites section. At a larger scale of ecological organization, we partitioned the landscape into ecodistricts (physiographic regions with repeating associations of terrain units) to delineate ecologically similar regions and to provide a useful nomenclature for identifying larger geographic areas.

Associations Among Ecosystem Components

Examination of the toposequences and cross-tabulation of the plot data reveal consistent patterns or associations among soil texture, terrain units that denote depositional environments, surface-forms related to ice aggradation and active-layer processes, slope position, hydrology, and vegetation structure (Table 8, Appendix Tables 8–10). The hierarchical organization of the ecosystem components reveals how tightly or loosely the components are linked together. For example, there were many terrain units (with their associated geomorphic processes) that resulted in similar soil textures. Similarly, there were numerous terrain units that could have the same vegetation type depending on surface form characteristics and hydrology. In contrast, some terrain units (e.g., Tidal Flats) were associated only with a few distinct vegetation types. The table provides an explicit summary of what ecosystem components are associated with each ecosystem class.

These relationships were used to develop conceptual models of the evolution of landscapes on the delta floodplain and adjacent coastal plain and were used during mapping to improve classification within a physiographic district. For example, the hierarchical organization of landscape relationships reveals that only a few vegetation types (e.g., Wet Sedge–Willow Meadow, Moist Sedge–Shrub Meadow, and *Dryas* Tundra) are found on Alluvial-Marine Terraces. This knowledge helps limit the decision-making during mapping and improves consistency.

Ecosites

Thirty-six ecosystem classes at the ecosite level (hereafter referred to as ecosystems) were derived from 178 ITU map classes (Figures 17–21, Tables 8 and 9). Within the delta, the most common ecosystems included Tidal Rivers, Coastal Barrens, Coastal Salt-killed Wet Meadow, Riverine Wet Meadows, Riverine Low and Tall Scrub, Lowland Wet Meadows, and Lowland Deep Lakes (Figure 17a, Table 10). In contrast, the most common ecosystems on the adjacent coastal plain included Lowland Deep and Shallow Lakes, Lacustrine Wet and Moist Meadows, Lacustrine Thaw Complex, Lowland Thaw Complex, Lowland Wet and Moist Meadows, and Upland Tussock Meadows.

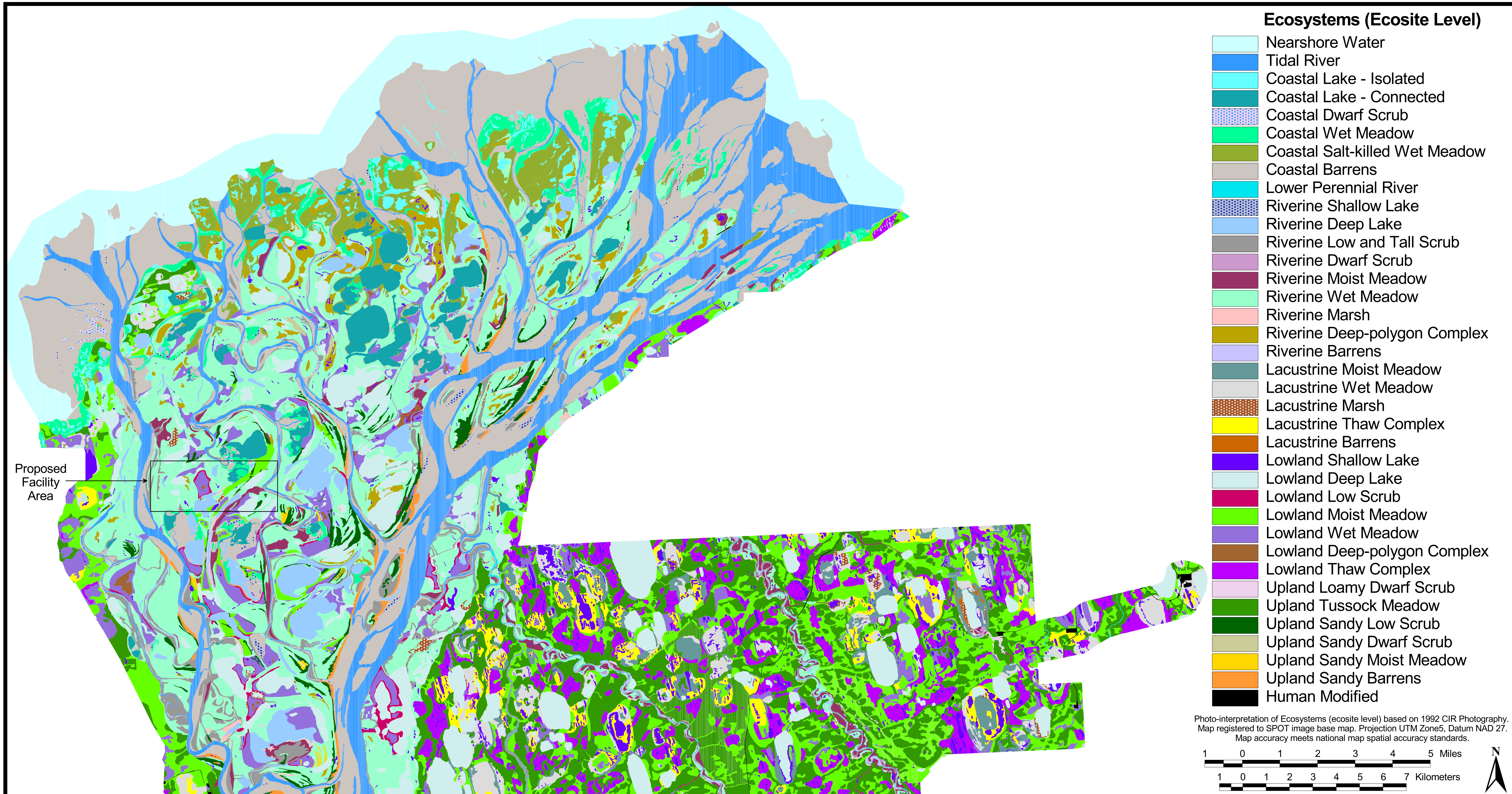
The linking of geomorphic processes, inherent in the terrain unit classification, with vegetation structure (or lack of) helped delineate areas with very different ecological characteristics. For example, we differentiated nine waterbody classes (e.g., Nearshore Water, Tidal River, Lower Perennial River, Deep Isolated Lake) that had large differences in salinity, sediment load, water velocity, water depth, and/or fish use (Moulton 1996). Water typically is treated as one class in most vegetation or land-cover maps. For some ecosystem classes, such as those with wet meadow vegetation, there appeared to be only minor differences in vegetation composition. Linking the vegetation to a geomorphic setting was particularly useful in these situations because slightly different soil and hydrologic characteristics translate to differing ecosystem

Table 8. Relationships among ecosystem components on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Physio-graphic	Soil Texture	Terrain Unit Class	Surface Form Class	Slope Position	Hydrology	Vegetation Class	Ecosystem Class (Ecosite Level)
Coastal	Water	Nearshore Water	Water	Water	Brackish water	Water	Nearshore Water
		Tidal River					Tidal River
		Brackish Ponds					Coastal Lake – Isolated
		Shallow Tapped Lake/Low Water Connect					Coastal Lake – Connected
	Loam	Tidal Flats, Delta Riverbed/Sandbar, Delta High-water Channel, Delta Thaw Basin Deposit, Ice-poor	Nonpatterned	Flat	Irregularly and seasonally flooded	Barren and Partially Vegetated	Coastal Barrens
			Nonpatterned or Disjunct Polygons	Flat		Halophytic Wet Sedge or Grass Meadow	Coastal Wet Meadow
		Delta Active-floodplain Cover Deposit (by coast), Ice-poor Thaw Basin	Nonpatterned	Flat	Seasonally flooded, well-drained	Halophytic Dwarf Scrub	Coastal Dwarf Scrub
		Delta Inactive-floodplain, Ice-poor Thaw Basin, High-water Channel	Nonpatterned, Disjunct Polygons, Low-centered Polygons	Flat	Seasonally flooded, saturated	Salt-killed Wet Meadow	Coastal Salt-killed Wet Meadow
Riverine	Water	Lower Perennial River	Water	Water	Freshwater	Water	Lower Perennial River
		Shallow Isolated Pond, Shallow Tapped Lake					Riverine Shallow Lake
							Riverine Marsh
		Deep Isolated Lake, Deep Tapped Lake/High Water Connection,					Riverine Deep Lake
	Loam	Delta High-water Channel,	Nonpatterned	Flat	Seasonally flooded	Wet Sedge–Willow Meadow	Riverine Wet Meadow
		Delta and Meander Active-floodplain Depos., Delta Ice-poor Thaw Bas.	Nonpatterned	Flat	Seasonally flooded, well drained	Open and Closed, Low and Tall Willow	Riverine Low and Tall Scrub
		Delta Inactive-floodplain Cover Deposit, Delta Ice-poor Thaw Basin, Delta Ice-rich Thaw Basin, Delta High-water Channel Meander Inactive-floodplain Cover Deposit,	Nonpatterned, Disjunct, or Low-centered Polygons (LCP)	Flat	Seasonally flooded, saturated	Wet Sedge–Willow Meadow (WSWM)	Riverine Wet Meadow
				Gentle banks	Seasonally flooded	Moist Sedge–Shrub Tundra	Riverine Moist Meadow
			LCP; Low-relief, Low-density Polygons	Flat	Seasonally flooded	Open and Closed Low Willow	Riverine Low Scrub
					Well-drained	*Dryas* Tundra	Riverine Dwarf Scrub
		Delta Inactive-floodplain Cover Deposit	LCP; High-relief, Low-density Poly.	Flat	Permanently flooded	Fresh Marsh, WSWM, (complex)	Riverine Deep-polygon Complex
	Gravel	Meander Floodplain Riverbed Deposit	Nonpatterned	Flat	Seasonally flooded	Barren and Partially Vegetated	Riverine Barrens

Table 8. (cont.)

Physio-graphic	Soil Texture	Terrain Unit Class	Surface Form Class	Slope Position	Hydrology	Vegetation Class	Ecosystem Class (Ecosite Level)
Lacustrine	Water	Shallow Isolated or Connected Pond	Water	Water	Permanently flooded	Fresh Sedge or Grass Marsh	Lacustrine Marsh
	Loam	Thaw Basin, Ice-poor	Nonpatterned, and Disjunct Polygons	Flat	Saturated	Barren, Partially Veg.	Lacustrine Barrens
						WSWM	Lacustrine Wet Meadow
				Gently sloping	Saturated	Moist Sedge–Shrub Tundra	Lacustrine Moist Meadow
			Nonpatterned	Flat	Complex	Basin Wetland Complex, Young	Lacustrine Thaw-Basin Complex
Lowland	Water	Shallow Pond	Water	Water	Water	Water	Lowland Shallow Lake
		Deep Lake					Lowland Deep Lake
	Loam	Delta and Meander Abandoned-floodplain Cover Deposit	LCP; Low-relief, High-density Polygons	Flat	Saturated	WSWM	Lowland Wet Meadow
						Moist Sedge–Shrub Tundra	Lowland Moist Meadow
						Open, or Closed Low Willow	Lowland Low Scrub
			LCP; High-relief, High-density Poly.	Flat	Permanently flooded	Fresh Marsh, Moist or Wet Sedge–Shrub	Lowland Deep-polygon Complex
	Loam (trace gravel)	Alluvial Terrace (Acidic), Alluvial-Marine Terrace (Non-acidic), Alluvial Plain, Ice-rich Thaw Basin	Low-centered, Low-relief Polygons	Flat, swales	Satur., Seasonally flooded	Wet Sedge–Willow Meadow	Lowland Wet Meadow
			LCP, Nonpatterned, Strang	Flats, swales	Saturated	Moist Sedge–Shrub Tundra	Lowland Moist Meadow
						Open, Close Low Willow	Lowland Low Scrub
			Basin Complex	Basin	Complex	Basin Wetland Complex, Old	Lowland Thaw-Basin Complex
Upland	Loam	Alluvial Terrace (Acidic), Alluvial-Marine Terrace. (Non-acidic) (AMV), Ice-rich Thaw Basin	High-centered, Low-relief Polygons; Nonpatterned	Upper slopes, ridges banks, pingos	Moderately well-drained to saturated	Tussock Tundra	Upland Tussock Meadow
					Well-drained	*Dryas* Tundra	Upland Loamy Dwarf Scrub
	Sand	Eolian Sand Dunes	Streaked Dunes	Upper slopes, ridges	Well-drained	Barren, Partially Veg.	Upland Sandy Barrens
						Open, or Closed Low Willow	Upland Sandy Low Scrub
						Dryas Tundra	Up. Sandy Dwarf Scrub
				Lower slopes	Well-drained	Moist Sedge–Shrub Tundra	Upland Sandy Moist Meadow
Human	Water	Sewage Lagoon, Reserve Pit	Water	Water	Perm. flooded	Water	Human Modified
	Loam	AMV, Peat Road	Mixed Pits, Polys	Varies	Varies	Barren or Partially Veg.	
	Gravel	Gravel Fill	Nonpatterned	Flat	Well-drained	Barren	



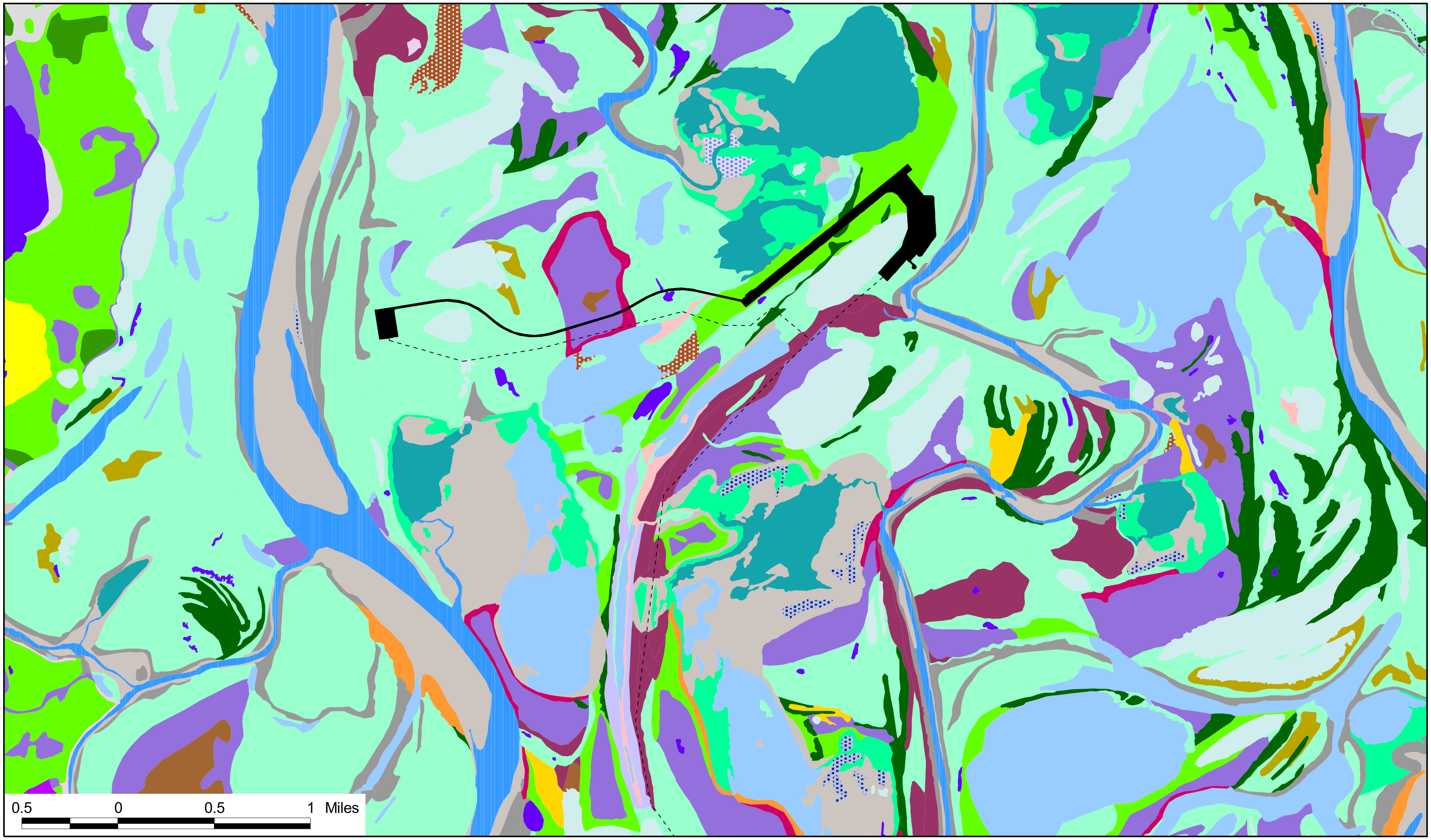
ARCO Alaska, Inc.

Colville Ecological Land Survey

Figure 17a. Map of ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

ABR, Inc.
Environmental Research and Services

16 Sept 1997 | File:96reportthematics.apr,Ecosite3



- Tidal River
- Coastal Lake - Connected
- Coastal Dwarf Scrub
- Coastal Wet Meadow
- Coastal Barrens
- Riverine Shallow Lake
- Riverine Deep Lake
- Riverine Low and Tall Scrub
- Riverine Moist Meadow
- Riverine Wet Meadow
- Riverine Marsh
- Riverine Deep-polygon Complex
- Riverine Barrens
- Lacustrine Wet Meadow
- Lacustrine Marsh
- Lacustrine Thaw Complex
- Lowland Shallow Lake
- Lowland Deep Lake
- Lowland Low Scrub
- Lowland Moist Meadow
- Lowland Wet Meadow
- Lowland Deep-polygon Complex
- Lowland Thaw Complex
- Upland Loamy Dwarf Scrub
- Upland Tussock Meadow
- Upland Sandy Low Scrub
- Upland Sandy Moist Meadow
- Upland Sandy Barrens
- Human Modified

ARCO Alaska, Inc.

Colville Ecological Land Survey

Figure 17b. Map of ecosystems (ecosite level) in the vicinity of the proposed Facility Area, Colville River Delta, 1996.

ABR, Inc.
Environmental Research and Services

17 Sept 1997 | File: ELS_Infield_Views.apr, Ecosite

Tidal River

Lower Perennial River

Coastal Lake - Connected

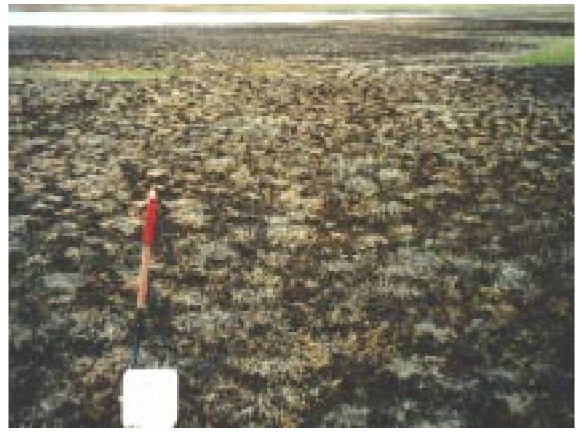
Riverine Shallow Lake

Lowland Shallow Lake

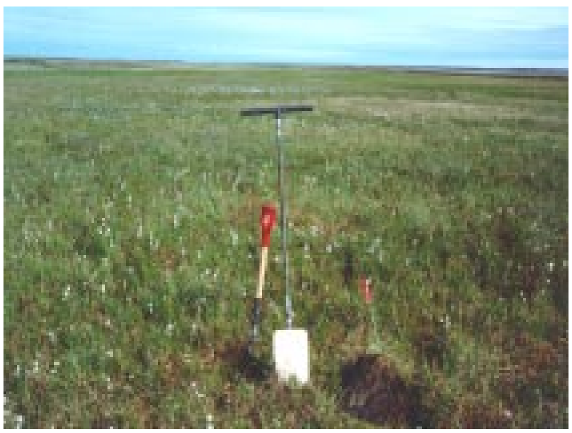
Lowland Deep Lake

Figure 18. Photographs of ecosystem dominated by open water on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

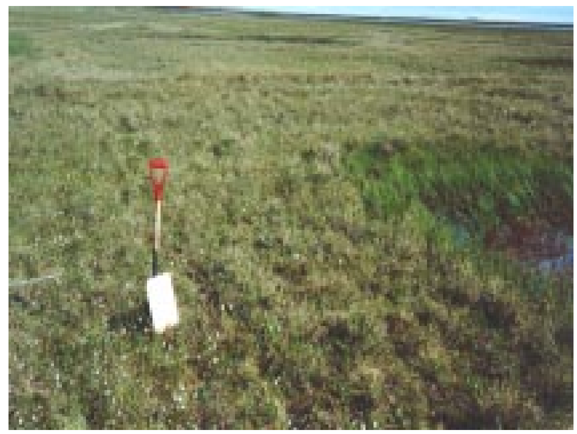
Coastal Wet Meadow



Coastal Salt-killed Wet Meadow



Riverine Wet Meadow



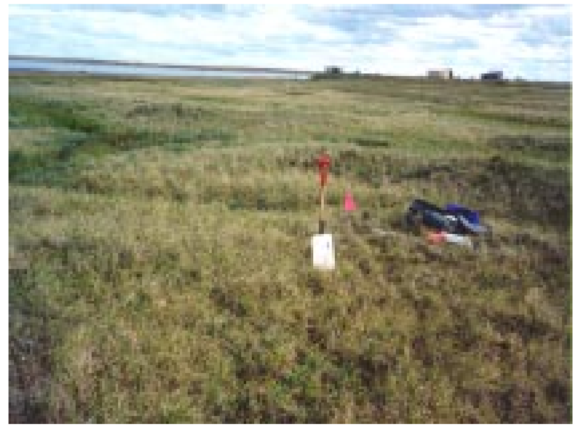
Lowland Wet Meadow

Lacustrine Wet Meadow

Riverine Marsh

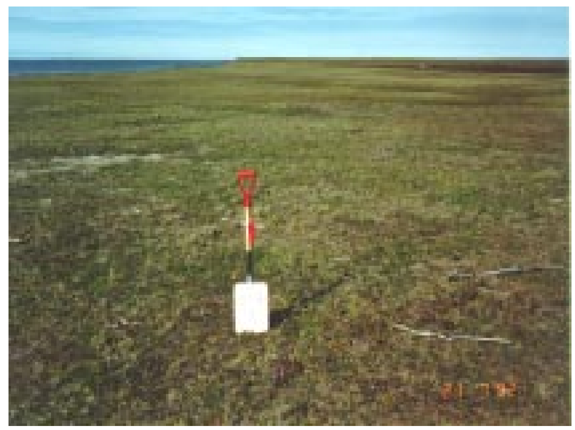
Figure 19. Photographs of ecoystems dominated by wet meadow and marsh vegetation on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

Riverine Moist Meadow

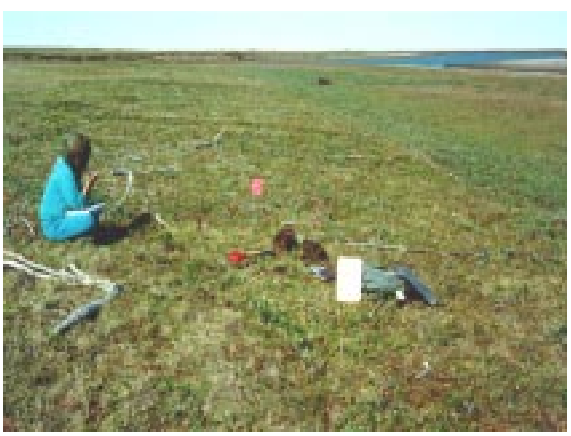


Lowland Moist Meadow

Upland Tussock Meadow



Coastal Dwarf Scrub



Riverine Dwarf Scrub

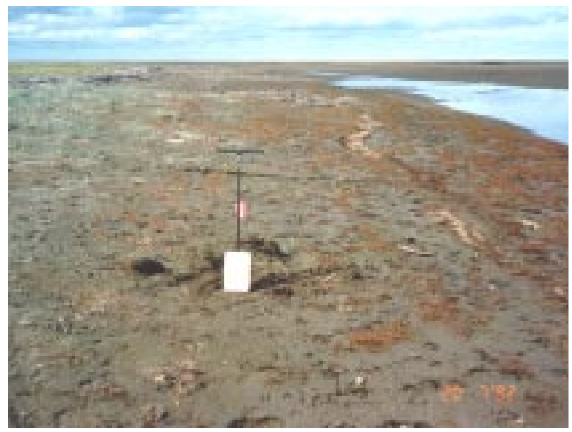
Upland Sandy Dwarf Scrub

Figure 20. Photographs of ecosystems dominated by moist meadow and dwarf scrub vegeta-tion on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

Riverine Tall Scrub

Riverine Low Scrub

Upland Sandy Low Scrub



Coastal Barrens

Riverine Barrens

Upland Sandy Barrens

Figure 21. Photographs of ecosystems dominated by tall and low scrub vegetation, and barrens on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

Table 9. Classification and descriptions of ecosystems (ecosite level) mapped on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Class	Description
Shallow Nearshore Water	Shallow (< 2m) 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 (< 0.2 m), but storm surges produced by winds may raise sea level as much as 2-3 m. Bottom sediments are mostly unconsolidated mud. The ice-free period extends from July until October. Winter freezing generally begins in late September.
Tidal River	Permanently flooded channels of the Colville River that are affected by daily tidal fluctuations and variable salinity levels. The channels generally experience peak flooding during spring breakup and lowest water levels during mid-summer. During summer and winter currents are negligible. During winter ice covers all channels to a depth of ~2 m and unfrozen water in deeper channels can become hypersaline.
Coastal Lake – Isolated	Coastal 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 is loamy and occasionally contains peat. Shorelines usually have halophytic vegetation.
Coastal Lake – Connected	Coastal waterbodies that have distinct outlets. Most have been partially drained through erosion of banks by adjacent river channels (tapped), and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish because the waterbodies occur within the delta, and the lakes are subject to yearly flooding. Because water levels have dropped after tapping, the lakes generally have broad flat shorelines with silty-clay sediments. Halophytic vegetation is common along the shore. Shallow lakes (< 1.5 m) freeze to the bottom during winter.
Coastal Dwarf Scrub	This class occurs on Tidal Flats and Delta Active-floodplain Cover Deposits subject to flooding and sedimentation nearly every year. These salt-affected areas are well drained, have high salinity and pH levels, and little organic accumulation. The dwarf willow Salix ovalifolia forms an open to closed mat and *Dupontia fisheri, Carex aquatilis, Eriophorum angustifolium* and *Deschampsia caespitosa* are common.
Coastal Wet Meadow	This class occurs on Tidal Flats, Delta Thaw Basin Deposits, and Delta Riverbed/Riverbars Deposits that are frequently flooded. The surface is nonpatterned and the loamy or clayey soils have high salinity and pH levels and little organic accumulation. Groundwater is near the surface. Vegetation is dominated by *Carex subspathacea, Puccinellia phryganodes* and *Dupontia fisheri*, and *Carex ursina, Puccinellia andersonii, Cochlearia officinalis* and *Stellaria humifusa* also are common. Non-vascular plants are absent or nearly so.
Coastal Salt-killed Wet Meadow	Barren or partially vegetated (< 30% cover) coastal areas on Delta Inactive-floodplain Cover Deposits and Alluvial Plain 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 meadow are common.
Coastal Barrens	Barren or partially vegetated (< 30% cover) Tidal Flats and Delta Riverbed/Riverbars where frequent sedimentation restricts vegetation establishment. Sediments usually are saline, alkaline, have deep thaw depths and little organic accumulation. Common colonizing plant include *Deschampsia caespitosa, Elymus arenarius, Salix ovalifolia* and *Stellaria humifusa* in well-drained areas and *Puccinellia phryganodes, Dupontia fisheri*, and *Carex subspathacea* in wetter areas.
Lower Perennial River	Permanently flooded channels of freshwater rivers and beaded streams where the gradient is low and water velocity is slow. There is no tidal influence and some water flows throughout the year, beaded streams freeze completely in winter. Peak flooding generally occurs during spring breakup and the lowest water levels occur during mid-summer. Riverbed materials can be either sand or gravel and the larger rivers have well-developed floodplains.

Table 9. (cont.).

Class	Description
Riverine Shallow Lake	Shallow (< 1.5 m) ponds or small lakes associated with old river channels, point bars and meander scrolls. Some may have connecting channels that flood during high water. Water typically is fresh, freezes to the bottom during winter, and thaws by early to mid-June. Sediments are fine-grained silt and clay. Shorelines usually are smooth (lack polygonization).
Riverine Deep Lake	Deep (≥1.5 m) waterbodies formed in old river channels. They do not freeze to the bottom during winter. These lakes may have connections that flood only at high water or have no distinct outlets. In either case they are inundated only during flooding events. Sediments are fine-grained silt and clay. Shorelines usually are smooth (lack polygonization).
Riverine Low and Tall Scrub	Riverine willow communities found on flat to gently sloping Active- and Inactive-floodplain Cover Deposits subject to variable flooding frequency. The most frequently flooded sites have well-drained soils, lack organic accumulations, and are dominated by tall (> 1.5 m) *Salix alaxensis*. In the understory *Equisetum arvense, Astragalus spp*. and *Aster sibericus* are common. On Inactive-floodplain Deposits, where soils are seasonally saturated with interbedded organic layers, *Salix lanata* is dominant. Common understory species include *Salix reticulata, Arctostaphylos rubra, Dryas integrifolia, Arctagrostis latifolia, Equisetum sp*., legumes, *Tomenthypnum nitens* and other mosses.
Riverine Dwarf Scrub	This class is found on Inactive-floodplain Cover Deposits where flooding is infrequent. The loamy to sandy soils are well-drained, nonsaline, neutral to slightly alkaline, and there is little organic accumulation. The dwarf shrub *Dryas integrifolia* is dominant and *Salix reticulata, Salix lanata, Carex bigelowii, Arctagrostis latifolia, Astragalus spp*. and *Equisetum scirpoides* are common. *Tomenthypnum nitens* and *Distichium capillaceum* are common mosses.
Riverine Moist Meadow	This class occurs on gently sloping Inactive-floodplain Cover Deposits. The surface usually is Nonpatterned and soils are moderately well drained. Vegetation is dominated by *Carex aquatilis* and *Eriophorum angustifolium*. *Dryas integrifolia, Salix lanata, Salix reticulata* and *Equisetum spp* are common associated vascular species. Common mosses include *Tomenthypnum nitens* and *Campylium stellatum.*
Riverine Wet Meadow	This class occurs on flat, Active- and Inactive-floodplain Cover Deposits. Surface forms vary from Nonpatterned to Low-relief, Low-centered Polygons, the latter are indicative of progressive ice-wedge development. Soils usually have a moderately thick organic layer (10-50 cm) over silt loam, are saturated ≥ 10 cm from the surface, and are nonsaline and neutral. Vegetation is dominated by the *sedges Carex aquatilis* and *Eriophorum angustifolium*, occasionally the willow *Salix lanata* is a co-dominant. Common associated species include *Dupontia fisheri, Equisetum scirpoides* and *Pedicularis sudetica*. The mosses *Campylium stellatum* and *Drepanocladus spp*. are common.
Riverine Marsh	This class occurs along margins of shallow waterbodies on Active- and Inactive-floodplain Cover Deposits. Due to shallow water depths (0.3-1.0 m), the water freezes to the bottom in the winter and the ice melts by early June. These sites usually have low pH values. The emergent vegetation is dominated by *Arctophila fulva* or *Carex aquatilis, Dupontia fisheri* and *Hippuris vulgaris* are common associates.
Riverine Deep-polygon Complex	This class is associated with permafrost degradation on Inactive-floodplain Cover Deposits. Most polygon centers are deep (up to 2 m) 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 ovalifolia*. Shallow (< 0.5 m) polygons support wet meadow vegetation dominated by *Carex aquatilis* and *Eriophorum angustifolium.*
Riverine Barrens	Barren or partially vegetated (< 30% cover) areas on Floodplain Riverbed Deposits associated with meandering or braided rivers. Frequent sedimentation and scouring restricts establishment and growth of vegetation. There is no organic accumulation on these sand and gravel sediments. Typical pioneer plants include *Arctagrostis latifolia, Poa lanata, Stellaria spp,* and *Polygonum bistorta*.
Lacustrine Moist Meadow	This class occurs on gently sloping Thaw Basin Deposits where soils are moderately well drained. The surface generally is Nonpatterned. These soils have little organic accumulation, a deep active layer, and are nonsaline and neutral to slightly alkaline. The vegetation is very uniform, consisting almost completely of *Carex aquatilis and Eriophorum angustifolium.*

Table 9. (cont.).

Class	Description
Lacustrine Wet Meadow	This class occurs in flat, low-lying areas on Ice-poor Thaw Basin Deposits where drainage is poor. Surface forms include Nonpatterned, Disjunct Polygons and Strang. The surface generally is flooded during early summer (depth < 0.3 m) and drains later, but remains saturated ≥ 5 cm from the surface throughout the growing season. Soils usually have a moderately thick (10-50 cm) organic layer over silt loam. Vegetation is dominated by sedges, usually *Carex aquatilis* and *Eriophorum angustifolium*, and *Carex saxatilis* and *Carex membranacea* also are common.
Lacustrine Marsh	This class occurs in shallow (depth < 1 m), permanent waterbodies and on shorelines within Thaw Basin Deposits. Water and bottom sediments freeze completely during winter, but the ice melts in early June, and continued melting through the summer produces some of the deepest active layers of any ecosystem in the study area. The sediments usually have a peat layer (10-50 cm deep) overlying silt loam. In deeper water (30-100 cm), *Arctophila fulva* can form sparse to dense stands and is the predominant vegetation. In shallower (< 30 cm) water, *Carex aquatilis* and *Eriophorum angustifolium* are dominant, and *Utricularia vulgaris* is common.
Lacustrine Thaw Complex	This class occurs in Ice-poor Thaw Basin Deposits and is characterized by a complex mosaic of vegetation types. During spring breakup, basins may be entirely inundated but water levels gradually recede following breakup. Basins may have distinct upland rims marking the location of old shorelines, but these boundaries are often indistinct due to the coalescence of Thaw Basins and the presence of several thaw-lake stages. Surface forms are Nonpatterned or Disjunct Polygons indicative of ice-poor permafrost. Soils generally are loamy and organic-rich. Vegetation is variable but Lacustrine Wet Meadow, Lacustrine Marsh and shallow ponds with irregular shorelines are common. Lacustrine Moist Meadow also may be present.
Lacustrine Barrens	Barren or partially vegetated (< 30% cover) areas on newly exposed sediments on Thaw Basin Deposits. The surface form generally is Nonpatterned, although occasionally Undifferentiated Mounds are present reflecting the degradation of ice-wedge polygons along shorelines. The soils vary from saturated to well-drained, and usually have little to no organic accumulation. Typical colonizers are *Arctophila fulva*, *Carex aquatilis, Dupontia fisheri, Scorpidium scorpioides,* and *Calliergon sp*. on wet sites and *Poa alpigena, Senecio congestus, Salix ovalifolia* and *Salix arctica* on drier sites.
Lowland Shallow Lake	Shallow (< 1.5 m) ponds or small lakes resulting from thawing of ice-rich permafrost. These lakes lack riverine influences and 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 loamy. Lowland Shallow Lakes can occur within or outside of Thaw Basins Deposits.
Lowland Deep Lake	Deep (≥1.5 m) waterbodies resulting from thawing of ice-rich permafrost. Water does not freeze to the bottom during winter in deeper portions of the lake. These lakes may or may not have distinct outlets or connections to rivers. Sediments are loamy or clayey.
Lowland Low Scrub	This class frequently occurs on Abandoned-floodplain Cover Deposits and occasionally on slopes on Alluvial and Alluvial-Marine Terraces. The soils typically are poorly drained, have shallow thaw depths and variable organic-layer thickness. Vegetation is dominated by *Salix planifolia* and *Carex bigelowii*, with generally greater sedge cover than the other low scrub types. Common associated species include *Salix lanata, Salix reticulata, Cassiope tetragona,* and *Arctagrostis latifolia*.
Lowland Moist Meadow	This class occurs on flat Abandoned-floodplain Cover Deposits and Ice-rich Thaw Basin Deposits and on slopes and ridges of Alluvial and Alluvial-Marine Terraces. Microrelief includes a variety of Frost Scars, High-centered Polygons and Nonpatterned Ground. Soils are saturated at intermediate depths (> 15 cm) but generally are free of surface water during summer. The active layer is relatively shallow and the organic horizon is moderately thick (10-15 cm). Vegetation is dominated by *Carex aquatilis, C. bigelowii, Eriophorum angustifolium,* and *Dryas integrifolia*. Other common species include *Salix reticulata, Tomenthypnum nitens* and *Hylocomium splendens*.

Table 9. (cont.).

Class	Description
Lowland Wet Meadow	Vegetation is dominated by sedges, usually *Carex aquatilis* and *Eriophorum angustifolium*. Willows, including *Salix lanata* and *S. planifolia*, are abundant. Other common associated species include *Dryas integrifolia, S. reticulata, C. bigelowii* and *Equisetum scirpoides*, which are found on drier polygon ridges. This class usually is associated with Low-centered Polygons, Disjunct Polygons or Strang. The surface generally is flooded during early summer (depth < 0.3 m) and drains later, but remains saturated ≥ 15 cm from the surface throughout the growing season. Soils usually have a moderately thick (10-50 cm) organic layer over silt loam.
Lowland Thaw Complex	Thaw Complexes occur in Thaw Basins Deposits and are characterized by a mosaic of vegetation types. This complex generally includes Lowland Wet Meadow, Lowland Moist Meadow, Upland Tussock Meadow, and Lowland Shallow Lake. During spring breakup, deeper basins may be entirely inundated. Water levels gradually recede following breakup. Basins often have distinct upland rims marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of Thaw Basins and the presence of several thaw-lake stages. These sites are characterized by well-developed Low- and High-center Polygons resulting from ice-wedge development and aggradation of segregated ice. Soils generally have a moderately thick (0.2-0.5 m) organic layer overlying fine-grained silt or sandy silt
Lowland Deep-polygon Complex	This ecosystem class is similar to the Riverine Deep-polygon Complex but this type occurs on Abandoned-floodplain Deposits and is not influenced by riverine processes. Consequently, the polygon rims support species commonly found in Lowland Wet and Moist Meadows instead of riverine types.
Upland Tussock Meadow	This class is found on better-drained uplands including Alluvial Terrace, Alluvial Plain Deposit, and Alluvial-Marine Terrace and within Ice-rich Thaw Basins. The surface form is Nonpatterned, High-centered Polygon or Pingo. Water generally is absent from the active layer during midsummer. Sites have low pH and EC values, shallow active layers, and moderate organic accumulation. The vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum. Carex bigelowii, Dryas integrifolia, Salix planifolia, Cassiope tetragona* and *S. reticulata* are common. Mosses also are common, especially *Tomenthypnum nitens* and *Hylocomium splendens*.
Upland Loamy Dwarf Scrub	The dwarf shrub *Dryas integrifolia* forms an open cover on well-drained Bluffs or High-centered Polygons on Alluvial and Alluvial-Marine Terraces and on Pingos in Thaw Basin Deposits. Common species include *Salix reticulata, Cassiope tetragona, Salix arctica, Carex bigelowii, Arctagrostis latifolia* and *Equisetum variegatum*. *Tomenthypnum nitens* and *Drepanocladus sp*. are common mosses in this class. Lichens also are common.
Upland Sandy Low Scrub	This ecosystem is found on well-drained, stable Eolian Sand Dunes. These sites have high pH, high surface relief, deep active layers, and little organic accumulation. *Salix glauca* is dominant and common associates include *Dryas integrifolia, Salix lanata, Arctostaphylos rubra*, and *Astragalus alpinus*.
Upland Sandy Dwarf Scrub	The dwarf shrub *Dryas integrifolia* forms an open to closed cover. Other common species include *Salix reticulata, Salix lanata, Arctagrostis latifolia, Carex bigelowii, Poa arctica* and forbs. This class is found on Eolian Sand Dunes and has the greatest depth to ground water of any class. The thaw depth is deep and there is little organic accumulation.
Upland Sandy Moist Meadow	This class occurs on Eolian Sand Dunes and has low pH and EC values, and little microrelief. Unlike other sand dune ecosystems, moist meadows retain more soil moisture and generally have a greater cover of vascular and non-vascular vegetation. *Carex bigelowii* and *Dryas integrifolia* are the dominant species. Common mosses and lichens include *Tomenthypnum nitens, Thamnolia sp.* and *Cetraria sp*.
Upland Sandy Barrens	Eolian Sand Dune Deposits with partial vegetative cover (< 50%). These deposits are well drained, with high pH, deep active layers, and little to no organic accumulation. The dunes are too steep and unstable to support full vegetation cover. Typical species include *Salix alaxensis, Salix glauca, Elymus arenarius* and *Chrysanthemum bipinnatum*.

Table 10. Areal extent of ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern alaska, 1996.

Ecosystem	Delta		Coastal Plain		Total	
	Area (ha)	Percentage of Area	Area (ha)	Percentage of Area	Area (ha)	Percentage of Area
Nearshore Water	7,179	9.6	0	0.0	7,179	6.1
Tidal River	9,979	13.3	0	0.0	9,979	8.5
Coastal Lake - Isolated	764	1.0	0	< 0.1	764	0.7
Coastal Lake - Connected	2,166	2.9	1	< 0.1	2,167	1.9
Coastal Dwarf Scrub	57	0.1	1	< 0.1	59	0.1
Coastal Wet Meadow	1,955	2.6	0	0.0	1,955	1.7
Coastal Salt-killed Wet Meadow	2,597	3.5	0	0.0	2,597	2.2
Coastal Barrens	16,344	21.8	4	< 0.1	16,348	14.0
Lower Perennial River	0	0.0	190	0.5	190	0.2
Riverine Shallow Lake	174	0.2	29	0.1	203	0.2
Riverine Deep Lake	2,317	3.1	53	0.1	2,370	2.0
Riverine Low and Tall Scrub	2,481	3.3	321	0.8	2,802	2.4
Riverine Dwarf Scrub	0	0.0	21	< 0.1	21	< 0.1
Riverine Moist Meadow	695	0.9	461	1.1	1,157	1.0
Riverine Wet Meadow	16,845	22.4	387	0.9	17,233	14.7
Riverine Marsh	80	0.1	0	0.0	80	0.1
Riverine Deep-polygon Complex	1,270	1.7	0	0.0	1,270	1.1
Riverine Barrens	79	0.1	144	0.3	224	0.2
Lacustrine Moist Meadow	0	0.0	1,657	3.9	1,657	1.4
Lacustrine Wet Meadow	12	< 0.1	2,762	6.6	2,774	2.4
Lacustrine Marsh	127	0.2	120	0.3	247	0.2
Lacustrine Thaw Complex	0	0.0	1,758	4.2	1,758	1.5
Lacustrine Barrens	0	0.0	19	< 0.1	19	< 0.1
Lowland Shallow Lake	272	0.4	2,144	5.1	2,416	2.1
Lowland Deep Lake	4,287	5.7	3,870	9.2	8,157	7.0
Lowland Low Scrub	441	0.6	12	< 0.1	453	0.4
Lowland Moist Meadow	386	0.5	9,466	22.5	9,852	8.4
Lowland Wet Meadow	2,640	3.5	1,608	3.8	4,248	3.6
Lowland Thaw Complex	62	0.1	4,244	10.1	4,306	3.7
Lowland Deep-polygon Complex	109	0.1	0	0.0	109	0.1
Upland Tussock Meadow	27	< 0.1	12,514	29.7	12,541	10.7
Upland Loamy Dwarf Scrub	14	< 0.1	133	0.3	147	0.1
Upland Sandy Low Scrub	1,148	1.5	0	0.0	1,148	1.0
Upland Sandy Dwarf Scrub	44	0.1	0	0.0	44	< 0.1
Upland Sandy Moist Meadow	54	0.1	0	0.0	54	< 0.1
Upland Sandy Barrens	465	0.6	0	0.0	465	0.4
Human Modified	2	< 0.1	147	0.3	149	0.1
Total Area	75,074		42,068		117,142	

functions and successional pathways (see Ecosystem Response to Landscape Evolution).

Ecodistricts

The landscape surrounding the Colville River Delta was divided into seven ecodistricts that have unique physiographic characteristics and repeating assemblages of terrain units, surface forms, and vegetation (Figure 22, Table 11). These in turn were subdivided into 13 ecosubdistricts that further reduce the variation in ecological characteristics. The ecodistricts of principal interest to our studies are the Beaufort Sea Shallow Nearshore Water, the Colville River Delta, and the Kuparuk-Sagavanirktok Coastal Plain. The ecosubdistricts of principal interest include the Harrison Bay Shallow Nearshore Water, Inner Colville River Delta, Outer Colville River Delta, Miluveach Floodplain, Kachemach Floodplain, Miluveach Lower Coastal Plain, and the Miluveach Upper Coastal Plain.

The ecodistricts provide a way of stratifying the distribution of larger-scale ecosystems that frequently are contextually related (Figure 23). For example, Coastal Dwarf Scrub, Coastal Wet Meadows and Coastal Salt-killed Meadows are found almost exclusively in the Outer Colville River Delta ecosubdistrict. Similarly, Lacustrine Wet Meadows, Lacustrine Marsh, Upland Tussock Meadows, and Lowland Thaw Complexes are found almost exclusively in the Miluveach Lower and Upper Coastal Plain ecosubdistricts.

ACCURACY ASSESSMENT

An accuracy assessment was conducted to provide end users with an estimate of the mapping products reliability and to provide information that could be used to modify and improve the maps. Although the wildlife habitat map (see Evaluation and Modeling) was the primary focus of the accuracy assessment, we also assessed the accuracy of the various mapping products including the ecosystem map and the individual components of the integrated terrain units. The overall accuracy of the wildlife habitat map was 70% for 24 classes (Table 12). Weighting each habitat by its percentage occurrence on the map yields an overall map accuracy of 71%. Overall accuracy of the ecosystem map was 60% for the 36 classes (Table 13). For individual components of the ITU's, the accuracy was 62% for 39 terrestrial and aquatic terrain units, 62% for 17 surface forms, and 60% for 18 vegetation types classes. The accuracy of the maps varies inversely with the number of classes mapped, however. For example, for the habitat classification the map accuracy was 84% with only ten classes, 71% for 24 classes, and 54% for 34 classes. An evaluation of our errors for the habitat map is provided below.

Nearly one third (22 of 69) of the errors identified in the accuracy assessment of the habitat map were cutpoint problems. That is, these sites did not clearly fall into one habitat type and were difficult to distinguish on the ground (as evidenced by the 52% agreement rate between the two ground observers). These sites also were difficult to photo-interpret, and although technically wrong, were mapped as types that are very similar to their true habitat types. These types of errors occur because tundra vegetation is characterized by subtle variation, with many common species found in several habitat types.

Almost one quarter (14 of 69) of the errors were due to definition problems. When the habitat type was not adequately defined both the photo-interpreters and the ground observers had difficulty making consistent, correct calls. The vegetation types of two coastal delta habitat classes needed to be better defined: Salt-killed Wet Meadow and Halophytic Wet-Sedge Meadow. In addition, the definition of when a lake had islands or not, presented some difficulty. Observers on the ground described lakes without islands, when islands were visible on the aerial photos. A revision of the mapping definition, where only a certain radius around islands would be mapped as lake with islands, and the rest as lake without islands, would solve this problem.

Some errors (10 of 69) were caused by inadequate description of the photo-signature. Areas that were mapped as partially vegetated often proved to have almost complete vegetation cover. The signature for partially vegetated areas was whiter than the photo-interpreters had thought. Similarly, the signature for aquatic sedge on the true color photography was poorly understood, leading to errors in mapping this type in the eastern part of the map.

The other major type of error (11 of 69) was spatial errors. These were due to patchy, intermingled vegetation types, where the ground observers identified an inclusion that should have been mapped separately within a larger polygon. This type of error also occurred when the mapped habitat existed within a polygon, but was not the dominant type. Ten percent (7 of 68) of the errors were due to misinterpretation of a photo-signature readily associated with a specific habitat by the photo-interpreters. Two errors were due to the mechanics of the mapping process, including digitizing and code transformation.

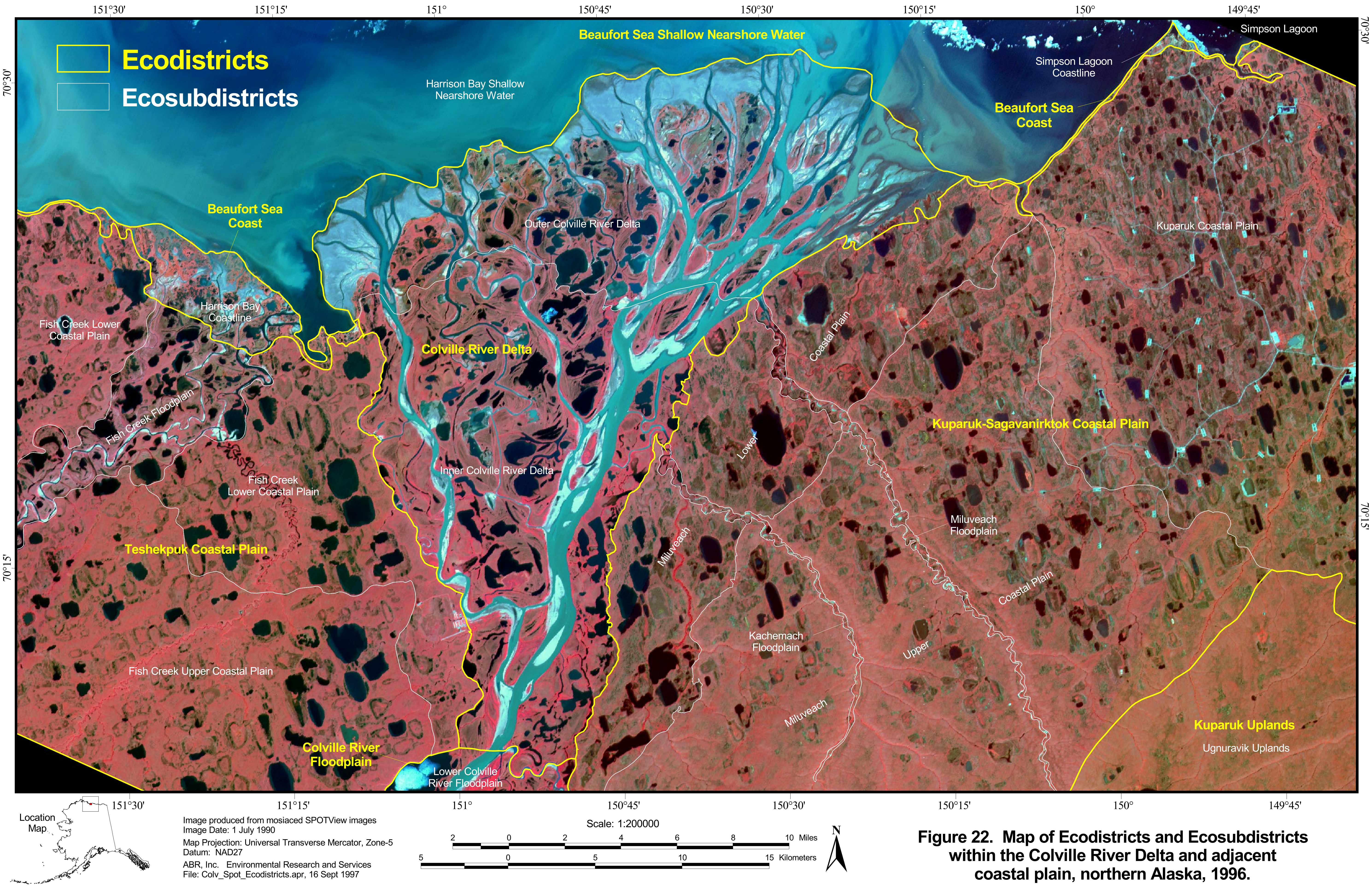


Image produced from mosiaced SPOTView images
Image Date: 1 July 1990
Map Projection: Universal Transverse Mercator, Zone-5
Datum: NAD27
ABR, Inc. Environmental Research and Services
File: Colv_Spot_Ecodistricts.apr, 16 Sept 1997

Figure 22. Map of Ecodistricts and Ecosubdistricts within the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

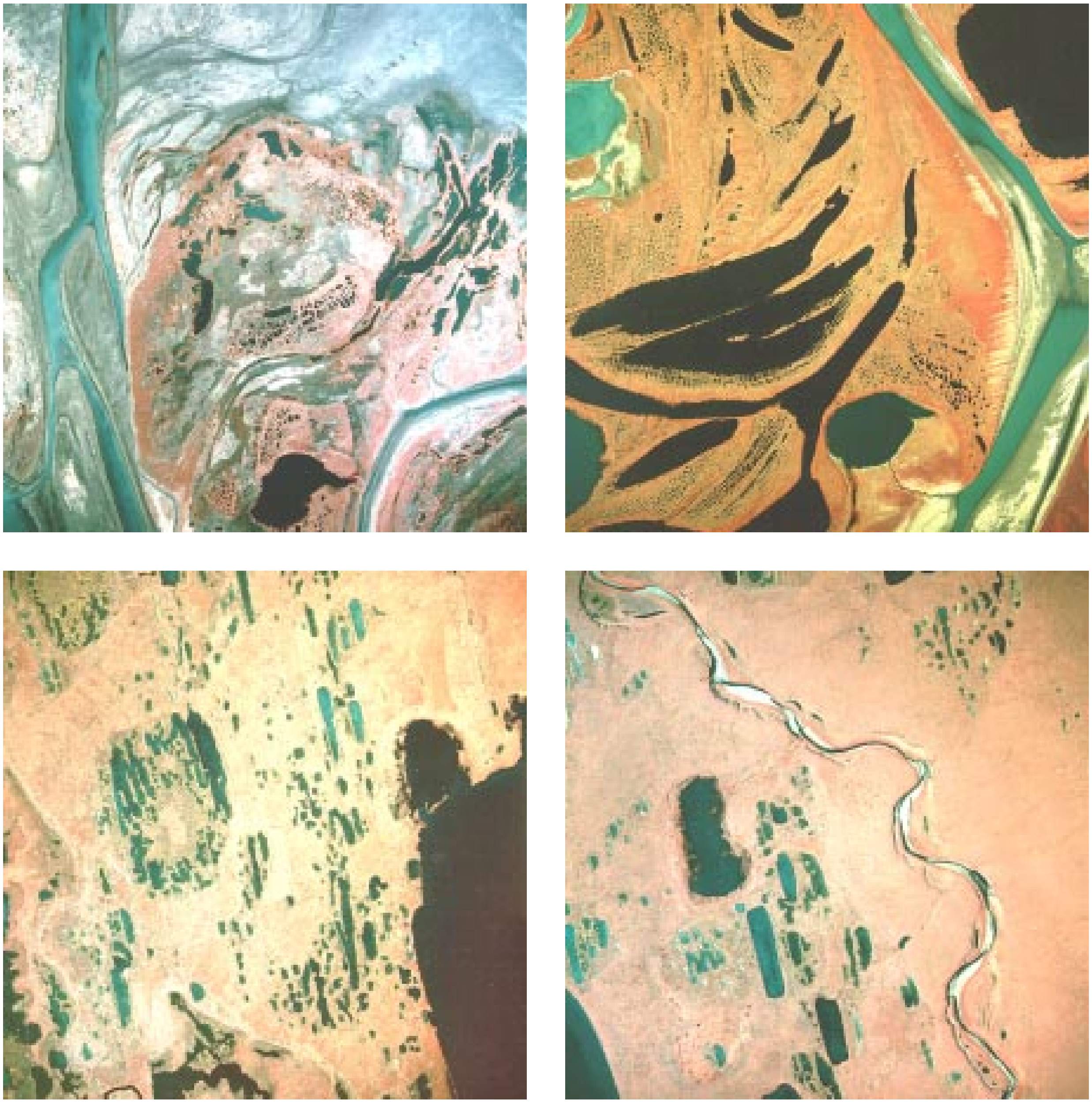


Figure 23. Aerial color-infrared photographs of representative portions of the Outer Colville River Delta (upper left), Inner Colville River Delta (upper right), Miluveach Lower Coastal Plain (lower left), and Miluveach Upper Coastal Plain and Miluveach Flood plain (lower right), northern Alaska, 1996

Table 11. Classification and description of ecosystems (ecodistrict and ecosubdistrict level) on the Colville River and adjacent coastal plain, northern Alaska, 1996.

Ecodistrict	Ecosubdistrict	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. Waters in this district 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.
Beaufort Sea Coast	Harrison Bay Coastline	A salt-affected coastal area between Cape Simpson and the Colville River Delta. The area lacks barrier islands and thus is exposed to wave action. Shoreline deposits are fine-grained muds and erosion rates average 5.4 m/yr. 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 Coastline	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 above.
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. Riverine Dwarf Scrub occurs on well-drained river terraces. 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 11. (cont.).

Ecodistrict	Ecosubdistrict	Description
Kuparuk-Saga-vanirktok	Miluveach Floodplain	The floodplain of the Miluveach River is affected by flooding, sedimentation, and river meandering. Common ecosystems are similar to those described for the Lower Colville Floodplain.
Coastal Plain	Kachemach Floodplain	The floodplain of the Kachemach River is affected by flooding, sedimentation, and river meandering. Common ecosystems are similar to those described for the Lower Colville Floodplain.
	Miluveach Lower Coastal Plain	A relatively flat portion of the coastal plain near the Miluveach River. The area was formed during 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 5.5–6.5). Common ecosystems include Lowland Shallow and Deep Lakes resulting from thawing of permafrost, and Lacustrine Wet Meadows and Lacustrine Thaw Complexes in Ice-poor Thaw Basins. 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 that also have been raised by accumulating ice.
	Miluveach Upper Coastal Plain	A gently rolling portion of the coastal plain near the Miluveach River. The area was formed during 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 neutral to slightly alkaline (typically 6.5–7.6). The area has been greatly affected by thaw lake processes, 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.
	Kuparuk 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.
Teshekpuk Coastal Plain	Fish Creek Floodplain	The floodplain of Fish Creek is affected by flooding, sedimentation, and river meandering. Common ecosystems are similar to those described for the Lower Colville River Floodplain.
	Fish Creek Lower Coastal Plain	A relatively flat portion of the coastal plain near Fish Creek. It's genesis and dominant ecosystems are very similar to those described for the Miluveach Lower Coastal Plain.
	Fish Creek Upper Coastal Plain	A gently rolling portion of the coastal plain near Fish Creek. Its genesis and dominant ecosystems are very similar to those described for the Miluveach Upper Coastal Plain.
Kuparuk Uplands	Ugnuravik 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 negligible. Common ecosystems include Upland Tussock Meadow and Riverine Low Scrub, and to a lesser extent Lowland Wet Meadow and Lowland Moist Meadow.

Table 12. Omission and commission errors used to assess the accuracy associated with mapping of wildlife habitats on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

	Consensus Ground Code																				Total	Number Correct	PercentCorrect	Map Area	%Map Area	%Map Correct
Map Code	Open Nearshore Water (205)	Salt Marsh (250)	Tide Flat (280)	Salt-killed Tundra (285)	Deep Open Water without Islands (312)	Shallow Open Water without Islands (322)	Shallow Open Water with Islands (323)	River or Stream (330)	Aquatic Sedge Marsh (361)	Aquatic Sedge with Deep Polygons (364)	Aquatic Grass Marsh (371)	Young Basin Wetland Complex (401)	Old Basin Wetland Complex (405)	Nonpatterned Wet Meadow (511)	Wet Sedge–Willow Meadow w/ Low-relief Polygons (521)	Moist Sedge–Shrub Meadow (542)	Moist Tussock Tundra (546)	Riverine or Upland Scrub (600)	Barrens (800)	Artificial (900)						
205	1																				1	1	100	10.5	1.2	1.2
250		11		1							2			3				2			19	11	58	16.7	1.9	1.1
280			3																		3	3	100	55.9	6.3	6.3
285		2		10											2						14	10	71	25.6	2.9	2.0
312					10	2					1										13	9	69	54.1	6.1	4.2
313					2																2	0	0	11.7	1.3	0
322						5	1														6	5	83	13.2	1.5	1.2
323							3				2										5	3	60	7.9	0.9	0.5
330								8													8	8	100	83.1	9.3	9.3
361									3					2							5	3	60	1.0	0.1	0.1
364							1			3											4	3	75	13.6	1.5	1.1
371									1		2					1					4	2	50	2.0	0.2	0.1
401									1			4			1						6	4	67	14.2	1.6	1.1
405													3	1		1	1				6	3	50	35.6	4.0	2.0
511		1							1					11	3	1		2			19	11	58	66.5	7.4	4.3
521													1	3	23	3		2			32	23	72	122.1	13.7	9.8
542															2	9	2				13	9	69	97.8	10.9	7.6
546																4	7	2			13	7	54	97.1	10.9	5.8
600		2														3		29			34	29	85	35.1	3.9	3.4
800		2		2														2	12		18	12	67	80.9	9.1	6.0
900																				2	2	2	100	0.5	0.1	0.1
210*																							70	6.5	0.7	0.5
232*																							70	21.4	2.4	1.7
235*																							70	20.5	2.3	1.6
Total	1	18	3	13	12	7	5	8	6	3	7	4	4	20	31	22	10	39	12	2	227	158	70	893.4	100	
# Correct	1	11	3	10	9	5	3	8	3	3	2	4	3	11	23	9	7	29	12	2	158					
% Correct	100	61	100	77	75	71	60	100	50	100	29	100	75	55	74	41	70	74	100	100	70					71.0

* Habitats not sampled during accuracy assessment; for weighted average calculation, accuracy for these habitats was assumed to be 70%.

Table 13. Omission and commission errors used to assess the accuracy associated with mapping of ecosystems on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

	Consensus Ground Code																														
Map Code	Nearshore Water (2001)	Tidal River (2010)	Coastal Dwarf Scrub (2043)	Coastal Wet Meadow (2053)	Coastal Salt-killed Wet Meadow (2053.1)	Coastal Barrens (2090)	Riverine Low and Tall Scrub (3042)	Riverine Dwarf Scrub (3043)	Riverine Moist Meadow (3052)	Riverine Wet Meadow (3053)	Riverine Marsh (3054)	Riverine Deep-polygon Complex (3073)	Riverine Barrens (3090)	Lacustrine Wet Meadow (4053)	Lacustrine Marsh (4054)	Lacustrine Thaw Complex (4071)	Lowland Shallow Lake (5023)	Lowland Deep Lake (5026)	Lowland Low Scrub (5042)	Lowland Moist Meadow (5052)	Lowland Wet Meadow (5053)	Lowland Thaw Complex (5071)	Upland Tussock Meadow (7058)	Upland Loamy Dwarf Scrub (7443)	Upland Sandy Low Scrub (7642)	Upland Sandy Dwarf Scrub (7643)	Upland Sandy Moist Meadow (7652)	Human Modified (12000)	Total	No. correct	% correct
2001	1																												1	1	100
2010		3											2																5	3	60
2043			1																										1	1	100
2053			2	8	1		2			3	2																		18	8	44
2053.1			1	1	10					2																			14	10	71
2090			1	1	2	12	1						3						1										21	12	57
3042			2				12	2	1										1						1		1		20	12	60
3052									1																				1	1	100
3053			1				3	1	1	25				2							2								35	25	71
3054															1														1	0	0
3073												3			1														4	3	75
3090													3																3	3	100
4052																				1									1	0	0
4053															1					1									2	0	0
4054														2	5					1									8	5	63
4071															1	4					1								6	4	67
5023															2		9												11	9	82
5026															1		2	12											15	12	80
5042							1												1										2	1	50
5052										1										7	1		2						11	7	64
5053									1	5										1	6	1							14	6	43
5071																				1	1	3	1						6	3	50
7058								1	1											4			6	1					13	6	46
7443																				1									1	0	0
7642							1																		2	8			11	2	18
12000																												2	2	2	100
Total	1	3	8	10	13	12	20	4	5	36	2	3	8	4	12	4	11	12	3	17	11	4	9	1	3	8	1	2	227	136	60
No. correct	1	3	1	8	10	12	12	0	1	25	0	3	3	0	5	4	9	12	1	7	6	3	6	0	2	0	0	2	136		
% correct	100	100	13	80	77	100	60	0	20	69	0	100	38	0	42	100	82	100	33	41	55	75	67	0	67	0	0	100	60		

ECOLOGICAL RELATIONSHIPS

VEGETATION COMPOSITION BY ECOSYSTEM

Dominant Species

The following discussion highlights some of the similarities and differences in species composition among ecosystems. Ecosystems with similar vegetation were grouped to facilitate comparisons (Tables 14–19).

Riverine and Lacustrine Marshes had high percentages of water, emergent graminoids, and submergent forbs (Table 14). Riverine Marshes were dominated by *Arctophila fulva, Carex aquatilis*, *Dupontia fisheri*, and *Hippurus vulgaris*, whereas Lacustrine Marshes were dominated by *C. aquatilis* and *Utricularia vulgaris*. These comparisons are limited, however, by the small sample sizes. For example, no *A. fulva* occurred on our transects on Ice-poor Thaw Basin Deposits, but we observed numerous stands of that species in recently drained-lake basins which typically are ice-poor.

Wet meadow communities showed large differences in species composition due mostly to differences in salinity (Table 15). Coastal Wet Meadows were dominated by halophytic species such as *Puccinellia phyrganodes, Carex subspathacea, Dupontia fisheri*, and *C. ursinus*. In contrast, the Riverine, Lacustrine, and Lowland Wet Meadows were dominated by *Carex aquatilis* and *Eriophorum angustifolium*. Additionally, Riverine Wet Meadows frequently had *Dupontia fisheri, Salix lanata,* and *Campylium stellatum*, whereas Lacustrine Wet Meadows frequently had *Carex membranacea* and *C. saxatilis*. Lowland Wet Meadows were distinguished by having more *Dryas integrifolia, Salix planifolia,* and *Carex bigelowii*. Lowland Wet Meadows also had more *Tomenthypnum nitens*, a moss which was associated with moist microsites on the rims of low-centered polygons. The Salt-killed Wet Meadows present an interesting situation where Riverine and Lowland Wet Meadows have been killed by salts from storm surges. These areas are being colonized by *Puccinellia phryganodes, Stellaria humifusa, Cochlearia officinalis*, and *Carex subspathacea*.

Moist meadow communities, which are dominated by shrubs and graminoids, occur on a wide variety of riverine, lacustrine, lowland, and upland settings (Table 16). Riverine Moist Meadows are dominated by *Carex aquatilis, Eriophorum angustifolium, Dryas integrifolia, Salix lanata*, and *S. reticulata* and differ from the other moist meadow types by having the most *Dupontia fisheri* and *Equisetum scirpoides*. Lacustrine Moist Meadows are similar, but have more *Carex saxatilis,* less *S. lanata* and very little *E. scirpoides.* Lowland Moist Meadows, dominated by *C. aquatilis, D. integrifolia, C. bigelowii,* and *E. angustifolium,* are the only moist meadow type with more than trace amounts of *C. misandra.* Upland Tussock Meadows are dominated by *Eriophorum vaginatum*. They have the most *Salix planifolia* and *Cassioppe tetragona,* and the least *Carex aquatilis* and *Eriophorum angustifolium* of the moist meadow types. We have data for only 1 Upland Sandy Moist Meadow, a type found on sand dunes. This sample is the only moist meadow in our data set with a high cover of *Salix glauca* (22%), it also has the most *Carex bigelowii* and little *C. aquatilis* and *E. angustifolium* compared with other moist meadows.

Dwarf shrubs are dominant growth forms on well-drained coastal and riverine terraces, upland ridges, and stable sand dunes (Table 17). Coastal Dwarf Scrub is dominated by *Salix ovalifolia* and differentiated from by other dwarf scrub types by the presence of *Dupontia fisheri, Deschampsia caespitosa*, and *Carex subspathacea*. Riverine Dwarf Scrub ("Dryas river terrace") is dominated by *Dryas integrifolia* commonly in association with *Salix reticulata*, and *Tomenthypnum nitens*. Upland Loamy Dwarf Scrub, which occurs on ridges and bluffs, is similar to Riverine Dwarf Scrub but has less total shrub cover. Upland Sandy Dwarf Scrub, which occurs on sand dunes, has the highest cover of *Dryas integrifolia* and *Cassiope tetragona* and is differentiated by the frequent occurrence of *Arctostaphylos rubra, Salix lanata*, and *Poa arctica*.

Low and tall shrubs typically were found on active floodplains and on inactive and abandoned floodplains adjacent to cut banks. Riverine Low and Tall Scrub, which includes both tall and low shrubs because they were difficult to differentiate during mapping, is dominated by *Salix lanata*, *S. alaxensis*, and *S. glauca* (Table 18). It is differentiated from the other scrub types by small amounts of *Equisetum arvense*, *E. scirpoides,* and *E. variegatum*. In contrast, Lowland Low Scrub is dominated by *Salix planifolia,* and commonly is associated with *Cassiope*

Table 14. Mean percent cover of the most abundant species and total cover of all species by growth form in Riverine Marsh (n=3) and Lacustrine Marsh (n=2) ecosystems on the Colville River Delta and adjacent coastal plain, 1992-1996. Blanks in table indicate 0% cover, values of 0 in table indicate less than 0.5% cover.

	Riverine Marsh			Lacustrine Marsh		
	Mean	SD	Freq.	Mean	SD	Freq.
Total Live Cover	**73**	**46**	**100**	**59**	**5**	**100**
Total Vascular Plant Cover	**72**	**46**	**100**	**55**	**11**	**100**
Total Deciduous Shrub Cover				**1**	**1**	**50**
Salix arctica				0	0	50
Salix lanata				0	0	50
Total Graminoid Cover	**59**	**46**	**100**	**39**	**9**	**100**
Arctophila fulva	26	25	100			
Carex aquatilis	10	17	67	32	0	100
Eriophorum angustifolium	2	3	33	3	4	100
Dupontia fisheri	21	36	33			
Total Forb Cover	**14**	**19**	**100**	**16**	**21**	**100**
Hippuris vulgaris	9	11	100			
Utricularia vulgaris	3	5	33	15	21	50
Total Moss Cover	**0**	**0**	**33**	**4**	**6**	**50**
Tomenthypnum nitens				0	0	50
Scorpidium scorpoides	0	0	33	1	1	50
Total Bare Ground*	**41**	**30**	**100**	**81**	**1**	**100**
Litter*	5	7	67	18	11	100
Water*	36	37	100	62	14	100
Soil*				1	1	50

* Riverine Marsh n = 3, Lacustrine Marsh n = 2

Table 15. Mean percent cover of the most abundant species and total cover of all species by growth form in Coastal Wet Meadow (n=15), Salt-killed Wet Meadow (n=5), Riverine Wet Meadow (n=55), Lacustrine Wet Meadow (n=7) and Lowland Wet Meadow (n=14) plots on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992-1996. Blanks in table indicate 0% cover, values of 0 in table indicate less than 0.5% cover.

	Coastal Wet Meadow			Salt-killed Wet Meadow			Riverine Wet Meadow			Lacustrine Wet Meadow			Lowland Wet Meadow		
	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq
Total Live Cover	**74**	**43**	**100**	**31**	**15**	**100**	**126**	**55**	**100**	**62**	**31**	**100**	**130**	**54**	**100**
Total Vascular Plant Cover	**73**	**43**	**100**	**30**	**16**	**100**	**97**	**32**	**100**	**47**	**27**	**100**	**105**	**43**	**100**
Total Evergreen Shrub Cover							**3**	**6**	**44**	**1**	**1**	**71**	**10**	**13**	**100**
Dryas integrifolia							2	5	44	1	1	71	5	3	100
Total Deciduous Shrub Cover	**3**	**7**	**40**	**1**	**2**	**40**	**15**	**11**	**98**	**2**	**1**	**86**	**18**	**12**	**100**
Salix reticulata							2	3	47	0	0	57	3	2	100
Salix lanata							8	8	85	0	0	43	9	11	86
Salix planifolia							2	6	38	0	0	29	5	7	64
Salix arctica	1	3	7				0	0	15	1	1	71	0	1	29
Salix ovalifolia	2	6	33	1	2	40	1	3	20	0	0	14			
Total Graminoid Cover	**65**	**40**	**100**	**14**	**9**	**100**	**68**	**24**	**100**	**43**	**24**	**100**	**62**	**35**	**100**
Carex aquatilis	1	3	7	0	0	20	32	22	98	13	6	100	18	15	100
Eriophorum angustifolium	1	3	27				14	15	91	17	16	100	25	25	100
Carex bigelowii							1	3	29	1	2	57	4	7	79
Dupontia fisheri	10	19	60	0	0	40	7	13	60	0	0	29	1	2	36
Puccinellia phryganodes	17	29	60	8	8	60	0	1	4						
Carex chordorrhiza							1	4	15				0	1	29
Carex subspathacea	16	23	53	0	1	20									
Carex membranacea							0	1	4	2	4	43	4	9	29
Carex rariflora							0	2	24	0	0	25	0	0	29
Carex saxatilis							2	4	29	4	6	57	4	9	50
Carex ursinus	5	9	33	0	0	40									
Hierochloe pauciflora				1	2	40	2	9	18	0	0	29	0	0	7
Puccinellia andersonii	2	3	33	0	0	40									
Eriophorum scheuchzeri	0	0	13				3	8	24	0	1	14	1	1	36
Elymus arenarius	2	6	20	0	1	20									
Arctophila fulva	5	14	13				0	0	2						
Total Forb Cover	**5**	**6**	**80**	**16**	**15**	**100**	**12**	**14**	**85**	**2**	**2**	**86**	**16**	**13**	**100**
Stellaria humifusa	3	4	47	15	15	80	0	0	2				0	0	7
Saxifraga hirculus							0	1	35				1	0	79
Polygonum viviparum							0	0	40	0	0	29	0	0	71
Pedicularis sudetica	0	0	7				1	2	67	0	0	57	1	1	64
Cochlearia officinalis	0	1	27	0	0	60									
Pedicularis capitata							0	0	13	0	0	29	0	0	57
Equisetum scirpoides							5	11	35				2	4	43
Total Moss Cover	**0**	**1**	**20**	**1**	**2**	**40**	**28**	**39**	**75**	**14**	**10**	**100**	**21**	**19**	**93**
Tomenthypnum nitens							2	7	27	0	1	71	5	8	79
Campylium stellatum							6	10	55	1	2	43	3	4	79
Drepanocladus sp.							5	12	47	3	4	71	2	4	50
Scorpidium scorpoides				0	0	20	3	9	18	4	7	43	2	5	43
Hylocomium splendens							0	1	9	0	1	29	0	0	29
Unknown moss	0	1	13	0	0	40	2	5	33	1	1	71	4	5	50
Polytrichum juniperinum							0	1	15	0	1	14	2	4	43
Total Lichen Cover	**0**	**0**	**7**				**0**	**1**	**16**	**1**	**1**	**43**	**3**	**6**	**50**
Total Bare Ground*	**40**	**22**	**100**	**81**	**7**	**100**	**24**	**18**	**96**	**59**	**20**	**100**	**30**	**21**	**100**
Litter*	16	12	83	16	20	100	16	15	85	39	18	100	20	16	90
Water*	1	1	33				6	9	63	12	15	86	8	14	60
Soil*	23	26	100	65	13	100	2	6	22	8	15	71	1	2	30

* Coastal Wet Meadow n = 6, Salt-killed Wet Meadow n = 2, Riverine Wet Meadow n = 26, Lacustrine Wet Meadow n = 7, Lowland n = 10

Table 16. Mean percent cover of the most abundant species and total cover of all species by growth form in Riverine Moist Meadow (n = 15), Lacustrine Moist Meadow (n = 2), Lowland Moist Meadow (n = 25), Upland Tussock Meadow (n = 14), and Upland Sandy Moist Meadow (n = 1) ecosystems on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992–1996. Blanks in table indicate 0% cover, values of 0 in table indicate less than 0.5% cover.

	Riverine Moist Meadow			Lacustrine Moist Meadow			Lowland Moist Meadow			Upland Tussock Meadow			Upland Sandy Moist Meadow
	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq	(n = 1)
Total Live Cover	**145**	**56**	**100**	**145**	**34**	**100**	**125**	**36**	**100**	**141**	**29**	**100**	**146**
Total Vascular Plant Cover	**112**	**38**	**100**	**122**	**63**	**100**	**99**	**30**	**100**	**113**	**33**	**100**	**87**
Total Evergreen Shrub Cover	**15**	**12**	**93**	**5**	**1**	**100**	**14**	**8**	**100**	**32**	**13**	**100**	**24**
Dryas integrifolia	14	12	93	5	1	100	11	6	96	14	9	93	16
Cassiope tetragona	1	2	33				3	4	60	11	8	100	8
Total Deciduous Shrub Cover	**25**	**11**	**100**	**16**	**2**	**100**	**14**	**11**	**100**	**24**	**24**	**100**	**23**
Salix arctica	0	1	13	1	1	100	1	2	32	0	2	14	
Salix planifolia	2	6	27	0	0	50	4	5	68	10	5	100	1
Salix reticulata	8	8	100	6	6	100	4	4	96	9	13	100	1
Salix lanata	12	13	80	0	0	50	4	8	52	0	0	7	
Total Graminoid Cover	**55**	**30**	**100**	**92**	**68**	**100**	**58**	**24**	**100**	**50**	**13**	**100**	**28**
Carex aquatilis	23	23	93	46	6	100	16	20	84	0	1	21	
Carex bigelowii	5	10	60	3	4	50	10	13	80	8	5	100	16
Eriophorum vaginatum	1	2	20				4	7	68	35	12	100	
Eriophorum angustifolium	15	12	93	35	49	50	9	7	92	4	4	64	2
Arctagrostis latifolia	1	2	47				1	2	52	1	1	57	2
Dupontia fisheri	3	5	53	1	1	50	0	0	28	0	0	29	
Carex atrofusca	0	1	13	0	0	50	2	6	16				
Carex membranacea	0	0	7	0	0	50	3	6	40	0	0	7	
Carex misandra	0	0	7	0	0	50	5	10	36	0	1	14	
Carex saxatilis	1	3	20	5	7	50	1	4	32	0	1	7	
Total Forb Cover	**16**	**13**	**87**	**10**	**7**	**100**	**13**	**13**	**92**	**7**	**4**	**100**	**12**
Polygonum viviparum	1	1	60	1		100	1	2	60	0	0	36	
Saussurea angustifolia	0	0	7				1	2	56	2	2	86	2
Pyrola grandiflora	0	1	13				1	2	60	1	1	71	
Pedicularis capitata	0	1	40	0	0	50	0	0	44	0	1	57	1
Astragalus umbellatus	1	1	53				0	0	24				1
Saxifraga hirculus	0	1	53				0	0	48	0	0	7	
Equisetum scirpoides	5	8	33	0	0	50	1	3	24				
Equisetum variegatum	2	4	33	7	10	50	1	4	20				
Lupinus arcticus	4	8	40				4	10	28				
Total Moss Cover	**31**	**30**	**73**	**23**	**30**	**100**	**20**	**22**	**88**	**20**	**13**	**100**	**47**
Drepanocladus sp.	6	10	53	8	11	100	1	2	32	0	1	14	4
Tomenthypnum nitens	9	16	60	1	1	100	6	8	88	6	10	93	16
Unknown liverwort	1	3	27	2	2	100	0	1	4				
Unknown moss	4	4	67				2	3	48	2	2	57	6
Hylocomium splendens	1	1	20				3	6	40	2	2	64	4
Campylium stellatum	4	6	60	7	10	50	1	4	24	1	1	29	
Total Lichen Cover	**2**	**3**	**40**				**6**	**6**	**84**	**8**	**4**	**100**	**12**
Thamnolia sp.	0	1	20				1	3	60	2	2	93	
Cetraria cucullata	0	1	13				1	2	48	2	2	71	4
Cetraria islandica	0	1	7				1	1	24	1	2	36	
Unknown crustose lichen	0	1	7				0	1	24	1	1	36	2
Total Bare Ground*	**19**	**17**	**80**	**50**			**32**	**13**	**100**	**26**	**11**	**100**	**14**
Litter*	15	15	70	50			28	13	100	26	11	100	14
Water*	4	13	20				2	3	29				
Soil*	0	1	20				2	3	29	0	1	10	

*Riverine Moist Meadow n = 10, Lacustrine Moist Meadow n = 1, Lowland Moist Meadow n = 17, Upland Tussock Meadow n = 10, Upland Sandy Moist Meadow n = 1

Table 17. Mean percent cover of the most abundant species and total cover of all species by growth form in Coastal Dwarf Scrub (n = 16), Riverine Dwarf Scrub (n = 12), Upland Loamy Dwarf Scrub (n = 9),and Upland Sandy Dwarf Scrub (n = 6) ecosystems on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992–96. Blanks in table indicate 0% cover, values of 0 in table indicate less than 0.5% cover.

	Coastal Dwarf Scrub			Riverine Dwarf Scrub			Upland Loamy Dwarf Scrub			Upland Sandy Dwarf Scrub		
	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq	Mean	SD	Freq
Total Live Cover	**84**	**40**	**100**	**114**	**51**	**100**	**109**	**16**	**100**	**139**	**42**	**100**
Total Vascular Plant Cover	**79**	**37**	**100**	**81**	**31**	**100**	**73**	**20**	**100**	**114**	**28**	**100**
Total Evergreen Shrub Cover	**0**	**1**	**13**	**35**	**13**	**100**	**29**	**10**	**100**	**54**	**9**	**100**
Dryas integrifolia	0	1	13	34	15	100	22	11	100	47	11	100
Cassiope tetragona				1	2	25	4	6	89	7	9	50
Total Deciduous Shrub Cover	**35**	**12**	**100**	**19**	**13**	**100**	**10**	**6**	**100**	**29**	**30**	**100**
Salix ovalifolia	35	12	100	0	1	8	1	2	22	2	3	33
Salix reticulata				9	6	100	3	2	89	7	5	100
Salix arctica	0	0	13	1	1	33	2	3	78	0	0	17
Salix lanata	0	1	13	4	7	42	0	0	22	7	10	67
Salix glauca	0	1	19	4	7	42	0	0	11	3	5	33
Arctostaphylos rubra				1	2	17				10	24	33
Total Graminoid Cover	**34**	**33**	**94**	**14**	**10**	**100**	**18**	**13**	**100**	**14**	**14**	**83**
Arctagrostis latifolia	1	1	19	3	6	67	1	2	56	2	2	83
Carex bigelowii				7	6	67	6	7	56	7	9	50
Eriophorum angustifolium	5	10	44	1	1	25	4	5	67			
Eriophorum vaginatum				0	0	8	2	2	67			
Poa arctica	0	1	6	0	1	33	0	0	22	0	0	67
Dupontia fisheri	8	13	50	0	0	8	0	1	11			
Luzula sp.				0	0	17	0	0	11	2	3	50
Trisetum spicatum				0	0	33	0	0	11	0	0	50
Carex aquatilis	4	8	44				1	2	33			
Deschampsia caespitosa	3	5	38									
Carex subspathacea	5	11	19									
Total Forb Cover	**9**	**16**	**94**	**13**	**9**	**100**	**16**	**7**	**100**	**17**	**8**	**100**
Astragalus alpinus	1	5	6	2	3	50	0	0	11	7	7	100
Astragalus umbellatus				2	3	75	1	1	44	1	1	83
Polygonum viviparum	0	0	13	0	0	58	1	1	56	1	0	83
Saussurea angustifolia				0	1	25	2	3	78	1	1	50
Papaver sp.				0	0	33	2	3	67	0	1	17
Pedicularis capitata	0	0	6	0	0	58	0	0	44	3	4	67
Senecio atropurpureus				0	0	58	1	1	56			
Polygonum bistorta				0	1	8	1	1	56	1	2	33
Silene acaulis				0	1	25	0	1	33	0	0	50
Equisetum variegatum	1	4	13				4	9	44			
Equisetum scirpoides	1	3	6	4	9	25						
Total Moss Cover	**6**	**14**	**31**	**26**	**27**	**92**	**24**	**9**	**100**	**13**	**15**	**67**
Tomenthypnum nitens				13	17	67	7	7	89	2	4	50
Drepanocladus sp.	1	4	13	1	2	17	2	3	78	1	1	33
Unknown moss	2	5	31	2	3	33	3	4	67	3	4	67
Hylocomium splendens				4	11	33	1	2	56	2	4	33
Dicranum sp.	0	1	6	0	1	8	4	11	44	0	1	33
Campylium stellatum	2	9	6	1	2	17	0	1	22	0	1	17
Total Lichen Cover				**7**	**9**	**75**	**12**	**9**	**100**	**12**	**12**	**67**
Cetraria cucullata				2	3	42	2	2	67	1	3	17
Thamnolia sp.				1	1	50	2	2	67	6	7	67
Unknown crustose lichen				1	3	33	5	9	67	1	1	33
Total Bare Ground*	**32**	**15**	**100**	**29**	**19**	**100**	**33**	**9**	**100**	**11**	**10**	**100**
Litter*	25	11	100	24	15	100	26	11	100	7	6	75
Soil*	7	6	80	4	8	29	7	8	56	5	7	50

* Coastal Dwarf Scrub n = 5, Riverine Dwarf Scrub n = 7, Upland Loamy Dwarf Scrub n = 9, Upland Sandy Dwarf Scrub n = 4

Table 18. Mean percent cover of the most abundant species and total cover of all species by growth form in Riverine Low and Tall Scrub (n = 34), Lowland Low Scrub (n = 2), and Upland Sandy Low Scrub (n = 11) ecosystems on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992–1996. Blanks in table indicate 0% cover, values of 0 in table indicate less than 0.5% cover.

	Riverine Low and Tall Scrub			Lowland Low Scrub			Upland Sandy Low Scrub		
	Mean	SD	Freq.	Mean	SD	Freq.	Mean	SD	Freq.
Total Live Cover	**165**	**62**	**100**	**104**	**44**	**100**	**126**	**53**	**100**
Total Vascular Plant Cover	**143**	**49**	**100**	**95**	**33**	**100**	**118**	**44**	**100**
Total Evergreen Shrub Cover	**6**	**11**	**53**	**12**	**1**	**100**	**15**	**26**	**64**
Dryas integrifolia	6	11	53	3	3	100	14	25	64
Cassiope tetragona	0	0	6	7	5	100	0	1	9
Total Deciduous Shrub Cover	**76**	**24**	**100**	**31**	**7**	**100**	**75**	**35**	**100**
Salix lanata	32	28	82	7	4	100	12	15	73
Salix planifolia	5	10	29	17	2	100			
Salix reticulata	4	6	59	5	7	100	2	6	18
Salix glauca	11	19	50				35	26	91
Arctostaphylos rubra	4	7	41				17	22	73
Salix alaxensis	15	31	32				4	9	36
Salix ovalifolia	4	11	26				2	5	27
Total Graminoid Cover	**20**	**22**	**94**	**25**	**3**	**100**	**11**	**8**	**91**
Arctagrostis latifolia	3	5	79	3	4	100	1	3	36
Carex bigelowii	3	8	29	14	16	100	1	2	9
Eriophorum vaginatum	0	1	12	1	0	100			
Poa arctica	1	1	41	1	1	100	0	0	9
Carex aquatilis	5	12	35	3	4	50	3	6	18
Eriophorum angustifolium	3	8	38	1	1	50			
Festuca rubra	0	1	26	1	1	50	0	1	36
Bromus pumpellianus	1	2	12				2	3	36
Total Forb Cover	**40**	**29**	**97**	**27**	**27**	**100**	**16**	**16**	**73**
Astragalus umbellatus	3	6	50	1	1	100	0	0	9
Pedicularis capitata	0	0	29	1	0	100	0	0	18
Petasites frigidus	2	4	59	1	0	100	0	0	18
Polygonum bistorta	1	2	26	1	0	100	0	1	9
Saussurea angustifolia	0	0	6	2	2	100	0	0	9
Polygonum viviparum	1	1	56	0	0	50	0	1	27
Astragalus alpinus	4	7	47	0	0	50	6	9	55
Lupinus arcticus	7	15	32	14	20	50	1	3	9
Pedicullaris verticillata	0	1	44	0	0	50	0	0	9
Pyrola grandiflora	1	2	26	2	3	50	0	1	18
Equisetum arvense	4	8	41				1	2	18
Equisetum scirpoides	6	16	32						
Equisetum variegatum	6	16	32				0	1	18
Total Moss Cover	**21**	**23**	**79**	**9**	**12**	**100**	**7**	**20**	**36**
Tomenthypnum nitens	5	11	62	4	6	100	4	13	36
Unknown moss	6	11	56				1	3	18
Campylium stellatum	4	13	35	0	0	50	1	2	36
Total Lichen Cover	**1**	**3**	**18**	**1**	**0**	**100**	**2**	**6**	**9**
Cetraria sp.	0	0	3	0	0	50	1	2	9
Thamnolia sp.	0	0	6	0	0	50	1	2	9
Total Bare Ground*	**17**	**16**	**86**	**10**			**26**	**20**	**100**
Litter*	12	14	81	10			9	5	100
Soil*	5	12	32				17	16	100

*Riverine Low and Tall Scrub n = 22, Lowland Low Scrub n = 1, Upland Sandy Low Scrub n = 3

Table 19. Mean percent cover of the most abundant species and total cover of all species by growth form in Coastal Barrens (n = 33), Riverine Barrens (n = 4), and Upland Sandy Barrens (n = 5) ecosystems on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992–1996. Blanks in table indicate 0% cover, values of 0 in table indicate less than 0.5% cover.

	Coastal Barrens			Riverine Barrens			Upland Sandy Barrens		
	Mean	SD	Freq.	Mean	SD	Freq.	Mean	SD	Freq.
Total Live Cover	**13**	**19**	**69**	**11**	**15**	**75**	**26**	**9**	**100**
Total Vascular Plant Cover	**13**	**17**	**69**	**10**	**13**	**75**	**26**	**9**	**100**
Total Deciduous Shrub Cover	**0**	**1**	**21**	**1**	**1**	**25**	**10**	**8**	**80**
Salix alaxensis	0	1	12				7	7	60
Salix glauca							2	3	40
Salix ovalifolia	0	0	9				1	2	20
Total Graminoid Cover	**9**	**13**	**67**	**4**	**6**	**75**	**16**	**10**	**100**
Elymus arenarius	1	3	22				13	12	80
Deschampsia caespitosa	3	7	44				1	2	20
Bromus pumpellianus	0	0	3	0	0	25	0	0	40
Poa sp.	0	0	3				1	2	40
Arctagrostis latifolia	0	2	6	1	1	25			
Puccinellia phryganodes	2	8	15						
Trisetum spicatum	0	0	3	0	0	25			
Calamagrostis sp.	0	1	3						
Total Forb Cover	**4**	**8**	**42**	**5**	**7**	**50**	**1**	**1**	**60**
Chrysanthemum bipinnatum	1	2	33				1	1	60
Petasites frigidus	0	2	6	1	1	25			
Artemisia tilesii	0	0	3				0	0	20
Equisetum palustre	0	0	3				0	0	20
Stellaria sp.	0	1	6	1	2	25	0	0	20
Polygonum bistorta				2	4	25			
Stellaria humifusa	0	2	9						
Equisetum arvense	1	4	9						
Total Moss Cover	**0**	**2**	**6**						
Total Lichen Cover				**1**	**2**	**25**			
Total Bare Ground	**85**	**17**	**100**	**91**	**16**	**100**	**72**	**13**	**100**
Soil*	75	34	100	50	57	50			
Water*	0	0	3						
Litter *	9	21	9						

* Coastal Barrens n = 8, Riverine Barrens n = 1, Upland Sandy Barrens n = 0

tetragona, Carex bigelowii, and *Lupinus arcticus*. Upland Low Scrub is dominated by *Salix glauca*, *Dryas integrifolia,* and *Arctostaphylos rubra*.

Barrens, which include partially vegetated areas, are the result of dynamic geomorphic processes that occur along the tidal flats, riverbed/riverbars, sand dunes, and recently drained-lake basins (Table 19). Coastal Barrens have small amounts of *Deschampsia caespitosa* and *Puccinellia phryganodes*. In Riverine Barrens, *Bromus pumpellianus, Arctagrostis latifolia, Petasites frigidus,* and *Polygonum bistorta* are more frequent colonizers. In Upland Sandy Barrens, *Salix alaxensis, S. glauca, Elymus arenarius,* and *Chrysanthemum bipinnatum* are more common. Although we did not sample Lacustrine Barrens, common colonizers in those areas were observed to include *Arctophila fulva, Carex aquatilis, Dupontia fisheri*, and *Senecio congestus* in wetter areas and *Salix ovalifolia* in better drained areas.

A total of 210 vascular taxa, 68 bryophytes and 25 lichens were identified within the study area (Appendix Tables 11 and 12). While there was a consistent effort to collect and identify vascular plants, the list of byrophytes and lichens represent only the more common taxa and were identified from voucher collections of the dominant taxa. No threatened or endangered plant species were found in the area. No occurrences of the relatively rare plants, *Mertensia drummundii* and *Thlaspi arcticum*, were found, although *M. drummondii* reportedly has been observed on a pingo on the east side of the delta (D. Helmericks *fide* J. Helmericks, Colville River Delta, AK, 15 September 1995 , 2 January 1996, pers. comm.). Two species were found at the head of the delta beyond their normal range of distribution, *Alnus crispa* and *Menyanthes trifoliata*.

Dominant Growth Forms

Graminoids, overall, were the most abundant growth form and were found in all vegetated ecosystems (Figure 24). They were abundant in both early (e.g., Riverine Marsh) and late successional (e.g., Upland Tussock Meadow) ecosystems but were least abundant in shrub-dominated ecosystems. Forbs also were found in all ecosystems but were most abundant in Riverine Low and Tall Scrub. Deciduous shrubs were found in nearly all ecosystems but were most abundant in early successional habitats associated with active floodplains and sand dunes. In contrast, evergreen shrubs were abundant in only a few late-successional ecosystems with well-drained soils (e.g., Riverine Dwarf Scrub, Upland Loamy Dwarf Scrub, Upland Sandy Dwarf Scrub) and were absent in many ecosystems. Mosses were moderately abundant in most ecosystems except those with deep water or those affected by frequent sediment deposition. Lichens were the least abundant and most restricted growth form and were moderately abundant only in well-drained late-successional ecosystems (e.g., Upland Sandy Moist Meadows, Upland Loamy Dwarf Scrub, and Upland Sandy Dwarf Scrub).

When comparing totals of the most productive growth forms (graminoids, forbs, and deciduous shrubs), the highest mean cover values were found in Riverine Low and Tall Scrub (136%), Upland Sandy Dwarf Scrub (102%), Lacustrine Moist Meadow (118%), Riverine Moist Meadow (96%), Riverine Wet Meadow (95%), and Lowland Wet Meadow (96%). These ecosystems generally are developing in newly exposed or disturbed sites or in areas receiving groundwater input. In contrast, the lowest mean cover values for stable ecosystems were found in Riverine Dwarf Scrub (46%), Upland Loamy Dwarf Scrub (44%), Lacustrine Wet Meadows (47%). While the first two are well-drained, late-successional ecosystems that can be expected to have low productivity, the low mean value for Lacustrine Wet Meadows was unusual for an early successional ecosystem and was attributed to the abundance of water and lack of shrubs. The lowest cover values for all ecosystems were found for those that are subject to frequent disturbance (e.g., Coastal Barrens, Riverine Barrens, Upland Sandy Barrens, and Salt-killed Wet Meadows).

The differences in coverage of growth forms is related to differences in productivity and the strategies that plants use to acquire resources under changing environmental conditions associated with landscape evolution (Figure 24). Because cover has been found to be correlated with biomass (Yarie and Mead 1988, Smith 1996), and biomass correlated with productivity (Shaver et al. 1996), we interpreted the repetitive cover values presented above as an indirect index for comparing productivity.

ENVIRONMENTAL CHARACTERISTICS

Single-factor Comparisons by Plant Species

Eight environmental parameters (elevation ratios, depth to groundwater, drainage index, pH, electrical conductivity, surface organic-horizon thickness, cumulative organic-horizon thickness, and thaw depth) were assessed to determine their influence on the dis-

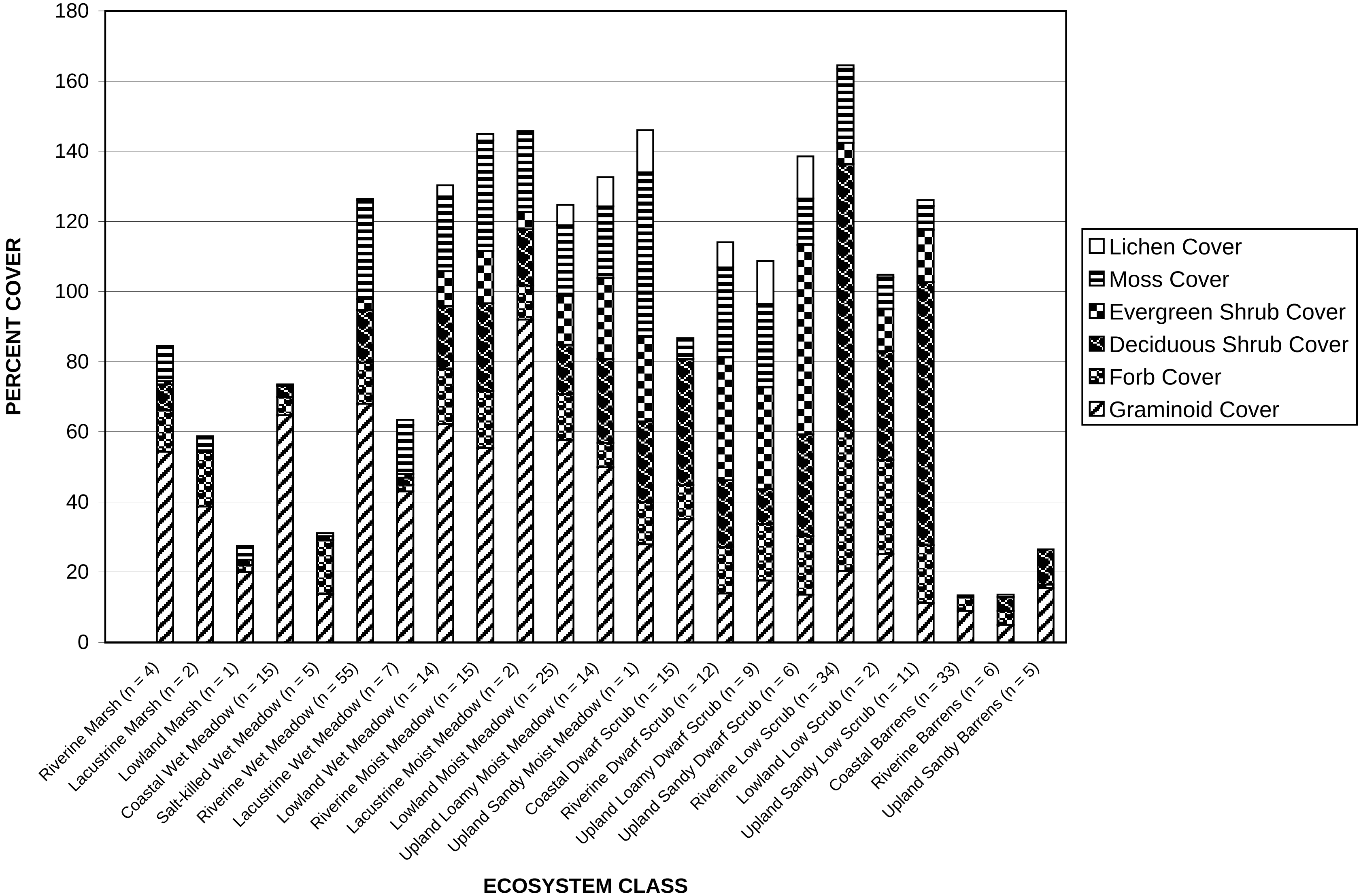


Figure 24. Repetitive cover values (proportional to biomass) for plant growth forms by ecosystem type on Colville River Delta and adjacent coastal plain, northern Alaska, 1996

tribution of 26 plant species. For each plant species, the mean value of each parameter was calculated for those locations where that species was typical. Differences among species for each parameter are presented below.

Mean elevation ratios (height of ecosystem relative to height of inactive floodplain) were similar for most species on the Colville Delta, and variation among sites where the species occurred was high (Figure 25). Species found on the lowest portions of the floodplain, and thus subject to the most frequent flooding, included *Arctophila fulva*, *Deschampsia caespitosa, Salix alaxensis* and *Dupontia fisheri*. Species found mainly on the highest sites included *Eriophorum vaginatum, Salix planifolia, Carex bigelowii, Dryas integrifolia* and *Salix reticulata.* Most species were in the intermediate range, occurring mainly on inactive floodplains where flooding is infrequent (every 5–25 years).

Depth to groundwater exhibited a strong gradient among species but was highly variable within species (Figure 26). Species found in areas where groundwater was nearest the surface include *Arctophila fulva, Carex aquatilis, Pedicularis suedetica* and *Dupontia fisheri*. *Arctophila,* in particular, was associated with a wide range of groundwater depths; it typically grows in water 30–100 cm deep but also was found frequently colonizing bare areas where groundwater was well below the surface. Species associated with the greatest depths to groundwater included *Salix glauca, S. alaxensis*, *Deschampsia caespitosa, Arctostaphylos rubra, Salix ovalifolia,* and *Eriophorum vaginatum.* The high variability within species indicates that most plants can tolerate a wide range of groundwater levels. In addition, depth to groundwater is highly variable both spatially and temporarily, contributing to the high standard deviations. Mean drainage-index values followed the same pattern (Figure 27).

The pH of groundwater or soil (when groundwater was not present) was neutral (6.6–7.3) for most species and highly variable within species (Figure 28). Species associated with slightly acidic (6.1–6.5) sites included *Eriphorum vaginatum* and *Salix planifolia*, which both tend to be later-successional species. In contrast, species associated with slightly alkaline (7.4–7.8) soils included *Salix alaxensis, S. glauca, Deschampsia caespitosa, S. ovalifolia, Arctostaphylos rubra,* and *Arctagrostis latifolia.* Most of these species typically occur early in successional ecosystems. The high variability associated with most species however, indicates, that they have broad ecological tolerances to pH conditions.

Electrical conductivity (EC) indirectly measures salinity, and most species occurred only on sites with low mean EC levels (Figure 29). Two species (*Stellaria humifusa* and *Carex subspathacea)* appeared to be restricted to saline sites where EC was high. Several species, including *Deschampsia caespitosa, Arctophila fulva, Salix ovalifolia, Dupontia fisheri, Arctagrostis latifolia,* and *Petasites frigidus,* had intermediate EC values and high standard deviations, indicating a broad tolerance to saline conditions.

Mean depth of the surface organic horizon (an indication of frequency of sedimentation) was highly variable among species and within species (Figure 30). Species typically found on sites with thin organic horizons at the surface (indicative of frequent sedimentation), included *Stellaria humifusa, Deschampsia caespitosa, Salix alaxensis, S. ovalifolia*, and *Carex subspathacea*. These species occur mainly in early successional ecosystems subject to frequent fluvial or eolian deposition. Species characteristic of sites with thick surface organic accumulations included *Pedicularis sudetica, Eriophorum angustifolium, Carex bigelowii*, and *Eriophorum vaginatum*. The first two species occur in a range of saturated, early- to late-successional ecosystems, whereas the latter two were found on better drained, late successional ecosystems. The pattern is similar with respect to mean cumulative thickness of the organic horizons (Figure 31).

Mean thaw depths were relatively consistent within and among species, a pattern that differed substantially from the other variables (Figure 32). A few species (*Salix alaxensis, Salix glauca*, and *Deschampsia ceaspitosa*) deviated from this and clearly were associated with deeper thaw depths. These typically were found on well-drained sandy soils in early successional ecosystems.

Single-factor Comparisons by Ecosystem

Mean values of the eight environmental parameters also were compared among the terrestrial ecosystems (including shallow water with emergent vegetation). The comparisons of differences among ecosystems does not always include a complete list of ecosystems. Elevation ratios are only presented for those ecosystems where at least 2 values are available and other parameters could not always be measured (e.g., groundwater occasionally was not present).

Mean elevation ratios of most ecosystems were in the intermediate range. Coastal Barrens, Riverine Marsh, and Coastal Wet Meadow typically occurr at

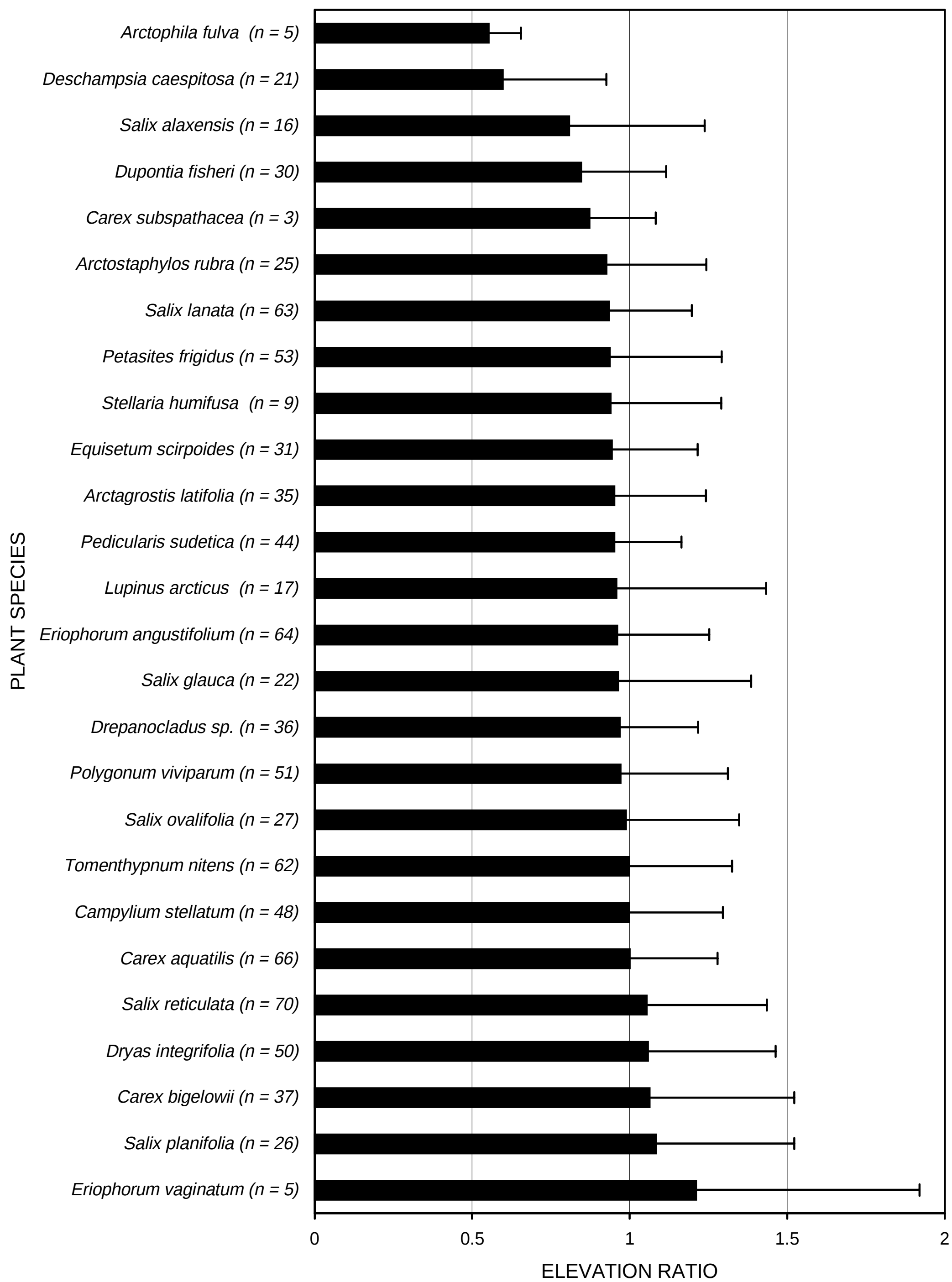


Figure 25. Mean (± SD) of elevation ratios of sample plots where selected plant species were found on the Colville River Delta, Alaska, 1996. Plots where species had only trace cover values were excluded from analysis.

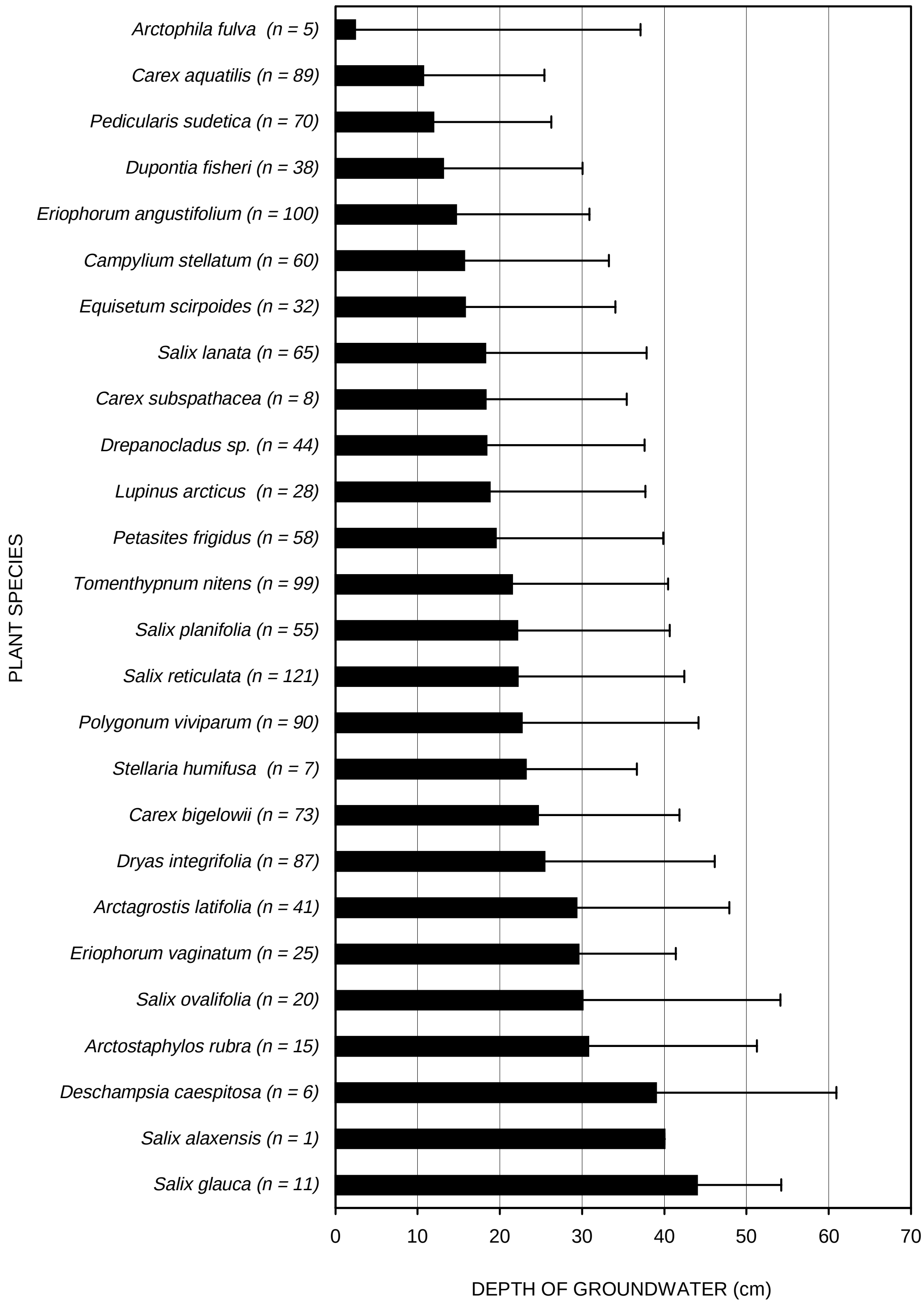


Figure 26. Mean (± SD) depth of groundwater in sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots where species had only trace cover were excluded from analysis.

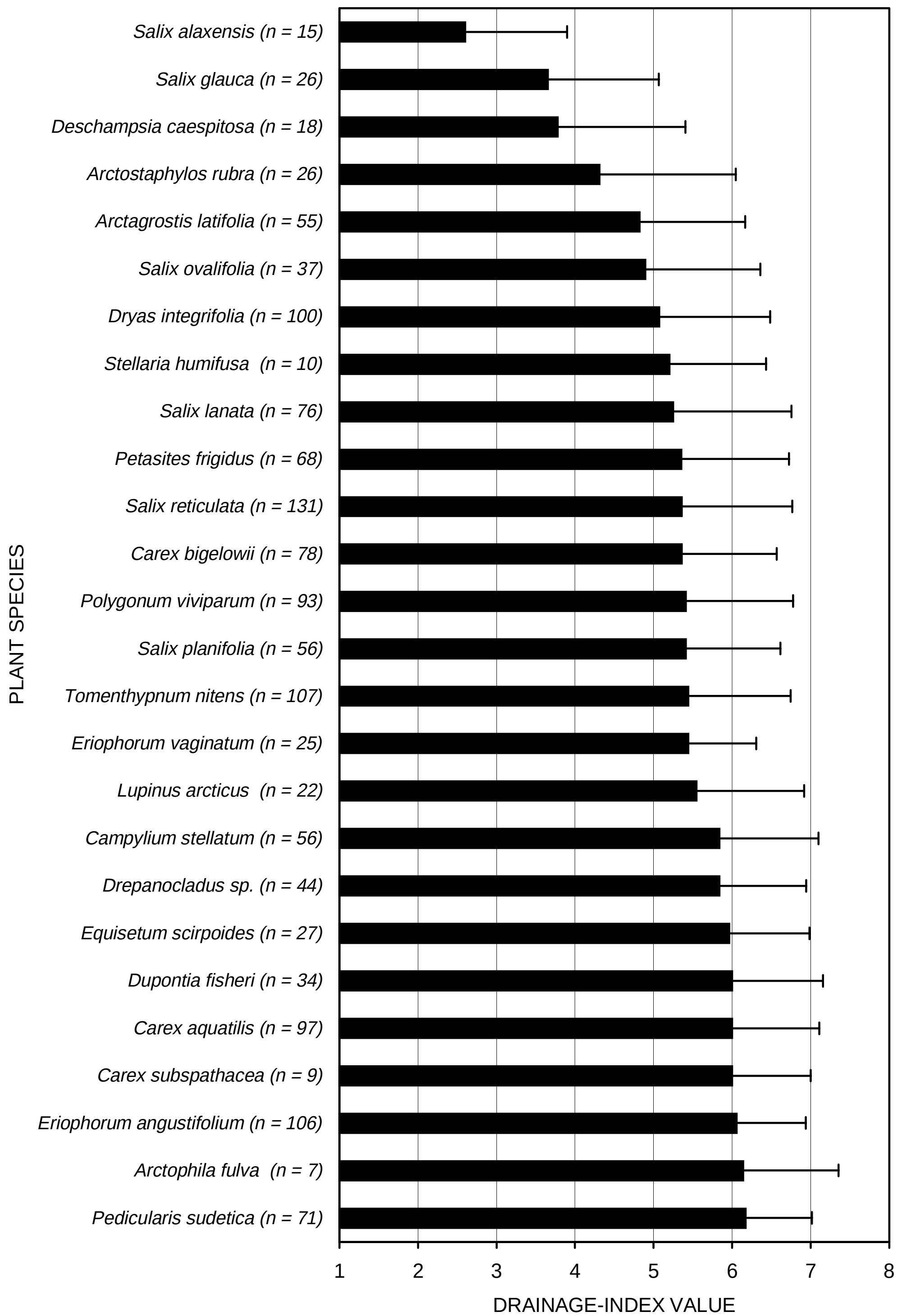


Figure 27. Mean (± SD) drainage-index values (1 = excessively drained, 7 = very poorly drained) determined for sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots where species had only trace cover values were excluded from analysis.

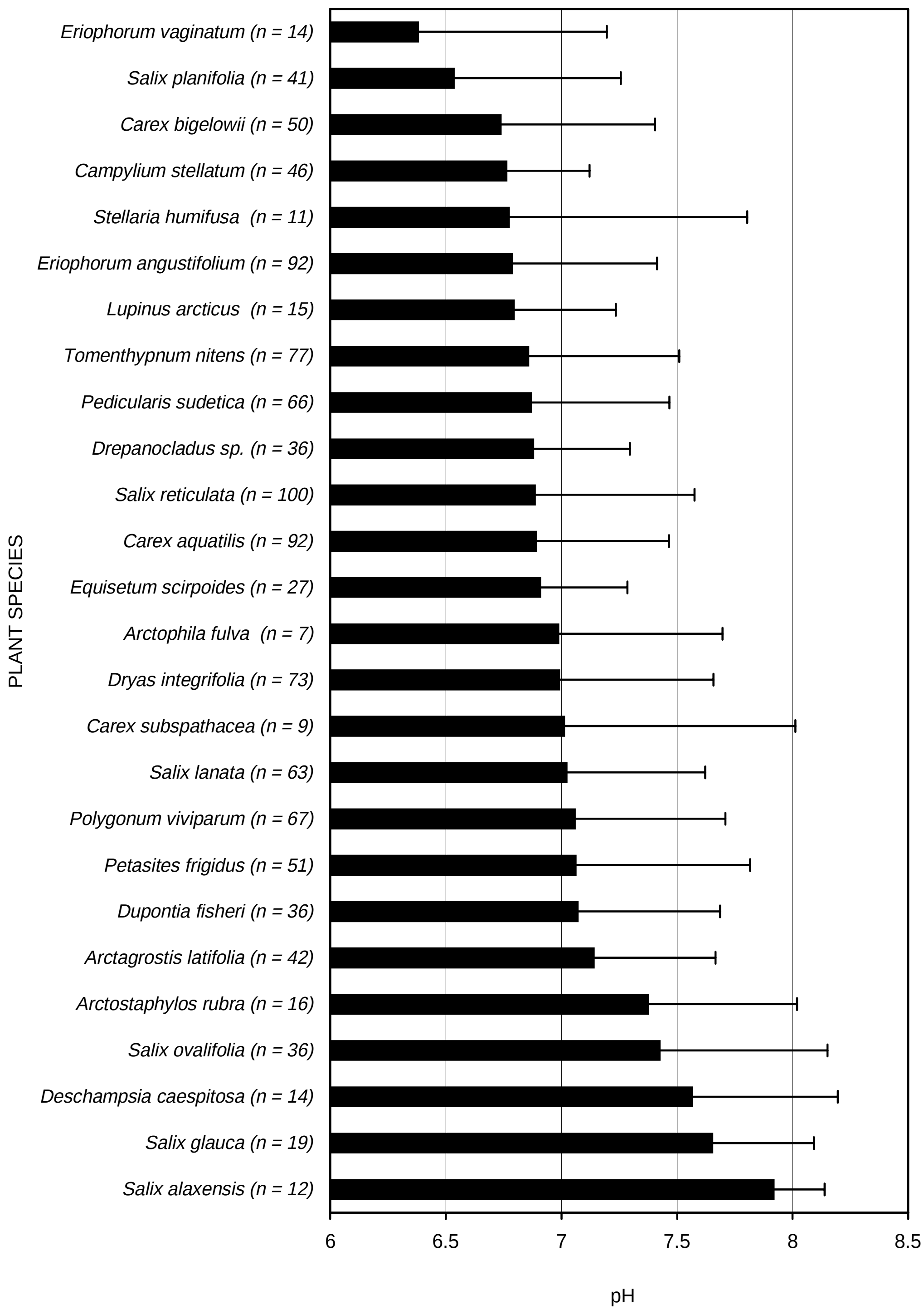


Figure 28. Mean (± SD) pH values of groundwater and soil (when water was not present) measured in sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots where species had only trace cover values were exlcluded from analysis.

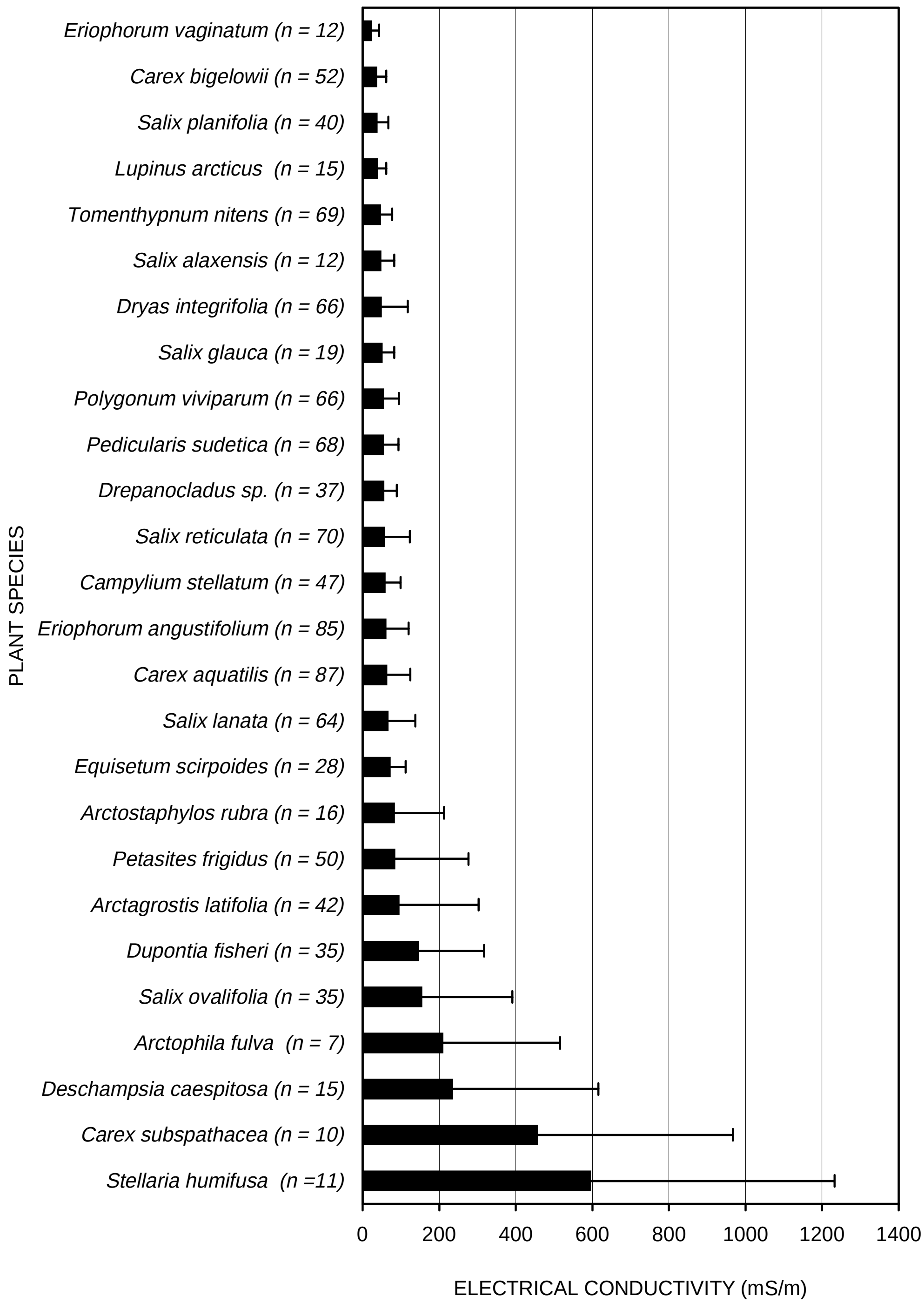


Figure 29. Mean (± SD) electrical conductivity (EC) values of groundwater and soil (when water was not present) measured in sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots where species had only trace cover values were excluded from analysis.

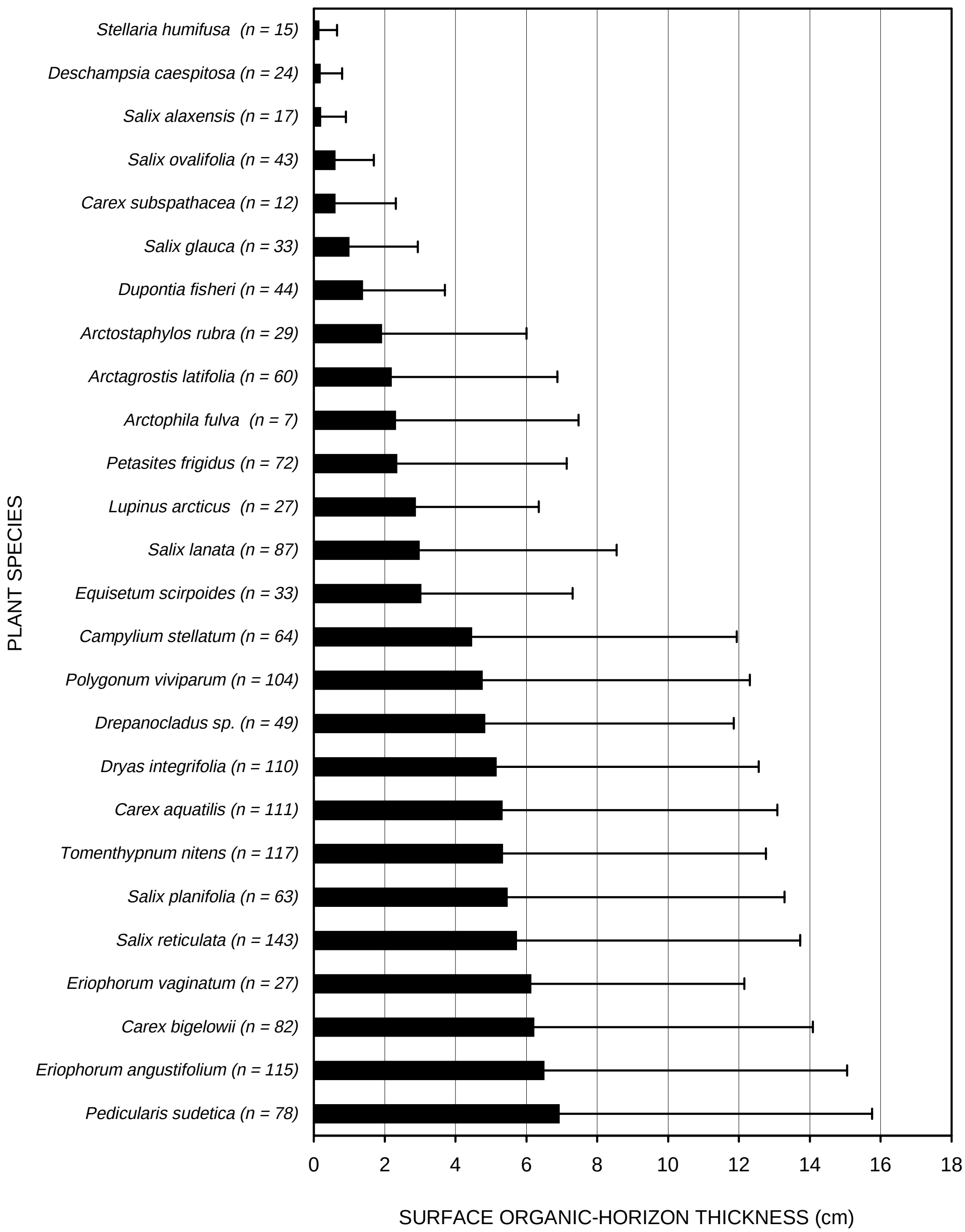


Figure 30. Mean (± SD) thickness of the surface organic horizon measured in sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots where species had only trace cover values were excluded from analysis.

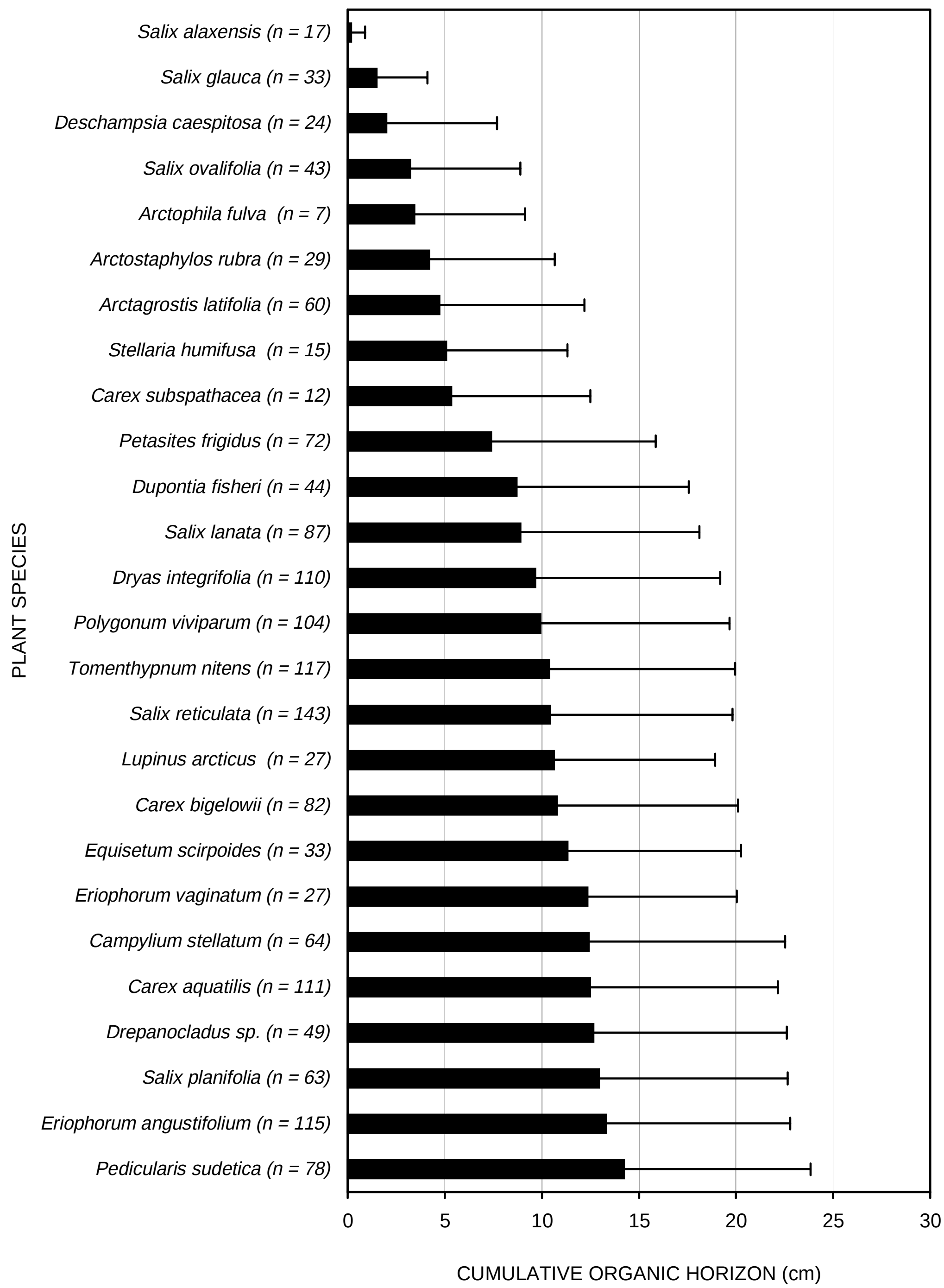


Figure 31. Mean (± SD) total thickness of organic-horizons, within the active layer, of sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots species had only trace cover values were excluded from analysis.

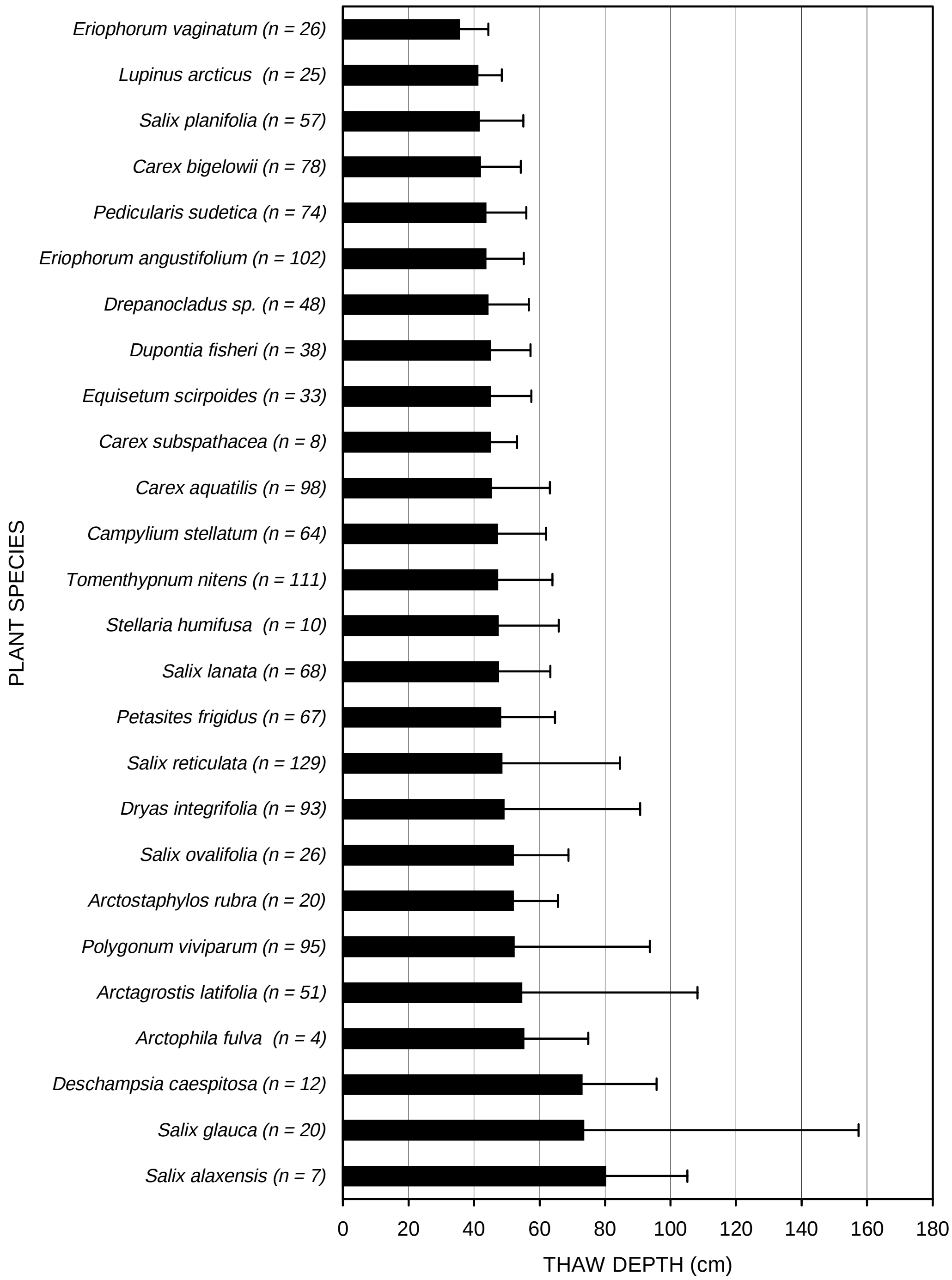


Figure 32. Mean (± SD) thaw depth measured in sample plots where selected plant species were found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Plots where species had only trace cover values were exluded from analysis.

the lower elevations, which are subject to more frequent flooding and sedimentation (Figure 33, Appendix Table 6). Upland Sandy and Riverine Dwarf Scrubs had the highest mean elevation ratios. These ecosystems occur on Eolian Sand Dunes and some of the highest Inactive-floodplain Deposits, which rarely are flooded.

Water depths showed a strong gradation among ecosystems and only a few ecosystems had highly variable values (Figure 34). Mean water depths were above the soil surface for four ecosystems: Riverine Marsh, Lowland Shallow Lake, and Lacustrine Marsh. Ecosystems where the water surface was farthest below the ground surface included Upland Sandy Dwarf Scrub, Riverine Dwarf Scrub, Upland Sandy Low Scrub, and Lacustrine Moist Meadow. Ecosystems where water depths were most variable included Coastal Barrens, and Coastal Salt-killed Wet Meadows. The qualitative drainage index showed a similar pattern, although the coastal ecosystems were more intermediate in the ranking (Figure 35).

Mean pH values showed a strong gradient among ecosystems (Figure 36). Ecosystems with the lowest pH values were Coastal Salt-killed Wet Meadows, Upland Tussock Meadows, and Upland Sandy Moist Meadows. The last two are late successional ecosystems, whereas strong reducing conditions from active decomposition due to recent salt damage to vegetation and relatively good drainage conditions probably account for low pH in the first. The highest pH values were found in Lowland Shallow Lakes, Upland Sandy Barrens, Upland Sandy Low Scrub, and Upland Sandy Dwarf Scrub. The high pH values of the sand dune ecosystems presumably are due to eolian input of coastal sediments.

Electrical conductivity (EC) measurements revealed that most ecosystems are non-saline and the variability of EC is low (Figure 37). Higher EC values occurred in salt-affected coastal ecosystems and in Upland Sandy Dwarf Scrub, which occurs on well-drained sites and receives eolian input. Salinity values for the coastal ecosystems were highly variable, however, indicating a wide range of salinity conditions across the outer delta.

The thickness of the surface organic-horizon (an indicator of frequency of sedimentation) showed a strong gradient among sites (Figure 38). Ecosystems where surface organic accumulations were absent included Upland Sandy Barrens, Riverine Barrens, Coastal Wet Meadows, Coastal Salt-killed Meadows, and Coastal Barrens. The soil stratigraphy of Coastal Salt-killed Meadows is unusual compared with other ecosystems with little or no surface organic material in that salt-killed areas typically have fairly thick accumulations of organic matter below the surface mineral horizon; thus, the recent sedimentation indicates a change in flooding regime that probably is related to sea level rise (Jorgenson et al. 1997). The thickest accumulations were found in Lowland Thaw Complex, Lacustrine Wet Meadow, and Lacustrine Marsh. These thick accumulations indicate that sedimentation events are rare or lacking. Total thickness of organic-matter followed a similar pattern with a few notable differences (Figure 39). Riverine Wet Meadows had relatively thick organic accumulations, but the thinness of the surface organic layer indicates frequent sediment deposition along with rapid organic accumulation in the saturated soils. This soil profile is typical of the layered soil horizons produced by rapid plant growth and frequent, but not annual, flooding. Coastal Wet Meadow showed a similar pattern, although organic accumulations were not as thick.

Mean thaw depths showed little variation among most ecosystems (Figure 40). The greatest thaw depths were found in well-drained ecosystems (Upland Sandy Dwarf Scrub, Upland Sandy Low Scrub, Upland Sandy Barrens) or areas where the presence of standing water enhances seasonal thawing (Lacustrine Marsh, Coastal Barrens). Ecosystem classes with the shallowest thaw depths were Upland Tussock Meadow and Lowland Low Scrub. These two classes occur predominantly on older deposits on the delta and adjacent coastal plain, which typically have thick organic layers and/or ice-rich permafrost.

Ordination of Multiple Environmental Factors

In addition to the single-factor comparisons, the relationships among environmental variables and ecosystem distribution were evaluated using canonical correspondence analysis (CCA) (Figure 41 and 42). Vectors of the environmental variables that had the most effect on ecosystem distribution were included with the ordination to indicate the direction (angle) and strength (length) of the relationships (Figure 41). When electrical conductivity (EC), pH, drainage, surface organic-horizon thickness, and cumulative organics (SumOrg) were included in the ordination, EC and cumulative organic thickness were found to be strong factors associated with the first axis. Most plots, however, were clumped within a tight ordination (environmental) space. When EC and pH were removed from the ordination, and the ordination was performed

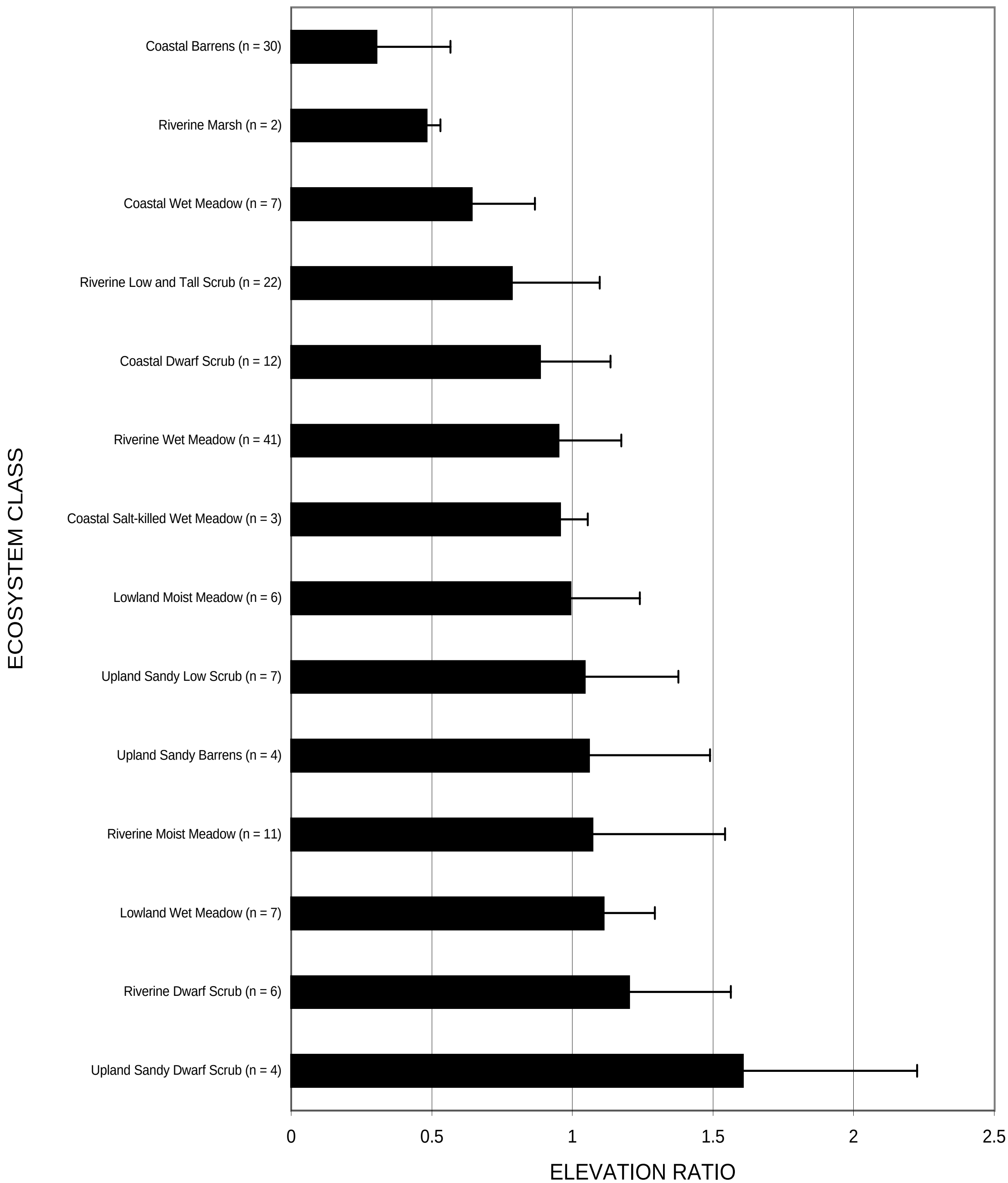


Figure 33. Mean (± SD) elevation ratios of ecosystems (ecosite level) on the Colville River Delta, Alaska, 1996

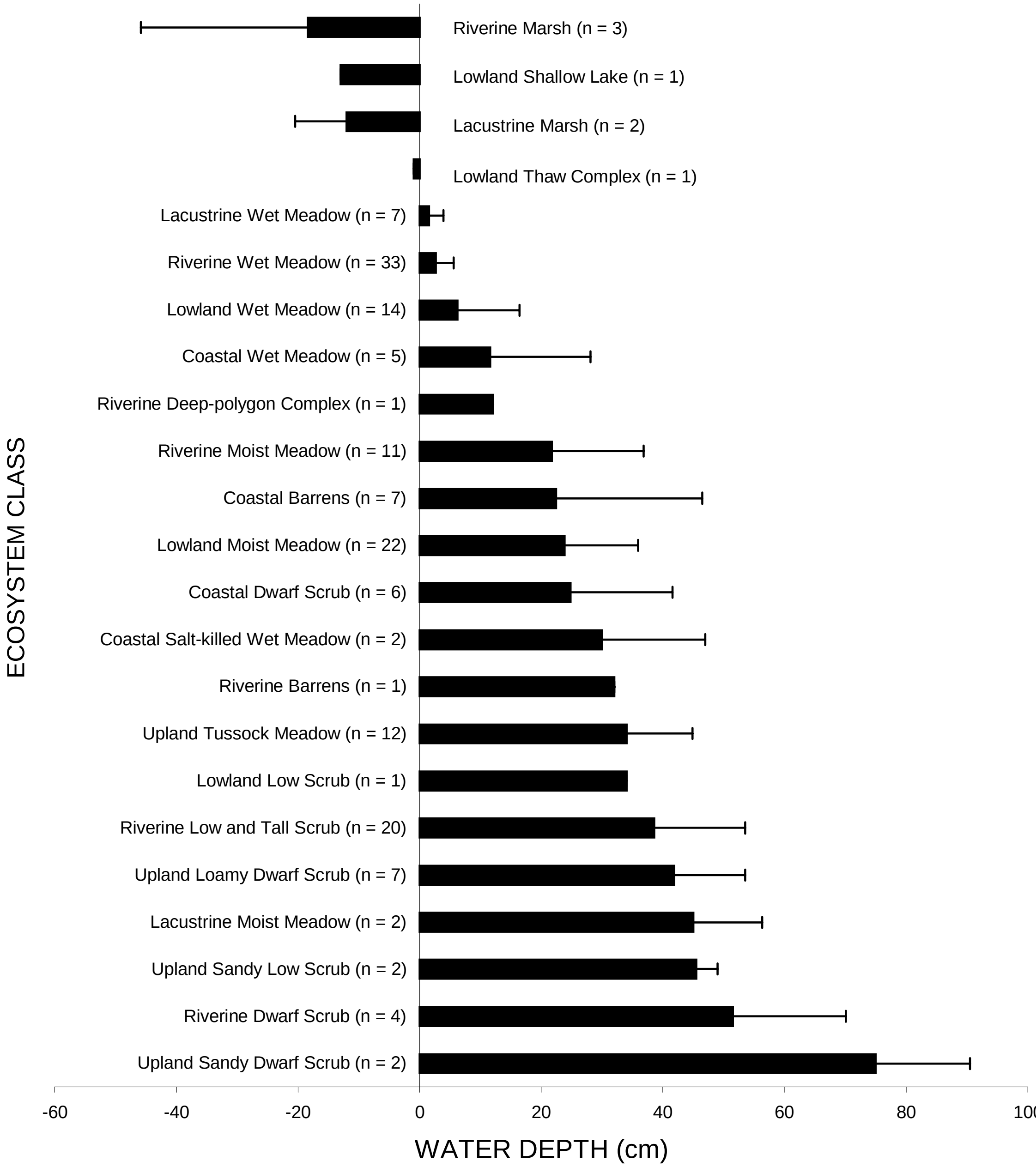


Figure 34. Mean (± SD) depths of water above (-) or below (+) the ground surface of ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

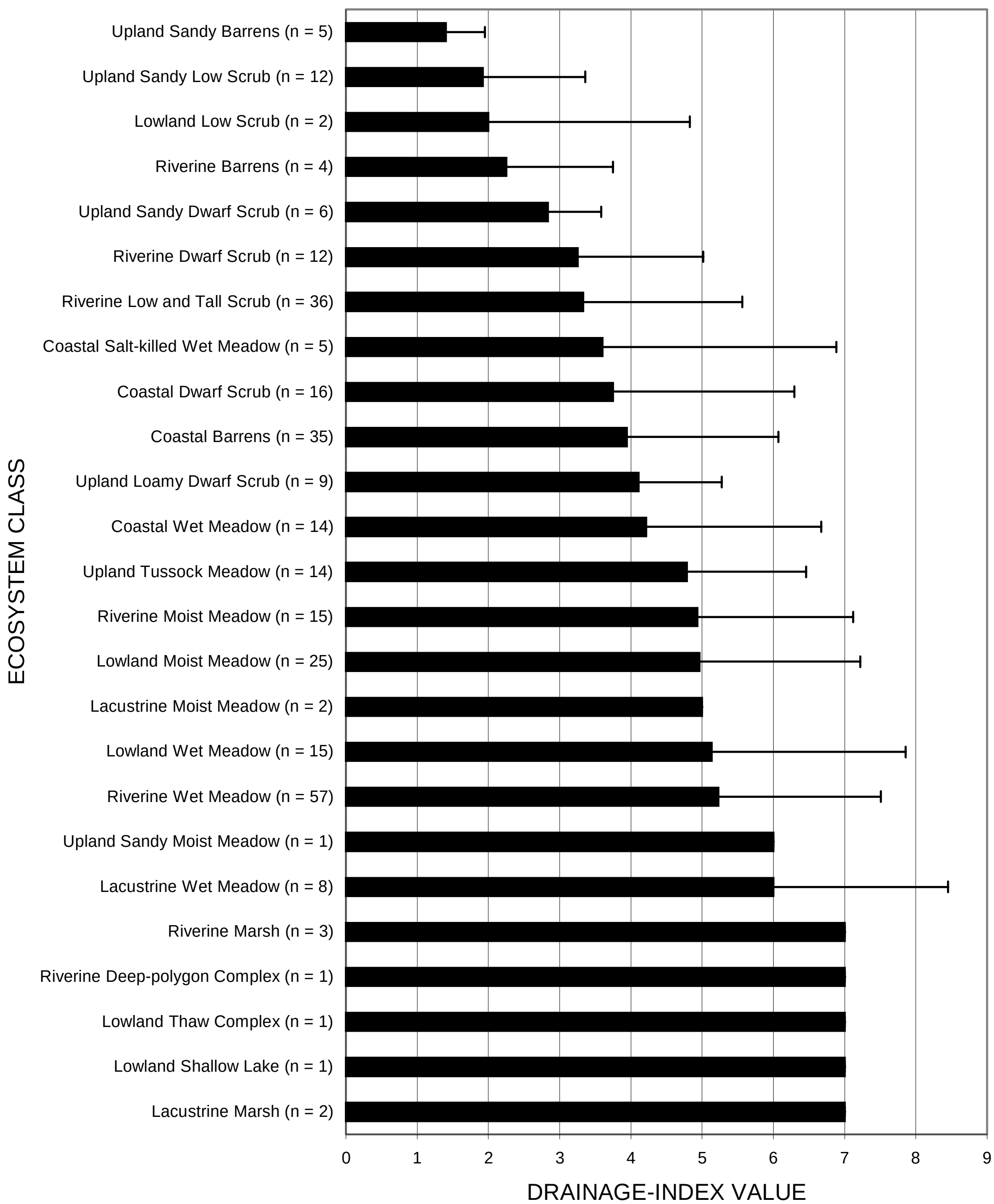


Figure 35. Mean (± SD) drainage-index values (1 = excessively drained, 7 = very poorly drained) of ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

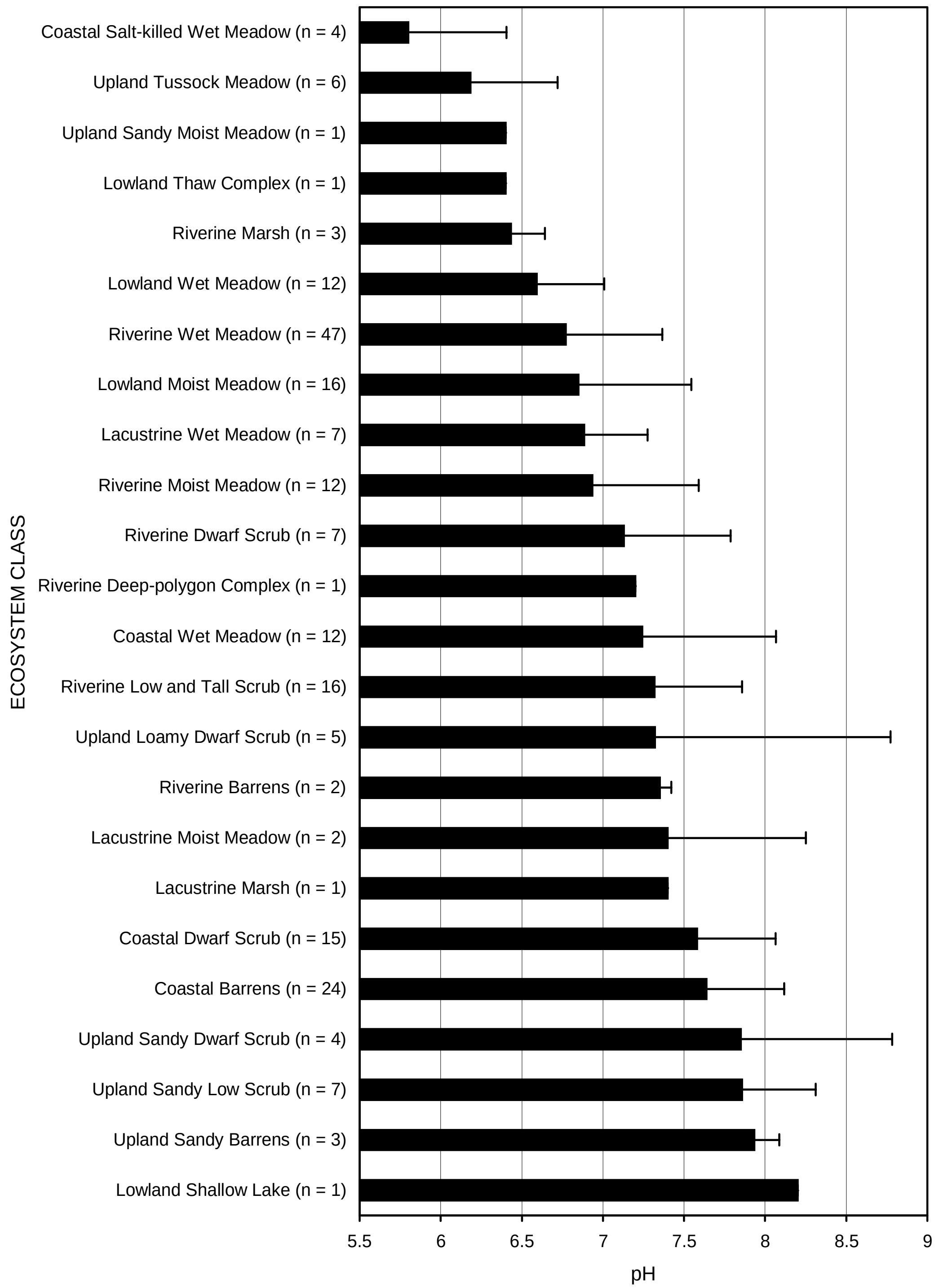


Figure 36. Mean (± SD) pH values of groundwater and soil (when water was not present) in ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

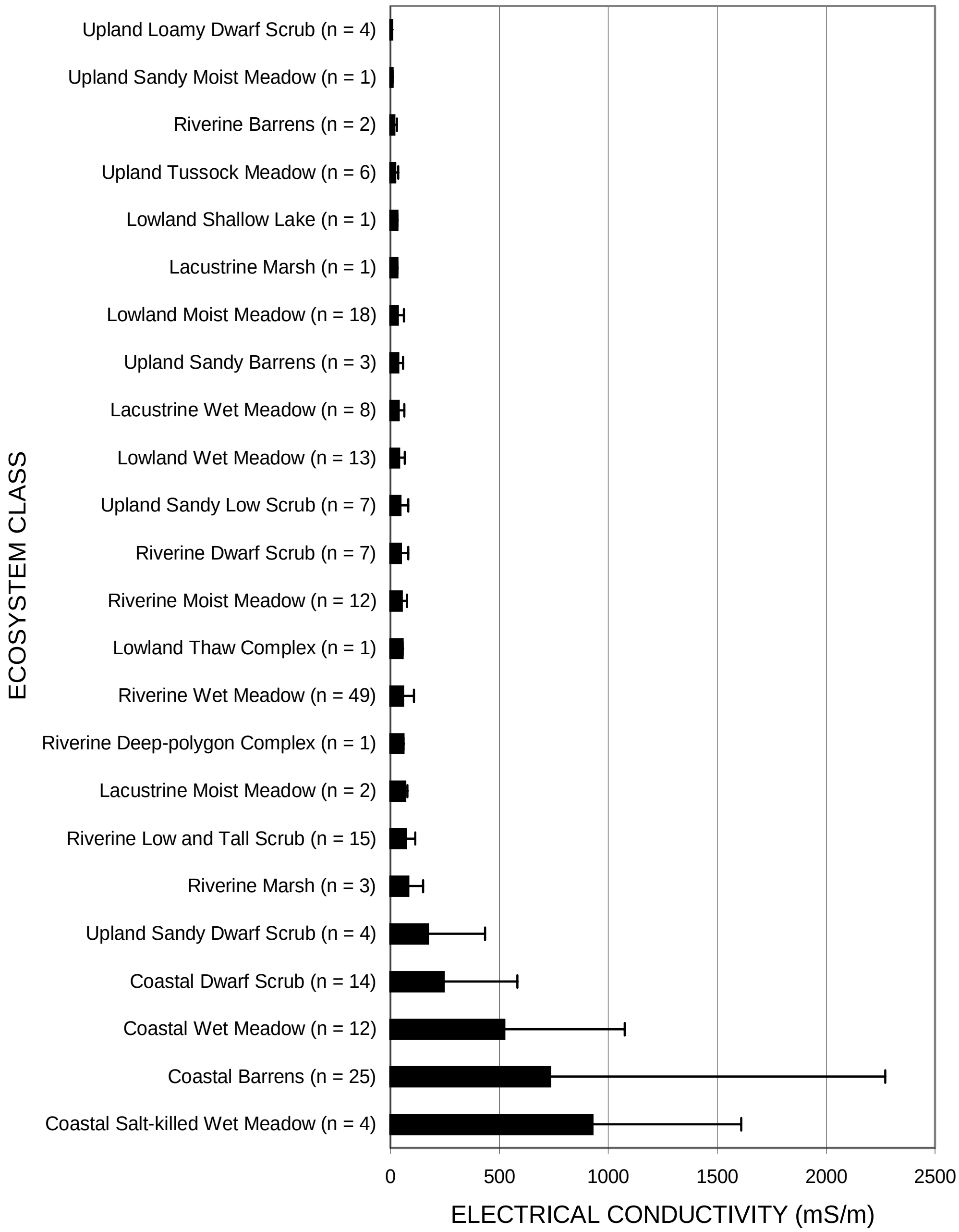


Figure 37. Mean (± SD) electrical conductivity (EC) values of groundwater and soil (when water was not present) in ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

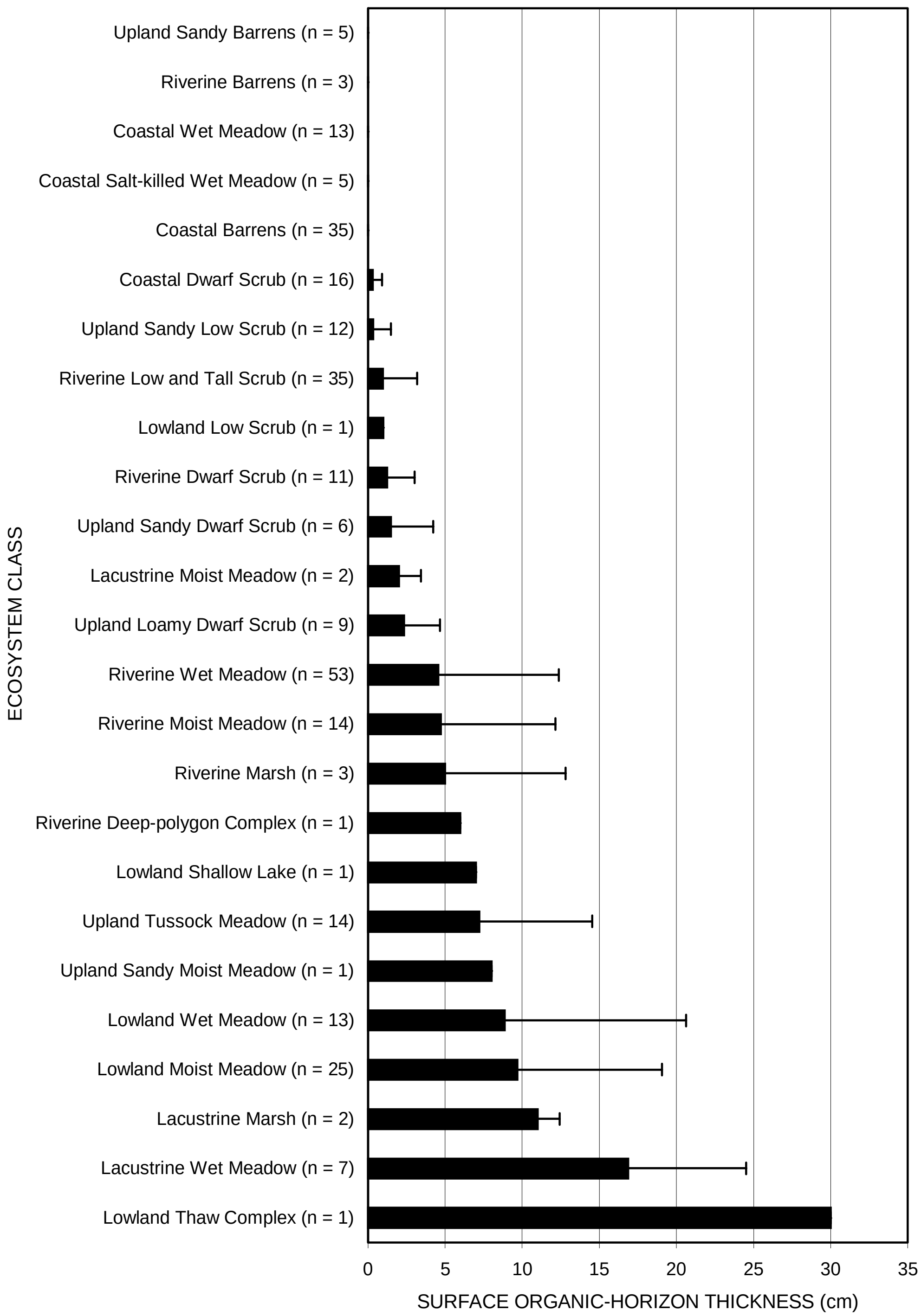


Figure 38. Mean (± SD) thickness of the surface organic-horizon in ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

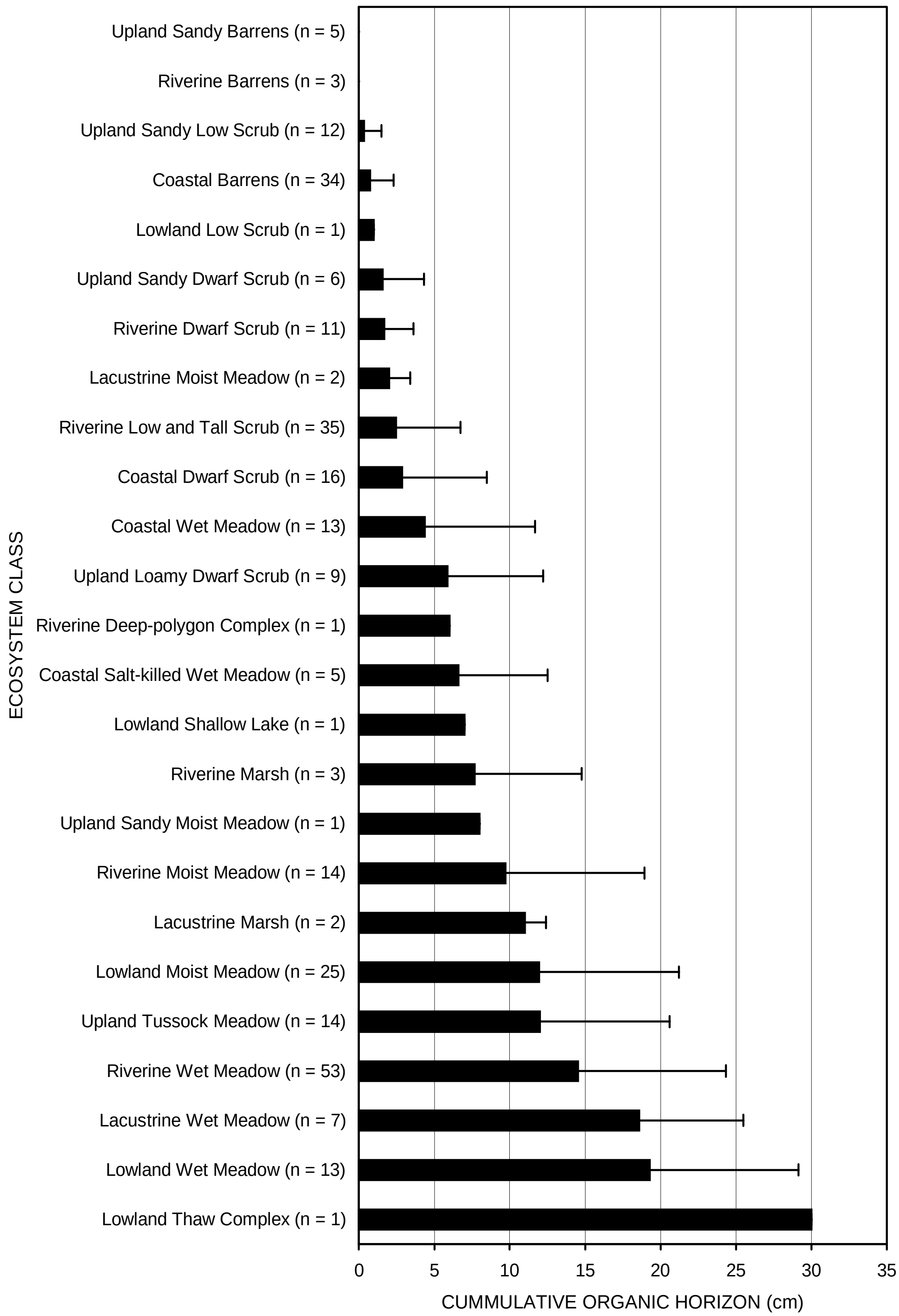


Figure 39. Mean (± SD) total thickness of organic horizons, within the active layer, in ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996

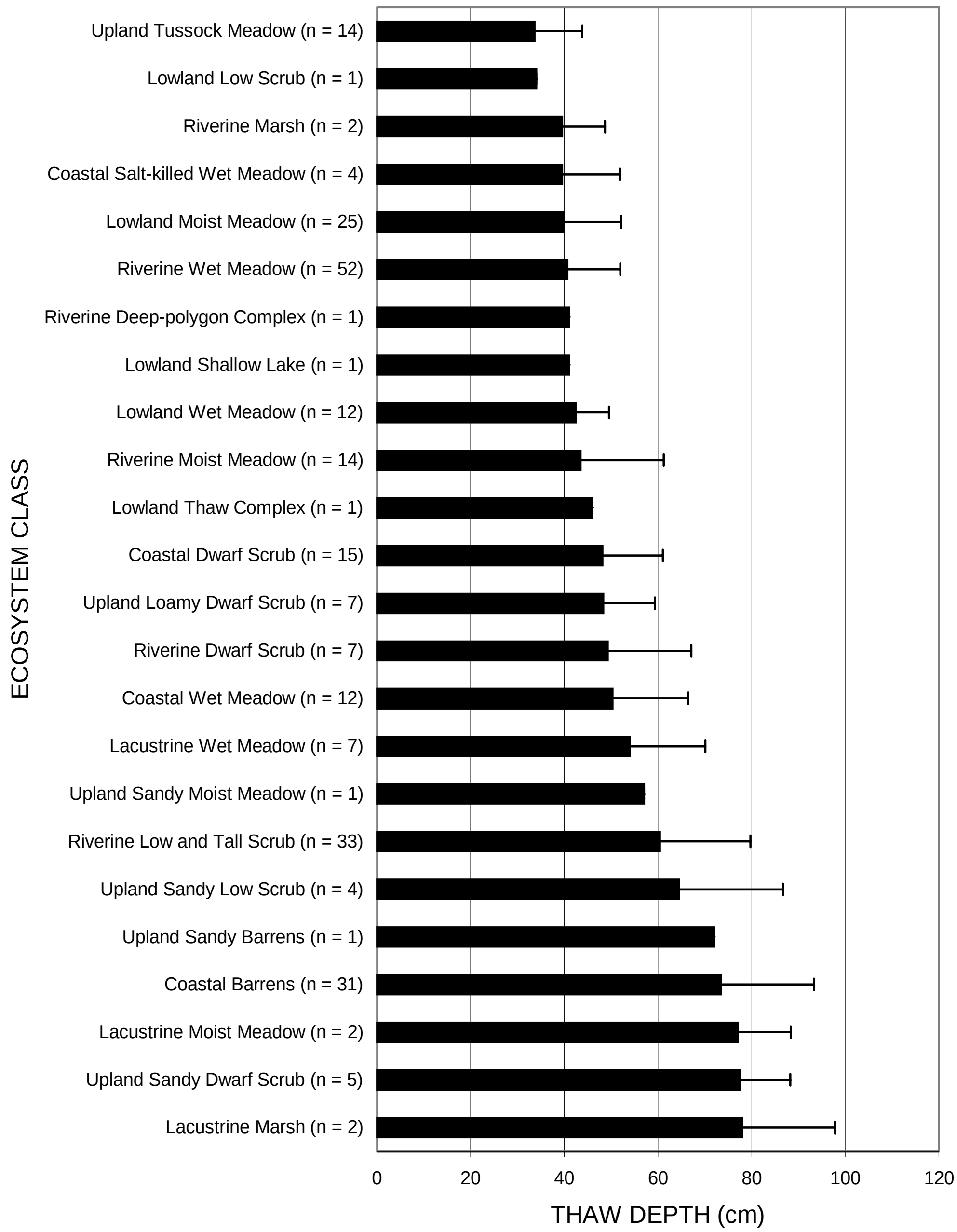
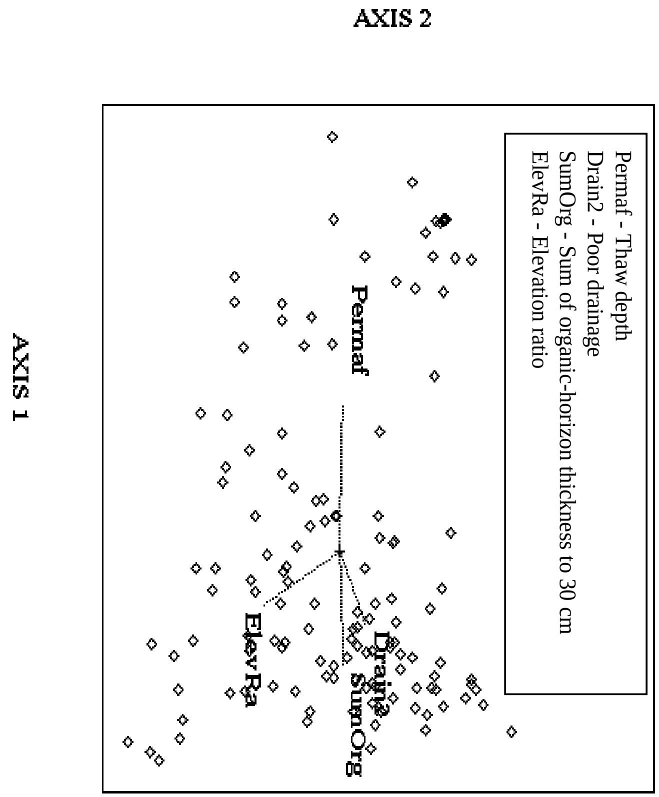


Figure 40. Mean (± SD) thaw depths in ecosystems (ecosite level) on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996



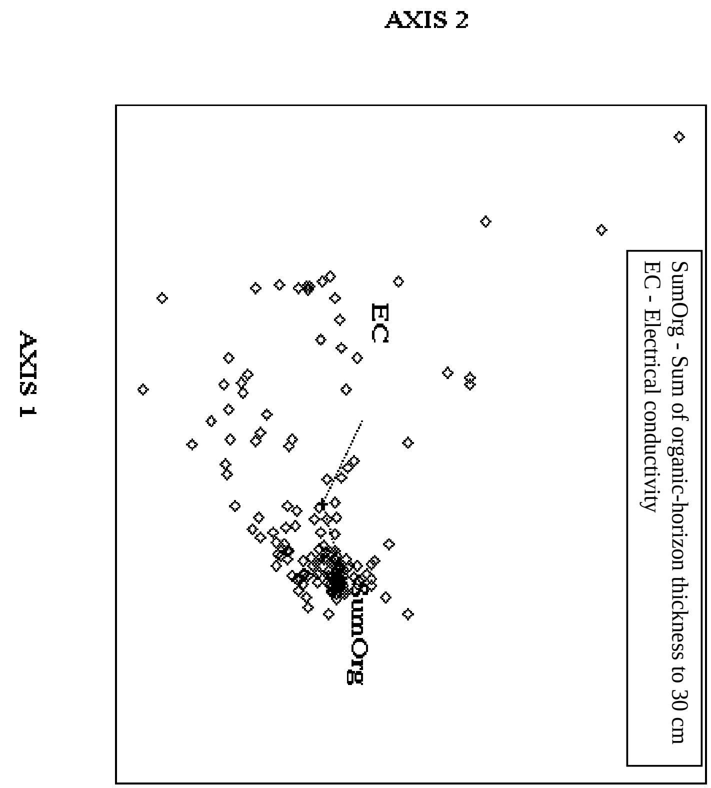


Figure 41. Canonical correspondence ordination of vegetation and environmental variables identifying principal environmental variables affecting ecosystem distribution on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Examples shown represent the significant variables from 2 subsets of the data, (the upper with all variables except thaw depth and elevation ratio, the lower with all variables exept EC and pH), length and direction of arrows represent strength and direction of the variables's relationship to the ordination

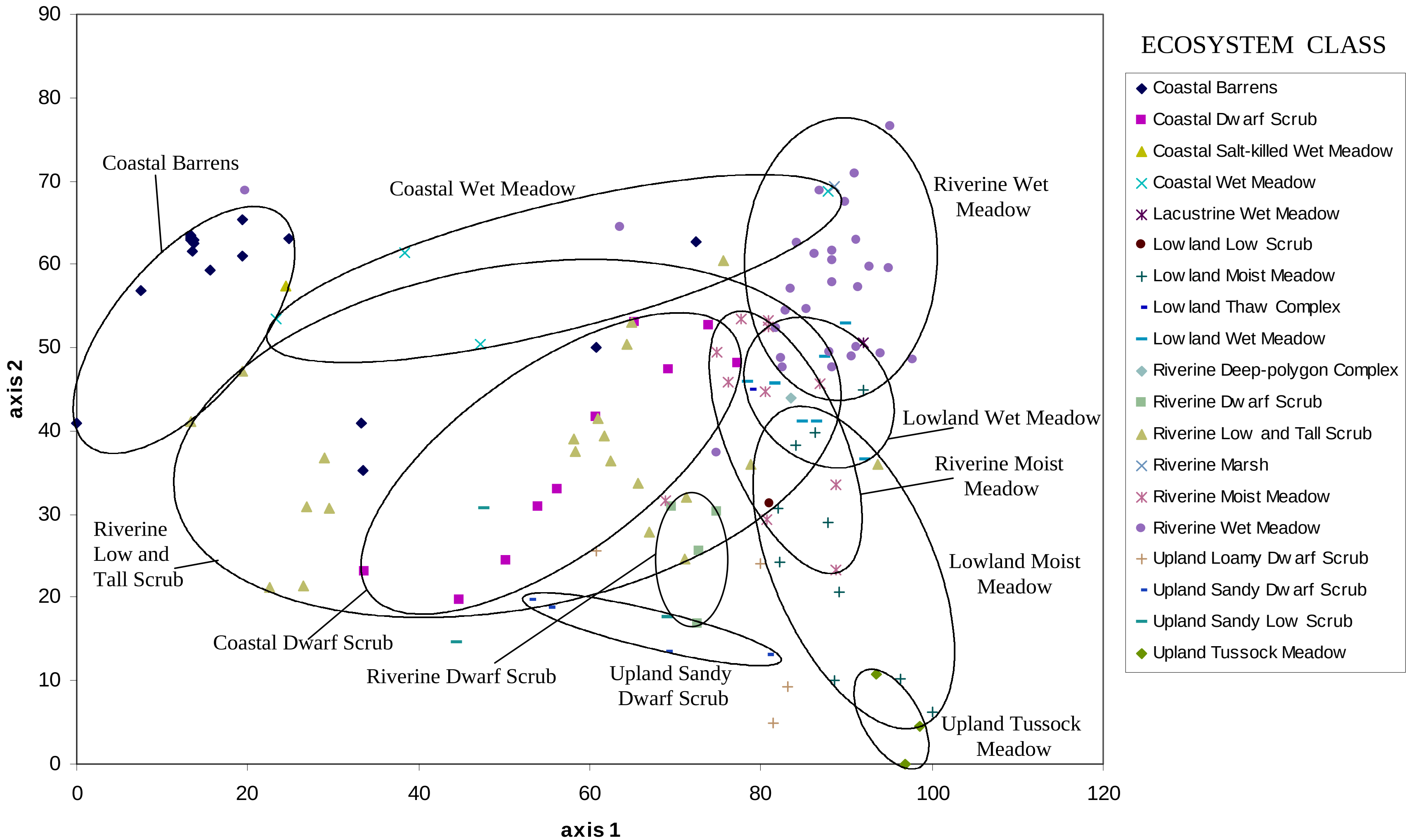


Figure 42. Canonical correspondence ordination of vegetation and environmental variables (drainage, elevation, depth of active layer, and organic horizons) from plots located on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. Ecosystem classes, derived independently, were manually superimposed on the analysis for comparison

using thaw depth (Permaf), drainage, surface organic-horizon thickness, cumulative organic thickness, and elevation ratio, the separation of plots was much greater. Thaw depth and cumulative organic thickness (SumOrg) were strongly associated with the first axis and elevation ratio (ElevRa) and poor drainage (Drain2) were associated with the second axis. Correlations among factors are provided in Appendix Table 13.

When the ecosystem classification associated with the plots was superimposed upon the ordination of the 132 plots, the ordination revealed that the ecosystems were widely distributed along the principal axes and that there was substantial overlap among the plots assigned to the various ecosystem classes (Figure 42). Coastal and shrub-dominated ecosystems were widely distributed across the first axis. Coastal Barrens were associated with the greatest thaw depths and lowest cummulative soil organic thickness, and Coastal Wet Meadows occurred on sites with deeper thaw depths and less cumulative organic material than other wet meadow classes. Non-coastal wet and moist meadows were separated by the second axis, indicating that meadow type was associated with drainage and landscape age (elevation ration being an index of age of landscape development). Riverine Wet Meadows occur on the lowest sites with the poorest drainage, while Upland Tussock Meadows occur on the highest sites with the best drainage.

These results indicate that multiple environmental factors affect the distribution of ecosystems on the delta. Greater thaw depths generally were associated with sandy or gravelly soils founds in early successional ecosystems (e.g., Coastal Barrens, Riverine Low and Tall Scrub, Coastal Dwarf Scrub) and well-drained soils on ridges (e.g., Upland Sandy Dwarf Scrub, Upland Loamy Dwarf Scrub). Greater thaw depths result in lower groundwater levels, improved soil aeration, and a larger rooting environment for acquisition of nutrients by plants. Relative elevation helps differentiate early (low elevation) from late (high elevation) successional ecosystems. Most ecosystems with high elevation ratios (e.g., Lowland Moist Meadow, Upland Tussock Meadows) have shallower thaw depths and a greater proportion of evergreen shrubs (low productivity). Greater accumulations of organic material are often associated with poor drainage in flat and low-lying areas (e.g., Riverine Wet Meadows, Lowland Wet Meadows), these sites typically have a greater percentage of graminoid growth forms (high productivity). Unfortunately, distribution of nutrients, one of the most important environmental factors (Chapin 1987), was not included in our study because of high analytical costs and high spatial and temporal variability.

The ordination also clearly shows why many of these ecosystems are difficult to classify and map consistently. There was substantial overlap among wet and moist meadow classes and among shrub types indicating gradual transitions in species composition and structure among these ecosystems. The lack of distinct cutpoints, or differentiating criteria, among them contributes to the problem of mapping them accurately. The pattern of overlap is similar to the pattern of omission and commission errors evident from the accuracy assessment.

ECOSYSTEM RESPONSE TO 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, salinization, and acidification. These models, which synthesize the interaction between abiotic and biotic processes over time and space, are useful in the extrapolation of ecosystem characteristics across the landscape and for improving our ability to map ecosystems and their associated characteristics and to predict the response of ecosystems to natural and human disturbance. The generalized models for floodplains (particularly deltaic floodplains) and thaw-lake plains presented below 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 delta (Jorgenson et al. 1996, 1997).

Delta Floodplains

On the Colville River Delta, ecosystem distribution and evolution are affected by numerous geomorphic factors including marine, fluvial, eolian, permafrost aggradation, and thaw lake processes (Figures 43 and 44). Our analysis of soil stratigraphy revealed that the deltaic deposits were formed by four processes: (1) fluvial deposition of mineral material, (2) eolian deposition of mineral material, (3) accumulation of organic material derived from partially decomposed plants, and (4) accumulation of ice. The relative importance of these processes in the development of delta

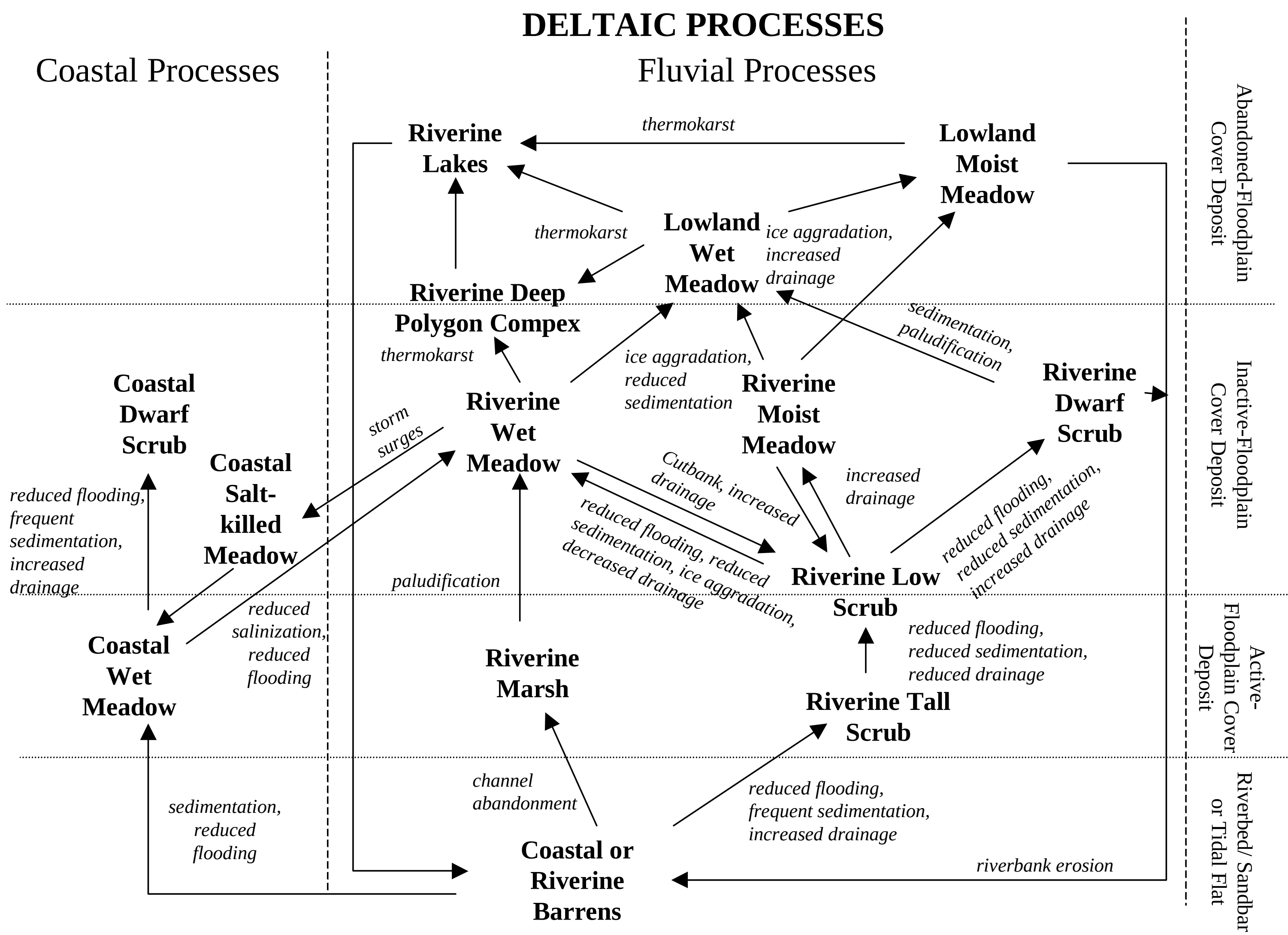


Figure 43. Conceptual model of the evolutionary pathways of ecosystem development on the floodplain of the Colville River Delta

floodplain deposits changes during evolution from Riverbed/Riverbar Deposits to Abandoned-floodplain Cover Deposits. Eolian Sand Deposits are included because they are prominent features on the western side of most distributary channels in the delta, although they are not usually a part of the evolutionary sequence of fluvial deposits.

Of particular importance in arctic floodplains, is the formation of syngenetic permafrost. Over the course of floodplain evolution, new material is added to the top of the active layer through fluvial deposition of sediment on the soil surface 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 result in new mineral and organic material being incorporated 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 cold permafrost during refreezing of the active layer in the fall. Over time, this accumulation of sediments, organic matter, and ice raises the ground surface, which in turn decreases the frequency of flooding and makes the surface more susceptible to thermokarst. Changes in ecosystem characteristics on delta floodplains in response to these geomorphic processes are described below.

Coastal Barrens, which occur on Delta Riverbed/Riverbar Deposits along the margins of active channels and along the fringe of the delta, are flooded frequently (every 1–2 yr). The sediments usually are composed of rippled sands or fines, which are typical of lateral accretion deposits, 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 = 73 cm). In Coastal Barrens, the water table is highly variable but averages 27 cm below the surface during mid-summer, and pH averages 7.7. Below the active layer, ice contents are low (40–50%) because of the sandy texture of the sediments, and ice wedges are absent. Due to the frequent scouring and sediment deposition, the surface is barren at lower elevations or has pioneering herbaceous vegetation along the upper margins. Species adapted to the frequent disturbance include *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum*, and *Equisetum arvense* in areas affected by spring flooding, and *Puccinellia phryganodes* and *Stellaria humifusa* in more saline areas affected by tides and storm surges. Riverine Barrens along the Miluveach and Kachemach rivers are similar but lack the salinity and tidal effects associated with Coastal Barrens and, thus, lack halophytic colonizers.

Riverine Marshes 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* and appear to be very productive due to newly exposed habitat and nutrients contributed by frequent sediment deposition. Water depths are highly variable but average 11 cm above the surface, and pH averages 6.4. Eventually, with infilling with sediments and organics, Riverine Marshes become Riverine Wet Meadows.

Riverine Low and Tall Scrub ecosystems occur as narrow strips immediately adjacent to channels and are associated with Delta Active-floodplain Cover Deposits. Flooding is fairly frequent (every 3–5 yr), but the accumulation rate (26 cm/100 yr) of material (mostly sediment) is lower than that of Riverbed/Riverbar Deposits. The sediments at the surface generally have layered (horizontally stratified silts and very fine sands) or massive fines and the active layer is relatively deep (64 cm) and well-drained. Below the active layer, ice structures become lenticular with occasional vertical veins and ice contents have increased to ~60% compared with more actively flooded areas. Contraction cracks are evident on the ground surface, although polygon rims are not, indicating that ice wedges are in the initial stage of development. Groundwater is usually absent in the well-drained soils near the channels and soil pH averages 7.8. In areas clsest to barren riverbars, tall shrubs dominate and there is vigorous growth of the willow *Salix alaxensis,* with *Bromus pumpellianus*, *Equisetum arvense*, *Hedysarum alpinum*, *Astragalus alpinus* common below the open-to-closed canopy. With increasing distance from channels, the Active-floodplain Cover Deposits cross a transition zone where flood deposition is less frequent and thin (<1 cm) layers of moss occasionally form at the surface. At this stage, the depth to the water table averages 18 cm, the pH averages 7.0, and the soils are mottled, indicative of more reducing conditions. These soil conditions support growth of the low willow *Salix lanata,* and *Equisetum scirpoides, E. variegatum*, *Carex aquatilis, Lupinus arcticus*, and *Tomenthypnum* *nitens* are common in the understory.

During this active-floodplain phase, approximately 0.5–1.0 m of loamy sediment can accumulate on top of the riverbed deposits, which in turn reduces the frequency of flooding. 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 in these deposits between 1955 and 1992 (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 Inactive-floodplain Cover Deposits.

Riverine Wet Meadows, Riverine Moist Meadows, and Riverine Dwarf Scrub occur on Inactive-floodplain Cover Deposits, depending on soil moisture status. Flood frequency (approximately every 5–25 yr) and sedimentation rates are substantially lower than on Active-floodplain Cover Deposits, allowing build-up of organic material and creating distinctive interbedded layers of silt and peat. Layered organics (averaging 20 cm total) generally are contained within the active layer but sometimes extend into the permafrost. Thaw depths (mean = 42 cm) 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. The newly formed layer of permafrost is extremely ice-rich (65–85% volume) and has distinctive cryostructures, including layered, vein, reticulate (net veined), and ataxitic (ice with suspended soil inclusions) ice. Ice wedges become well developed and create 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) have neutral soil pH (mean 6.8) and usually support Wet Sedge–Willow Meadows dominated by *Carex aquatilis*, *Eriophorum angustifolium,* and *Salix lanata*. On slightly better drained areas (mean water depth below the surface = 22 cm), such as on gently sloping point bars, Riverine Moist Meadows with *C. aquatilis*, *E. angustifolium,* and *Dryas integrifolia* are prevalent. On well-drained areas (mean water depth below surface = 47 cm when present), such as old point bar ridges, Riverine Dwarf Scrub, dominated by *D. integrifolia*, commonly is found. Under these more aerobic soil conditions, there is very little organic matter accumulation over the same time period.

The decrease in thaw depth, change to saturated conditions, and reduced sedimentation occurring during this phase all contribute to the accumulation of ice at the top of the permafrost. The accumulation rate of materials (mostly ice, with some organics and sediments) is substantial (7 cm/100 yr). The total thickness of Inactive-floodplain Cover Deposits ranges from 0.5 m on new deposits to 3 m on older deposits. Eventually, the surface becomes raised high enough that flooding is rare, at which point the deposit can be considered an Abandoned-floodplain Cover Deposit. The time required to reach this transition is about 1500–2500 yr.

Riverine Low and Tall Scrub also occurs on Inactive-floodplain Cover Deposits where channel migration has undercut the bank and increased soil drainage. The banks are subject to renewed sedimentation from overbank flooding events due to release of suspended sediments when water velocity drops. The sites are converted from Riverine Wet Meadows to Scrub due to the increased drainage and sedimentation.

Delta Abandoned-floodplain Cover Deposits represent the oldest portions of the delta landscape (with the exception of a few isolated Alluvial Terraces). These areas support Lowland Wet Meadow and Moist Meadow ecosystems. Flooding and sedimentation are sufficiently rare (every 25–150 yr) that the ecosystems are no longer 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 occasionally is present. Due to the accumulation of organic material and shallow thaw depths (mean = 36 cm), the active layer becomes almost entirely organic. Below the active layer, the organic-rich sediments have extremely high ice contents (80–90%) and are dominated by organic-matrix ice. Accumulation rates (2 cm/100 yr) of surface materials (mostly organics, ice, and trace amounts of eolian silt and sand) decrease sharply. The continued development of massive ice wedges creates a network of High-density, High-relief, Low-centered 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 Wet Sedge–Willow and Moist Sedge–Shrub Meadows. In Wet Sedge–Willow Meadows water depths average 7 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 organic matter and ice accumulation, to become high-centered polygons supporting Moist Sedge–Shrub Meadows. In Moist Sedge–Shrub Meadow ecosystems, water depths and pH average 24 cm below the soil surface and 6.9, respectively. The vegetation is dominated by *C. aquatilis, C. bigelowii, D. integrifolia* and *Salix planifolia*. We estimate that this phase occurs 2000–3000 yr after the active-floodplain phase.

By the time the floodplain has evolved to the abandoned-floodplain stage, so much ice has accumulated in the sediments that the deposits become susceptible to thermal degradation and collapse. Riverine Deep-polygon Complexes occur in areas where the centers of low-centered polygons have degraded enough to form permanent waterbodies (0.3–3 m deep). In some areas, the polygonal rims degrade and the small ponds coalesce into larger Riverine Lakes. Most Riverine Lakes, however, form and expand from thawing of the extremely ice-rich floodplain cover deposits without going through the deep-polygon stage.

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 process begins again, starting with salt-affected Coastal Barrens. There are very few locations in the delta, however, where tapped lakes have evolved all the way back to Inactive-floodplain Cover Deposits. It appears that rates of channel migration usually prevents completion of a thaw-lake cycle. Indeed, analysis of rates of landscape change indicates that most of the delta is reworked by erosion and deposition over a period of approximately 2000 years (Jorgenson et al. 1993), so there is little chance to complete two cycles of floodplain evolution.

Complicating this analysis of evolutionary trends are the effects of sea-level rise. Sea level has risen about 4 m in the past 5000 yr, an average rise of 8 cm/100 yr (Hopkins 1982). Recently, sea level has been rising worldwide at an average rate of 20 cm/100 yr (Peltier and Tushingham 1989). This increase in sea level is evident in soil profiles: the surface elevations of new riverbed deposits and of organic horizons in inactive floodplains are considerably higher than the elevations at which these deposits formed in older soil profiles. For example, at Cross Section X11 (S9.08), organic material dating to 2906 ybp was found at an elevation of 1.8 m in an Abandoned-floodplain Cover Deposit (core X11.09), whereas organic material now starts to accumulate at an elevation of approximately 3.5 m. This difference indicates that sea level was approximately 1.7 m lower 2900 years ago. Due to sea level rise and storm surges, there are large areas in the outer delta where the tundra vegetation has been killed. These Coastal Salt-killed Wet Meadows typically have thick organic layers near the surface accumulated over centuries. They now are being colonized by salt-tolerant species such as *Puccinellia andersonii, P. phryganodes, Stellaria humifusa, Cochlearia officinalis,* and *Salix ovalifolia.*

In Coastal Wet Meadows and Coastal Dwarf Scrub ecosystems, the salt-tolerant vegetation is in equilibrium with the coastal processes. Coastal Wet Meadows occur in low lying areas that are subject to frequent flooding and sedimentation during spring breakup and occasional flooding during high tides and storm surges. Coastal Dwarf Scrub occurs in better drained, elevated areas along channels and is a coastal equivalent to Riverine Tall and Low Scrub.

This conceptual model of floodplain evolution is similar to those developed for the Meade River by Peterson and Billings (1978, 1980) and to the upper Colville River by Bliss and Cantlon (1957). Most of the patterns and processes are the same, although we also included coastal processes and saline ecosystems because of the coastal environment on the delta. We also were able to include more information on fluvial processes based on our years of monitoring flood distribution and depositional processes.

Thaw Lake Cycle on the Coastal Plain

The development of thaw lakes on the Arctic Coastal Plain has been described by Black and Barksdale (1949), Hopkins (1949), Carson and Hussey (1962), Webber (1978), and Walker et al. (1980). In the following discussion, we rely heavily on these earlier studies but add to the understanding of ecosystem development by contributing additional information on vegetation changes, environmental characteristics, and the role of ice-aggradation in modifying the structure of the drained lake basins (Figure 45).

The development of thaw lakes begins when changes in surface-water regime, energy balance, or disturbance to the surface cause ice-rich permafrost to degrade, forming small thermokarst pits at the inter-

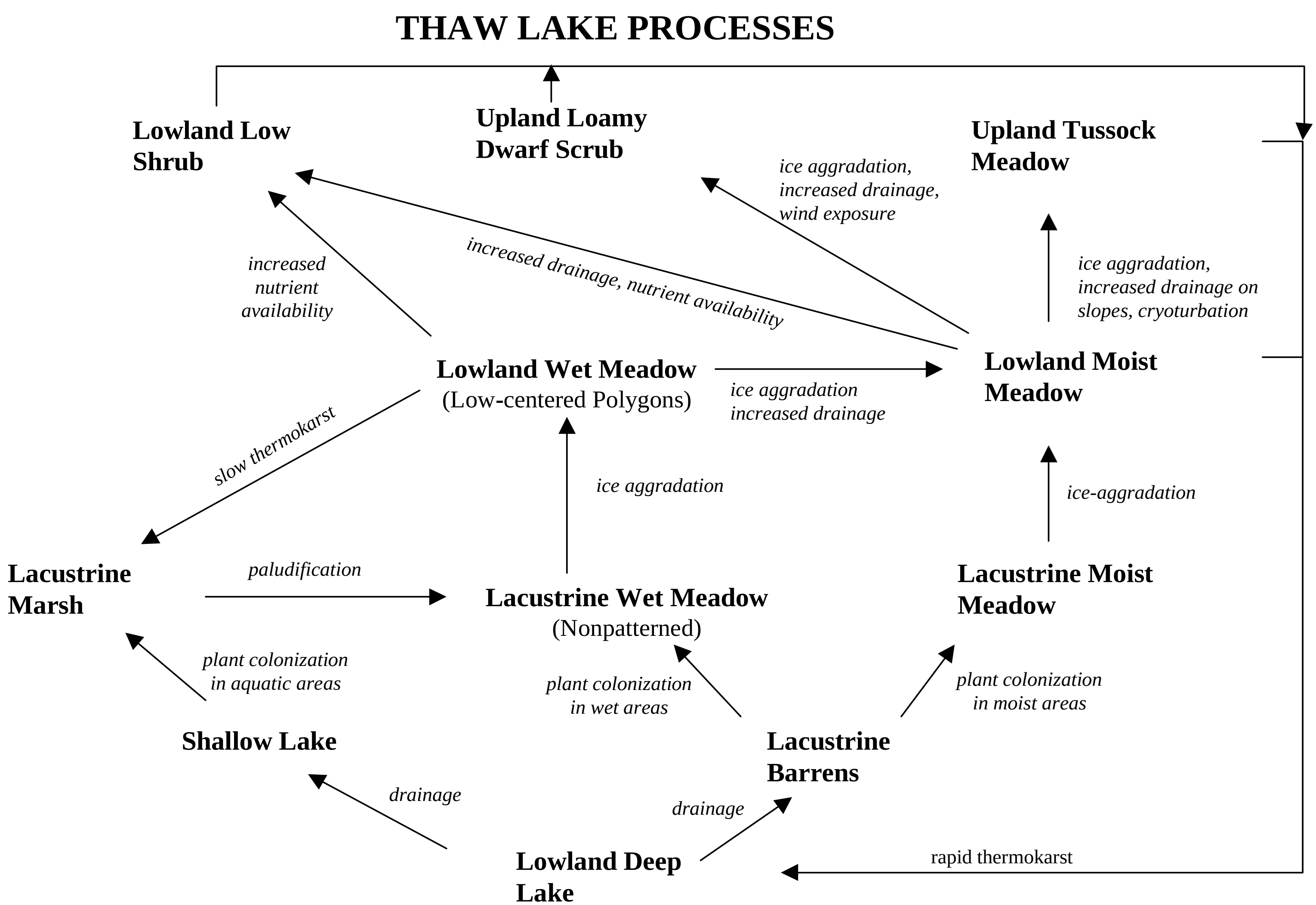


Figure 45. Conceptual model of the evolutionary pathways of ecosystem development of thaw basins on the coastal plain adjacent to the Colville River Delta

section of ice-wedges. Continued melting of ice wedges and segregated ice leads to their coalescing into small deep ponds. This usually occurs where the permafrost is extremely ice rich, allowing thaw settlement to create ponds deep enough to maintain some unfrozen water during the winter. The ponds rapidly develop into Lowland Deep Lakes that have steep cut banks and rapidly eroding margins due to both thermal and physical erosion. Thawed and frozen blocks of tundra collapse into the growing lake and their organic and mineral components are redistributed by wave and current action. This material frequently forms broad underwater shelves in the large deep lakes. Expansion of the lake is most rapid at the ends normal to the prevailing wind direction due to increased water velocities and heat flux associated with shoreline currents. Consequently, the lakes typically have their long axes perpendicular to the prevailing wind. Thaw lakes within the Kuparuk–Sagavanirktok Coastal Plain ecodistrict can be up to 2–3 m deep, whereas on the Colville River Delta depths of 4–5 m are common.

Expansion of the deep lakes into low-lying areas or drainages, or migration of drainages toward deep lakes, can cause breaching of the shoreline and total or partial draining of the lake. Depending on the extent of the breaching and configuration of the bottom, a wide range of water levels and shoreline conditions can result. Some lakes tapped by lower streams are totally drained, in which case most of the basin contains moderately well-drained bare soils on the gently sloping lake bottom. Where the lake only partially drains, typically there is a large, shallow central pond and broad expanses of poorly drained sediment forming Lacustrine Barrens.

The Lowland Shallow Ponds that initially form within the thaw basins usually are fairly large, oval, and in the central part of the basin. As ice begins to aggrade in the sediments within and adjacent to the ponds, and organics accumulate along the margins, the ponds become smaller and more dissected. At this stage (Ice-poor Thaw Basins that lack low-centered polygons), the ponds typically have highly irregular shorelines and are highly interconnected. As more ice accumulates, (Ice-rich Thaw Basins with low-centered polygons), the ponds typically are smaller, rectangular, and isolated. This last stage of pond development can appear similar to the small ponds and thermokarst pits that are the initial stages in the development of thaw lakes. These old ponds differ in being very shallow (<1 m) and relatively thaw stable because they freeze to the bottom. They have low, smooth, rounded shorelines, usually have reddish diatomaceous algal mats on the bottom or along the shoreline, and appear to be relatively unproductive.

Immediately after being tapped, the Lacustrine Barrens are rapidly colonized by *Carex aquatilis, Eriophorum angustifolium, Arctophila fulva, Puccinellia andersonii,* and *Deschampsia caespitosa*, depending on drainage conditions. Through colonization and growth, the barren areas are converted to Lacustrine Wet Meadows in poorly drained areas and Lacustrine Moist Meadows in moderately drained areas. In the poorly drained areas, the surface is generally flooded during the early summer and remains saturated throughout the summer. *Carex aquatilis* and *Eriophorum angustifolium* can develop vigorous stands, presumably due to the exploitation of newly available habitat with abundant nutrients. Due to the high productivity and anaerobic soil conditions, peat accumulation is rapid, resulting in some of the thickest organic accumulations for any of the ecosystems that we surveyed (mean = 18 cm). Lacustrine Moist Meadows occur in better-drained conditions and are dominated by *Carex aquatilis* and *E. angustifolium,* with lesser amounts of *Salix reticulata, Dryas integrifolia,* and *Carex bigelowii.*

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, and greater microsite diversity. 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 the older, ice-rich thaw basins become indistinguishable from the adjacent lowlands.

During this transition, Lacustrine Wet Meadows, dominated by *Carex aquatilis* and *Eriophorum angustifolium*, develop into Lowland Wet Meadows. They are dominated by the same species but evergreen and deciduous shrubs also become important as polygon rims develop. Similarly, shrubs gain importance as Lacustrine Moist Meadows develop into Lowland Moist Meadows. Lowland Low Scrub is not common on the coastal plain but does occur in some drainages, or "water tracks", and along well-drained lake shores.

The highest and oldest surfaces on the thaw lake plains consist of broad gentle rolling hills that are barely distinguishable on 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. Although ice-wedges form a dense network below the surface they frequently are not evident due to soil movement on the slopes. Upland Tussock Tundra generally occurs on the better-drained portions of the slopes and on broad ridges, where groundwater is absent or at substantial depth (mean = 34 cm) during mid-summer. Thaw depths are very shallow and the soils are highly turbated by freezing and thawing. The vegetation is dominated by *Eriophorum vaginatum* and numerous shrubs, including *Dryas integrifolia, Salix planifolia, Cassiope tetragona,* and *S. reticulata*. On steep or more exposed ridges and bluffs, Upland Loamy Dwarf Scrub commonly occurs. Because of the good drainage conditions, groundwater is usually absent and organic accumulation is negligible. This is a relatively unproductive ecosystem as indicated by the low cover of graminoids (mostly *Carex bigelowii*) and deciduous shrubs, and a relatively high cover of slow-growing evergreen shrubs (mainly *Dryas integrifolia)* and various lichens.

ECOLOGICAL LAND EVALUATION

The integrated terrain unit mapping provides a spatial database that can be used for a wide range of ecological and engineering applications. In this section we illustrate two uses of the ITU map that were developed as part of wildlife (Johnson et al. 1997), and geomorphology and hydrology (Jorgenson et al. 1997) studies.

WILDLIFE HABITAT

For analysis of wildlife habitat use, particularly waterbirds, the integrated terrain units were aggregated into a reduced set of habitat classes that emphasized slightly different ecological characteristics than did the more general ecosystem classification. The habitat and the ecosystem classifications are similar in that they recognize similar ecological factors, but differ in the way that ecological factors are hierarchically linked. For example, the habitat classification differentiated several waterbody characteristics (e.g., presence of islands, shoreline configuration) and grouped barrens, shrub types, wet meadow classes in different ways than did the ecosystem classification. Our habitat classification system originally was developed in 1988 (Jorgenson et al. 1989) and has undergone only minor modifications. In contrast, the ecosystem classification is a newly evolving approach that reflects recent developments in the field of landscape ecology that places greater emphasis on geomorphic and hydrologic linkages. Eventually, we would like to merge the habitat classification into the ecosystem classification to avoid duplicative applications and analyses. We include the habitat classification in this report because it is the basis of habitat analyses that have been conducted on the Colville River Delta (Johnson et al. 1996, 1997) and is consistent with earlier efforts to analyze habitat use in the North Slope Oilfields (Johnson et al. 1990, Anderson et al. 1991, Murphy and Anderson 1993).

For analysis of habitat selection, the complete set of integrated terrain units were reduced to 24 wildlife habitat classes for the delta and adjacent coastal plain (Figures 46a, 46b and Tables 20, 21). This aggregation resulted in 12 waterbody, 10 terrestrial, and 2 wetland-complex types. A comparison between habitat and ecosystem classes is provided in Table 22.

The relative availability of habitats differed greatly between the delta and the adjacent coastal plain, reflecting differences in salinity and riverine processes between the two areas. In the delta, the most abundant habitats were Wet Sedge–Willow with Low-relief Polygons (18.5% of the area), River or Stream (14.8%), Barrens (14.3%), and Tide Flats (10.1%). Other habitats that were less abundant but were unique to the delta included Brackish Waters (1.2%), Tapped Lakes with Low-water Connections (3.9%), Salt Marshes (3.0%), Salt-killed Tundra (4.6%), and Aquatic Sedge with Deep Polygons (2.5%). The most abundant habitats in the adjacent coastal plain were Moist Tussock Tundra (27.6%), Moist Sedge–Shrub Tundra (24.7%), and Deep Open Waters without Islands (9.0%).

Because of the need to reduce the number of habitats to facilitate analysis and presentation, some habitat classes combined some rather dissimilar ecosystem classes. For example, the Riverine and Upland Shrub class combined tall willows on the floodplains with *Dryas* tundra on upland ridges, because the *Dryas* tundra covered a very small total area. Similarly, several integrated terrain units with differing surface-forms (e.g., High-density and Low-density, Low-centered Polygons) were combined into one (e.g.,

Tapped Lake w/ Low-water Connection
Tapped Lake w/ High-water Connection
Salt Marsh
Deep Open Water w/o Islands
Deep Open Water w/ Islands or Polygonized Margins
Shallow Open Water w/o Islands
Shallow Open Water w/ Islands or Polygonized Margins
River or Stream
Aquatic Sedge w/ Deep Polygons
Aquatic Grass Marsh
Young Basin Wetland Complex
Old Basin Wetland Complex
Nonpatterned Wet Meadow
Wet Sedge-Willow Meadow
Moist Sedge-Shrub Meadow
Moist Tussock Tundra
Riverine or Upland Shrub
Barrens (riverine, eolian, lacustrine)
Artificial (water, fill, peat road)

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ARCO Alaska, Inc.

Colville Ecological Land Survey

Figure 46b. Map of wildlife habitat types in the vicinity of the proposed Facility Area, Colville River Delta, 1996.

ABR, Inc.
Environmental Research and Services

17 Sept 1997 | File: ELS_Infield_Views.apr, Habitats

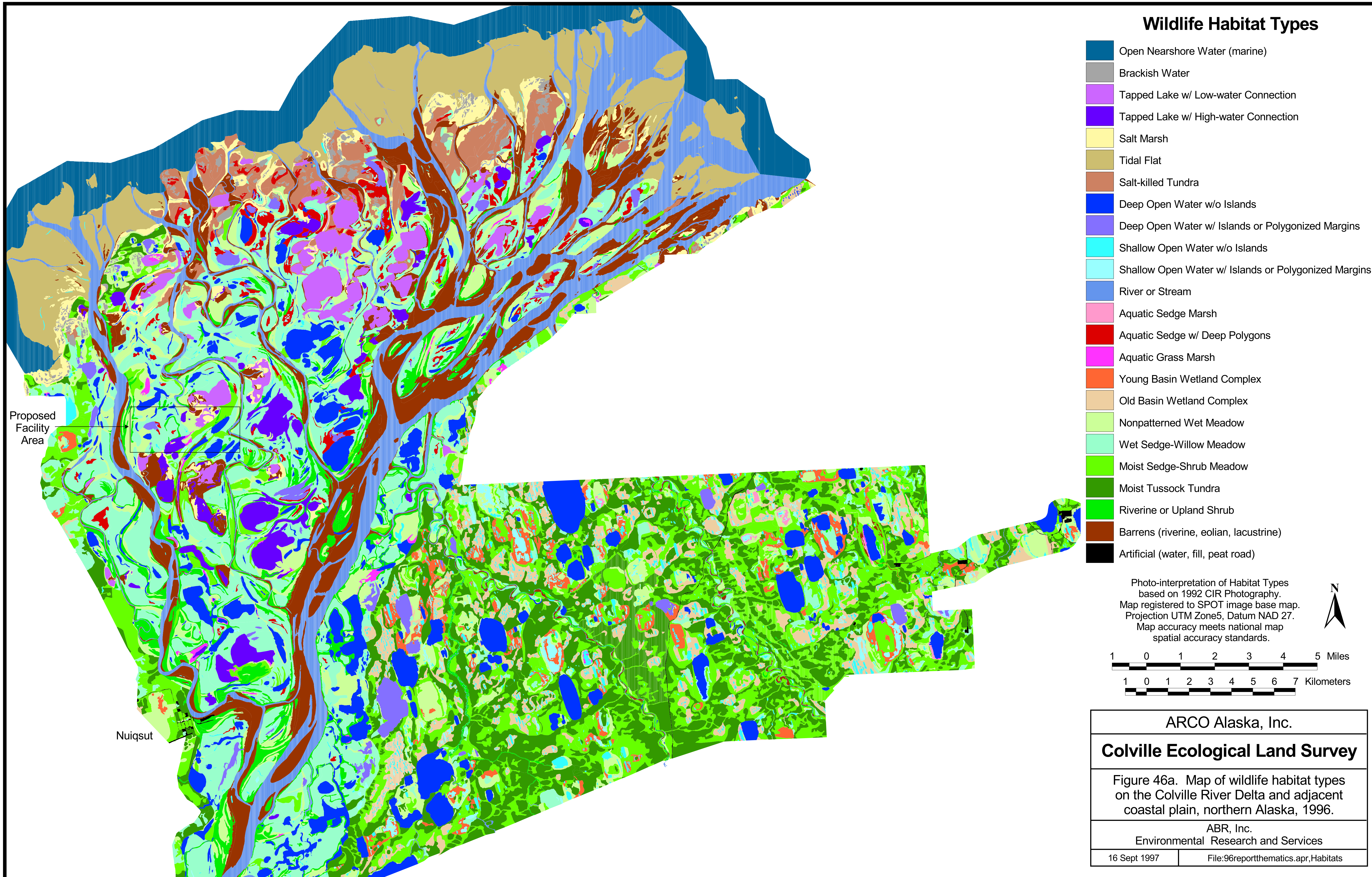


Figure 46a. Map of wildlife habitat types on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Table 20. Classification and descriptions of wildlife habitat types found in the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Habitat Class	Description
Open Nearshore Water (Estuarine Subtidal)	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 (< 0.2 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. An important habitat for some species of waterfowl for molting during spring and fall staging.
Brackish Water	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. The substrate may contain peat, reflecting its freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake (or Pond) 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 habitat do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes form important overwintering habitat for fish.
Tapped Lake (or Pond) 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 and Grass Wet Meadows, Halophytic Dwarf Willow Scrub, and small barren patches. Dominant plant species usually include C*arex 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 Wet Sedge–Willow Meadows and Basin Wetland Complexes, or, less commonly, along drier coastal bluffs that originally supported Moist Sedge–Shrub Meadows 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 (Lakes and Ponds) without Islands	Deep (≥ 1.5 m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes and 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. Lakes usually are not connected to rivers. Sediments are fine-grained silt and clay. Deep Open Waters without Islands are differentiated from those with islands because of the lack of nest sites for waterbirds that prefer islands.

Table 20. (cont.)

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.
Shallow Open Water (Lakes and Ponds) without Islands	Ponds and small lakes < 1.5 m 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. Although these ponds generally are surrounded by wet and moist tundra, ponds located in barren areas also are included in this category. Sediments are fine-grained silt and clay.
Shallow Open Water with Islands	Shallow lakes and ponds with islands or complex low-center polygon shorelines. 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 of the Colville River and its tributaries and smaller stream channels in the Transportation Corridor. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of the Colville River Delta are slightly saline, whereas streams in the Transportation Corridor are non-saline. During winter unfrozen water in deeper channels can become hypersaline.
Aquatic Sedge Marsh	Permanently flooded waterbodies and dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤ 0.3 m 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 (0.2–0.5 m deep) overlying fine-grained silt.
Aquatic Sedge with Deep Polygons	A mainly coastal habitat in which thermokarst of ice-rich soil has produced deep (> 1 m), 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 *Dryas integrifolia, Salix reticulata, S. phlebophylla,* and *S. ovalifolia*..
Aquatic Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva.* Due to shallow water depths (< 1 m), 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 the thaw lake cycle and is more productive than Aquatic Sedge Marshes. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (Ice-poor)	Basin Wetland Complexes (both young and old) occur in drained-lake basins and are characterized by a complex mosaic of open water, Aquatic Sedge and Grass Marshes, and Wet and Moist Meadows in patches too small (<0.5 ha) to map individually. During spring breakup, deeper basins may be entirely inundated and following breakup, water levels gradually recede. Basins often have distinct upland rims marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw lake stages. Soils generally are fine-grained, organic-rich, and ice-poor. The lack of ground ice results in poorly developed polygon rims in wetter areas and indistinct edges of waterbodies. Ecological communities within younger basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating between 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. The waterbodies in old complexes tend to have smoother, more rectangular shorelines and are not as interconnected as in young complexes. The vegetation types generally include Wet Sedge–Willow Meadow with Low-relief Polygons, Moist Sedge–Shrub Meadows, and Moist Tussock Tundra, whereas Aquatic Sedge and Grass Marshes are absent. Soils generally have a moderately thick (0.2-0.5 m) organic layer overlying fine-grained silt or sandy silt.

Table 20. (cont.)

Nonpatterned Wet Meadow	Sedge-dominated meadows that typically occur within young 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 strangmoor cover < 5% of the ground surface. The surface generally is flooded during early summer (depth < 0.3 m) and drains later, but remains saturated within 15 cm of 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 present. Low and dwarf willows (*Salix lanata, S. arctica,* and *S. planifolia*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying fine-grained silt.
Wet Sedge–Willow Meadow (with Low-relief Polygons; High- or Low-density)	Occurs in lowland areas within drained lake basins, level floodplains, and swale on gentle slopes and terraces and are associated Low-centered Polygons and Strang (undulating raised sod ridges). Water depth varies through the season (< 0.3 m maximum). 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. chordorriza,* and *E. russeolum*. Willows, including *Salix lanata, S. arctica,* and *S. planifolia,* usually are abundant.
Moist Sedge–Shrub Meadow (Low- or High-relief Polygons)	Occurs on better-drained uplands between thaw basins, riverbanks, old stabilized dunes, lower slopes of pingos, and foothill slopes and generally associated with Nonpatterned Ground, Frost Scars, and High-centered Polygons with low relief. Vegetation is dominated by *Carex aquatilis, C. bigelowii, Eriophorum angustifolium, Salix planifolia* and *Dryas integrifolia*,. The ground is covered with a nearly continuous carpet of mosses. Soils generally have a thin layer (20–30 cm) of organic matter over silt loam.
Moist Tussock Tundra	Similar to above, except that the vegetation is dominated by the tussock-forming sedge *Eriophorum vaginatum.* It tends to occur on the upper portions of slopes and slightly better drained conditions that Moist Sedge–Shrub Tundra.
Riverine or Upland Shrub	Both open and closed stands of low (≤ 1.5 m high) and tall (> 1.5 m high) willows along riverbanks and *Dryas* tundra on upland ridges and stabilized sand dunes. Tall willows occur mainly along larger streams and rivers, where the vegetation is dominated by *Salix alaxensis*. Low willow stands are widespread and typically have a canopy of *S. lanata* and *S. glauca*. Understory plants include the shrubs *Arctostaphylos rubra, S. reticulata,* and *Dryas integrifolia* and the forbs *Astragalus* spp., *Lupinus arcticus*, and *Equisetum* spp. *Dryas* tundra is dominated by *D. integrifolia* but may include abundant dwarf willows such as *S. phlebophylla*. Common forbs include *Silene acaulis, Pedicularis lanata,* and *Astragalus umbellatus,* and *Carex bigelowii* frequently is present. In Riverine Shrub, an organic horizon generally is absent or buried due to frequent sediment deposition. In Upland Shrub, the soils generally have a thin (<5 cm) organic horizon.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (< 30% plant cover) areas related to riverine, eolian, or thaw lake processes. Riverine Barrens on river flats and bars are flooded seasonally and can have either silty or gravelly sediments. The margins frequently are colonized by *Deschampsia caespitosa, Elymus arenarius, Chrysanthemum bipinnatum*, and *Equisetum arvense*. Eolian Barrens generally are located adjacent to river deltas and include active sand dunes that are too unstable to support more than a few pioneering plants (< 5% cover). Typical pioneer plants include *Salix alaxensis, Elymus arenarius,* and *Deschamspia caespitosa.* Lacustrine Barrens occur along margins of drained lakes and ponds. These areas may be flooded seasonally or can be well drained. On the delta, sediments usually are clay-rich, slightly saline, and are being colonized by Salt Marsh plant species. Barrens may receive intense use seasonally by caribou as mosquito-relief habitat.
Artificial (Water, Fill, Peat Road)	A variety of small disturbed areas, including impoundments, gravel fill, and a sewage lagoon at Nuiqsut. Gravel fill is present at Nuiqsut, and at the Helmericks residence near the mouth of the Colville River. A peat road runs roughly north-south within the Transportation Corridor.

Table 21. Areal extent of habitat classes on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Habitat	Delta		Coastal Plain		Total	
	Area (ha)	Percentage of Area	Area (ha)	Percentage of Area	Area (ha)	Percentage of Area
Aquatic Grass Marsh	205	0.3	23	0.1	228	0.2
Aquatic Sedge Marsh	0	0.0	97	0.2	97	0.1
Aquatic Sedge w/ Deep Polygons	1,381	1.8	0	0.0	1,381	1.2
Artificial (water, fill, peat road)	2	0.0	147	0.3	149	0.1
Barrens (riverine, eolian, lacustrine)	9,070	12.1	168	0.4	9,238	7.9
Brackish Water	764	1.0	0	< 0.1	764	0.7
Deep Open Water w/ Islands	710	0.9	1,417	3.4	2,126	1.8
Deep Open Water w/o Islands	3,904	5.2	2,470	5.9	6,374	5.4
Moist Sedge-Shrub Meadow	1,117	1.5	11,686	27.8	12,804	10.9
Moist Tussock Tundra	27	0.0	12,513	29.7	12,540	10.7
Nonpatterned Wet Meadow	5,331	7.1	3,049	7.2	8,380	7.2
Old Basin Wetland Complex	62	0.1	4,244	10.1	4,306	3.7
Open Nearshore Water (marine)	7,179	9.6	0	0.0	7,179	6.1
River or Stream	9,979	13.3	190	0.5	10,168	8.7
Riverine or Upland Shrub	4,120	5.5	390	0.9	4,510	3.9
Salt Marsh	2,050	2.7	1	< 0.1	2,051	1.8
Salt-killed Tundra	2,597	3.5	0	0.0	2,597	2.2
Shallow Open Water w/ Islands or Polygonized Margins	78	0.1	828	2.0	906	0.8
Shallow Open Water w/o Islands	325	0.4	1,345	3.2	1,669	1.4
Tapped Lake w/ High-water Connection	2,034	2.7	37	0.1	2,071	1.8
Tapped Lake w/ Low-water Connection	2,166	2.9	1	< 0.1	2,167	1.9
Tidal Flat	7,814	10.4	0	0.0	7,814	6.7
Wet Sedge-Willow Meadow w/ Low-relief Polygons	14,158	18.9	1,705	4.1	15,863	13.5
Young Basin Wetland Complex	0	0.0	1,758	4.2	1,758	1.5
Total Area	75,074		42,068		117,142	

Table 22. Comparison of ecosystem and derived habitat classes on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Ecosystem (ecosite level)		**Habitat**		**Integrated Terrain Unit**
Code	Name	Code	Name	Codes
2001	Nearshore Water	205	Open Nearshore Water	963
2010	Tidal River	330	River or Stream	905
2021	Coastal Lake -Isolated	210	Brackish Water	989, 989/96, 989/97
2022	Coastal Lake - Connected	232	Tapped Lake with Low-water Connection	983, 986
2043	Coastal Dwarf Scrub	250	Salt Marsh (Coastal Wetland Complex)	415/0/295, 818/0/295
2053	Coastal Wet Meadow	250	Salt Marsh (Coastal Wetland Complex)	412/0/346, 413/0/345, 413/0/346, 413/2/346, 818/0/345, 818/0/346, 818/2/346, 862/0/346
2053.1	Coastal Salt-killed Wet Meadow	285	Salt-killed Tundra	413/0/348, 413/2/348, 416/0/348, 416/2/348, 416/5/348, 417/6/348, 818/2/348, 818/5/348
2090	Coastal Barrens	280	Tide Flat	862/0/0
		800	Barrens	412/0/0, 412/0/10, 818/0/0, 818/0/10, 862/0/10
3015	Lower Perennial River	330	River or Stream	910, 918
3023	Riverine Shallow Lake	235	Tapped Lake with High-water Connection	987
		322	Shallow Open Water without Islands	943
3026	Riverine Deep Lake	235	Tapped Lake with High-water Connection	984
		312	Deep Open Water without Islands	925
		313	Deep Open Water with Islands or Polygonized Margins	984/96
3042	Riverine Low and Tall Scrub	600	Riverine or Upland Shrub	413/0/242, 415/0/242, 416/0/242, 416/2/242, 416/2/260, 416/5/242, 416/5/260, 443/0/242, 444/0/242, 444/11/242, 444/2/242, 444/5/242, 818/0/231, 818/0/242, 818/0/260, 818/2/242, 818/2/260, 818/5/242, 819/35/260, 819/5/242, 819/5/260
3043	Riverine Dwarf Scrub	600	Riverine or Upland Shrub	444/0/270
3052	Riverine Moist Meadow	542	Moist Sedge–Shrub Meadow	413/2/320, 416/0/320, 416/2/320, 416/5/320, 444/0/320, 444/11/320, 444/12/320, 444/2/320, 444/5/320, 818/0/320, 818/2/320
3053	Riverine Wet Meadow	511	Nonpatterned Wet Meadow	413/0/334, 413/2/334, 416/0/334, 416/2/334, 443/0/334, 444/0/334, 444/2/334, 818/0/334, 818/2/334
		521	Wet Sedge–Willow Meadow with Low-relief Polygons	413/5/334, 416/5/334, 444/5/334, 818/5/334, 819/2/334, 819/5/334
3054	Riverine Marsh	364	Aquatic Sedge	416/5/336
		371	Aquatic Grass Marsh	987/0/337
3073	Riverine Deep-polygon Complex	364	Aquatic Sedge with Deep Polygons	416/7/336, 819/7/336
3090	Riverine Barrens	800	Barrens	413/0/10, 441/0/0, 441/0/10
4052	Lacustrine Moist Meadow	542	Moist Sedge–Shrub Meadow	816/0/320, 816/2/320, 816/31/320
4053	Lacustrine Wet Meadow	511	Nonpatterned Wet Meadow	816/0/334, 816/2/334

Table 22. (cont.)

4054	Lacustrine Marsh	361	Aquatic Sedge Marsh	941/0/336, 941/96/336, 950/96/336
		371	Aquatic Grass Marsh	941/0/337, 941/96/337, 943/0/337, 950/0/337
4071	Lacustrine Thaw Complex	401	Young Basin Wetland Complex (Ice Poor)	816/101/411
4090	Lacustrine Barrens	800	Barrens	816/0/10
5023	Lowland Shallow Lake	322	Shallow Open Water without Islands	941, 948, 950
		323	Shallow Open Water with Islands or Polygonized Margins	941/96, 941/97, 950/96, 950/97
5026	Lowland Deep Lake	312	Deep Open Water without Islands	922, 930, 930/96
		313	Deep Open Water with Islands or Polygonized Margins	922/96, 922/97
5042	Lowland Low Scrub	600	Riverine or Upland Shrub	417/6/242, 417/6/260, 545/11/242, 545/11/260, 545/12/242, 817/5/260
5052	Lowland Moist Meadow	542	Moist Sedge–Shrub Meadow	417/6/320, 545/0/320, 545/11/320, 545/12/320, 595/0/320, 595/11/320, 817/11/320, 817/12/320, 817/5/320, 860/0/320, 860/11/320, 860/12/320, 860/2/320
5053	Lowland Wet Meadow	511	Nonpatterned Wet Meadow	545/0/334, 545/2/334, 860/0/334, 860/2/334
		521	Wet Sedge–Willow Meadow with Low-relief Polygons	380/62/334, 417/6/334, 545/5/334, 595/5/334, 817/5/334, 860/5/334
5071	Lowland Thaw Complex	405	Old Basin Wetland Complex (Ice Rich)	817/101/412
5073	Lowland Deep-polygon Complex	364	Aquatic Sedge with Deep Polygons	417/7/336, 417/8/336
7058	Upland Tussock Meadow	546	Moist Tussock Tundra	545/0/314, 545/11/314, 545/12/314, 595/11/314, 817/11/314, 817/12/314, 817/35/314, 860/11/314, 860/12/314
7443	Upland Loamy Dwarf Scrub	542	Moist Sedge–Shrub Meadow	545/98/320, 860/98/320
		600	Riverine or Upland Shrub	545/11/270, 817/35/270, 818/35/270, 860/11/270
7642	Upland Sandy Low Scrub	600	Riverine or Upland Shrub	380/62/242, 380/62/260
7643	Upland Sandy Dwarf Scrub	600	Riverine or Upland Shrub	380/62/270
7652	Upland Sandy Moist Meadow	542	Moist Sedge–Shrub Meadow	380/11/320, 380/62/320
7690	Upland Sandy Barrens	800	Barrens	380/62/10
12000	Human Modified	900	Artificial (Water, Gravel Fill, Peat Road)	860/0/10, 872/0/0, 874/17/320, 995, 996, 997

Wet Sedge–Willow with Low-Relief Polygons).

The habitat map, in conjunction with wildlife survey data, were used to quantify habitat selection for various bird and mammal species (Johnson et al. 1996, 1997). Analyses revealed there were large differences in habitat use among species and preferences frequently changed over the season. Thus, the analysis of habitat use, becomes exceedingly complex when differences in wildlife species, seasonal use (i.e., prenesting, 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 that are most used by the most species (Parametrix 1996).

FLOOD FREQUENCY

A simple spatial model of the distribution of five flood-frequency classes was developed based on the differences in relative heights of the terrain units, the amount of flooding among terrain units that were observed from 1992 to 1995, and differences in soil stratigraphy (Figures 47a and 47b, from Jorgenson et al. 1996). The rationale for assigning terrain units to the various flood-frequency classes, the range in relative heights of terrain units grouped into the classes, and how these relative heights correspond to flood stages at the head of the delta are described below.

Flood-frequency Class 1 includes Delta Riverbed/Riverbars, Tidal Flats, Shallow Riverine Ponds, and Tidal River terrain units (Appendix Table 14). On Delta Riverbed/Riverbar Deposits, flooding is sufficiently frequent that vegetation cannot develop (except pioneer vegetation along margins) and organic matter cannot accumulate. This class was assigned a flood frequency of every 1–2 yr, because most of the terrain units in this class were flooded every year from 1992 to 1995. The mean relative height, plus 1 standard deviation (1 SD was added so that values represent the height below which 84% of the deposits were found instead of 50%), for the highest terrain unit (Riverine Ponds) in this class was 0.56. At the head of the delta (Cross Section 6 [E27.09]), a relative height of 0.56 corresponds to a flood stage of 3.7 m (12 ft, relative to British Petroleum Mean Sea Level datum).

Flood-frequency Class 2 includes Delta Active-floodplain Cover Deposits, Ice-poor Thaw Basins, High-water Channels, and Tapped Lakes with Low-water Connections. On Delta Active-floodplain Cover Deposits, the extensive development of riverine shrub communities that depend on the input of nutrients from sediment deposition, the lack of organic matter accumulation, and the abundance of driftwood all indicate that flooding is still frequent. This class was assigned a flood frequency of every 3–4 yr because none of its terrain units were entirely flooded during our monitoring, although all were partially flooded (27 to 59%) during the highest floodwater in 1993. The mean relative height, plus one standard deviation, for the highest terrain unit (Tapped Lakes with Low-water Connections) in this class was 0.84. At the head of the delta, a relative height of 0.84 corresponds to a flood stage of 5.4 m (17.7 ft).

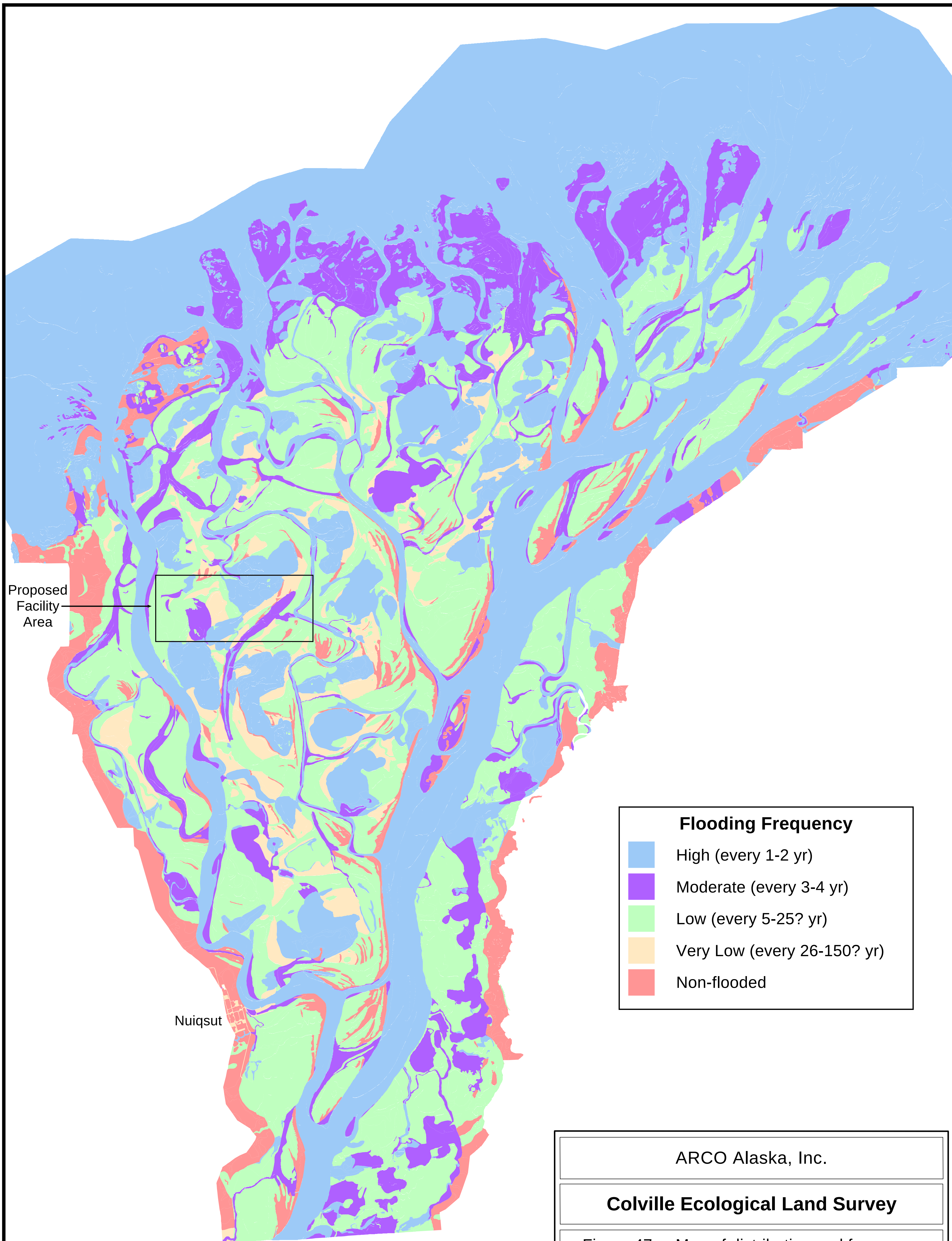
Flood-frequency Class 3 includes Inactive-floodplain Cover Deposits and the Deep and Shallow Thaw Ponds that usually are associated with ice-rich deposits. On Inactive-floodplain Cover Deposits, development of a well-established vegetation community and accumulation of peat indicate that flood frequency has decreased substantially. However, surface soils still show distinct interbedding of peat and mineral horizons indicating periodic flooding. This class was assigned a flood frequency of every 5–25 yr because most of these terrain units were not flooded during 1992–1995, but were flooded in 1989 (the largest flood that Jim Helmericks has observed in his ~39 yr on the delta). Obviously, there is substantial uncertainty about the upper range of the flood-frequency estimate, because we have no observations at high-flood stages. Mean relative heights, plus one standard deviation, for the highest terrain unit (Inactive-floodplain Cover Deposits) in this class was 1.07. At the head of the delta, a relative height of 1.07 corresponds to a flood stage of 6.8 m (22.4 ft).

Flood-frequency Class 4 includes Abandoned-floodplain Cover Deposits in the central delta. The absence of fluvial sediment near the surface, and the lack of driftwood on most deposits in the central delta indicate that flooding is rare. This class was assigned a flood frequency of every 26–150 yr because most of these units were not flooded during 1992–1995, although the presence of driftlines and sediment deposition indicates that at least some of these deposits were flooded in 1989. As with Class 3, there is great uncertainty about the flood frequency of this class. Mean relative height, plus one standard deviation, of this terrain unit was 1.23. At the head of the delta, a relative height of 1.23 corresponds to a flood stage of 7.8 m

(25.7 ft).

Flood-frequency Class 5 includes Eolian Sand and Alluvial Terraces. We do not consider these units to be affected by flooding under the current flooding regime. The small amount of flooding observed on these terrain units during 1992–1995 occurred almost entirely along the margins of the units. There are some small, low patches of Eolian Sand, however, that occur in the middle of barren Riverbed/Riverbar Deposits, and these are subject to flooding. Mean relative heights, plus one standard deviation, for the highest terrain unit (Eolian Sand Deposit) in this class was 1.88.

Comparison of the predicted flood distribution, developed from data collected in 1992–1995, with actual flood distributions from flooding maps from 1992–1996 (Jorgenson et al. 1997) and those developed by Walker (1976 and unpubl. data), reveal a fairly high correspondence at the higher flood-frequency classes (Classes 1 and 2). There is substantial uncertainty regarding the reliability of Classes 3 and 4, because of the lack of long-term discharge data for estimating the flood frequency and the small topographic differences between Inactive- and Abandoned-floodplain Cover Deposits. Recent development of a two-dimensional hydrologic model resolves much of this uncertainty (Shannon and Wilson, in prep.), although the model is still subject to uncertainties associated with estimating the discharge-frequency relationship at the head of the delta, and with subtle topographic relief on the floodplain. Some of this uncertainty has been resolved by a paleoflood analysis that compared slackwater deposits from the 1989 flood event with other deposits over an observation period established through radiocarbon dating (Jorgenson et al. 1997). The 1989 event was estimated to have a return period of 128 (SD ± 32) years. Based on analysis of driftlines and sediment deposition, this flood covered Abandoned-floodplain Cover Deposits at the head of the delta but covered only a small portion of the deposits toward the outer delta. In summary, the delineation of areas with different flooding frequencies through this simplified modeling approach provided useful, initial information for locating facilities in areas that are least prone to flooding and for minimizing the obstruction of flood water.



Flood-frequency model based on relative heights
of Terrain Units and analysis of flood distribution, 1992-1995.
Map registered to SPOT image base map.
Projection: UTM Zone 5, Datum NAD 27

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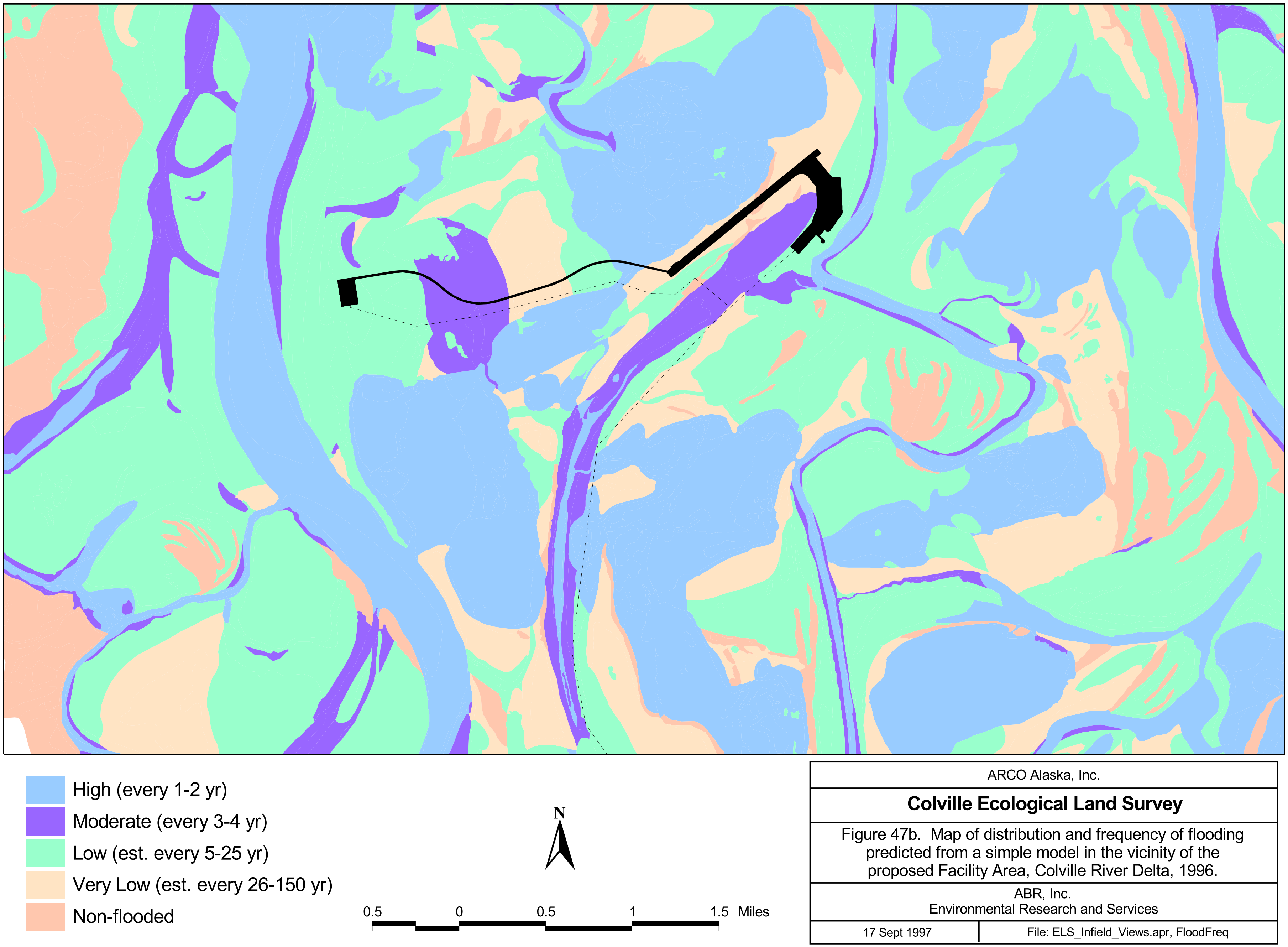
Figure 47a. Map of distribution and frequency of flooding predicted from simple model based on integrated terrain units and flooding information, Colville River Delta, northern Alaska, 1996

ABR, Inc.
Environmental Research and Services

2 Sept 1997 | File: FlodFreqELS.prj



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Colville Ecological Land Survey

Figure 47b. Map of distribution and frequency of flooding predicted from a simple model in the vicinity of the proposed Facility Area, Colville River Delta, 1996.

ABR, Inc.
Environmental Research and Services

17 Sept 1997 | File: ELS_Infield_Views.apr, FloodFreq

SUMMARY AND CONCLUSION

This report presents the results of three years of research (1992, 1995, and 1996) that inventoried, classified, mapped, and analyzed the ecological characteristics of the Colville River Delta and adjacent coastal plain with a focus on geomorphic and vegetative patterns and processes. By analyzing the dynamic physical processes associated with the deltaic and coastal environment and the abundance and distribution of it diverse ecological resources, this study contributed to efforts to mitigate potential ecological impacts of oil development on the delta.

Classification and mapping were done at three scales. At the landscape level (1:200,000 scale), the study area and surrounding coastal plain were divided into 7 ecodistricts and 17 ecosubdistricts (e.g., Colville River Delta and Inner Colville River Delta, respectively) representing physiographic regions with a repeating assemblage of terrain units and vegetation. Ecosections (1:100000) were not specifically mapped but are closely approximated by a terrain unit map. This classification deliniates areas that are homogenous with respect to geomorphic features, classes have repeating associations of soils and vegetation that are linked through successional processes (e.g., Alluvial-Marine Terrace). The most detailed classification and mapping was at the ecosystem level (ecosites, 1:18,000 scale).

Ecosystem classification of the 117,142-ha (289,464 acres) study area used an integrated terrain unit (ITU) approach that incorporated terrain units (surficial geology and waterbodies), surface forms (related to permafrost processes), and vegetation. A total of 19 terrestrial terrain units, 19 waterbodies, 16 surface forms, and 17 vegetation classes were identified for mapping and combined into 178 ITUs. To reduce the complexity for presentation and analysis, these ITUs were combined into a reduced set of 36 ecosystem classes that incorporated both geomorphic and vegetative characteristics.

Large differences were found between the delta and the adjacent coastal plain. Within the delta, the most common ecosystems included Tidal Rivers, Coastal Barrens, Coastal Salt-killed Wet Meadow, Riverine Wet Meadows, Riverine Low and Tall Scrub, Lowland Wet Meadows, and Lowland Deep Lakes. In contrast, the most common ecosystems on the adjacent coastal plain included Lowland Deep and Shallow Lakes, Lacustrine Wet and Moist Meadows, Lacustrine Thaw Complex, Lowland Thaw Complex, Lowland Wet and Moist Meadows, and Upland Tussock Meadows. Overall map accuracy was 60% for the 36 ecosystem classes and 71% for a derived set of 24 wildlife habitat classes.

Multiple environmental factors contributed to the distribution of ecosystems and their associated plant species. Of eight physical and chemical characteristics examined (elevation ratio, water depth, drainage index, pH, EC, surface organic-horizon thickness, cumulative organic-horizon thickness, and thaw depths), all except pH and surface organic-horizon thickness, were found to have significant effects on ecosystem distribution based on an ordination analysis. Deeper thaw depths generally were associated with sandy or gravelly soils found in early successional ecosystems (e.g., Riverine Low and Tall Scrub, Coastal Barrens, Upland Sandy Low Scrub) and well-drained soils on ridges (Upland Loamy Dwarf Scrub). Deeper thaw depth lowers groundwater levels, improves soil aeration, and provides a larger rooting environment for acquisition of nutrients by plants. Relative elevation helps differentiate early and late successional ecosystems on the delta floodplain and most ecosystems with relatively high elevations (e.g., Lowland Moist Meadow, Upland Tussock Meadows) have shallower thaw depths, more organic matter, and a greater proportion of evergreen shrubs. Accumulation of organic material was associated with poor drainage and thicker organic accumulations are found in flat and low-lying areas (e.g., Riverine Wet Meadows, Lowland Wet Meadows), 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.

In the delta, ecosystem distribution and evolution are affected by numerous geomorphic factors including marine, fluvial, eolian, permafrost, and thaw lake processes. Coastal Barrens, which are associated with marine processes and 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, Elymus arenarius,* and *Puccinellia phryganodes.* Saline areas affected by tidal flooding and storm surges include Coastal Wet Meadows, dominated by *Carex subspathacea*, *C. ursina*, *Puccinellia phryganodes,* and *Dupontia fisheri*, and Coastal Salt-killed Wet Meadows, which are being colonized by *Puccinellia phryganodes*, *P. andersonii*, and *Stellaria* *humifusa*. Salt becomes less important on slightly higher areas that are affected only by freshwater flooding events. Riverine Marshes occur in High-water Channnels and small ponds created by channel meandering and frequently are colonized by *Arctophila fulva* and *Carex aquatilis*. Riverine Tall and Low Scrub, which occur as narrow strips slightly higher on the floodplain, are subject to less flooding and sedimentation, have well-drained soils, and are dominated by *Salix alaxensis, S. lanata, Bromus pumpellianus, Equisetum* spp., and legumes. Riverine Wet 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 *C. aquatilis, Eriophorum angustifolium*, and *S. lanata*. Lowland Wet 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 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-polygon Complexes and Deep Riverine Lakes. These lakes may become tapped by channel migration, drain, and once again become Coastal Barrens. Finally, eolian sand is frequently deposited in large dunes downwind of large, barren sandbars contributing to the development of Upland Sandy Barrens, Upland Sandy Low Scrub, Upland Sandy Dwarf Scrub, and Upland Sandy Moist Meadows.

On the adjacent coastal plain, ice aggradation and thermokarst are the primary geomorphic processes that modify the landscape, although fluvial processes are evident to a lesser extent along small rivers and streams. Deep Open Lakes form from the development and coalescing of thermokarst pits and ponds, and later expand by degrading permafrost along steep cutbanks. Breaching and drainage of these lakes creates Lowland Shallow Ponds and Lacustrine Barrens depending on how much of the basin is drained. Lacustrine Wet and Moist 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 Meadows evolve from Lacustrine Wet Meadows after ice aggradation causes development of polygonal rims and raises the ground surface. Further raising of the surface by ice aggradation creates broad, gently rolling surfaces that become dissected by erosion and mass wasting, thereby providing modest differentiation in relief. Upland Tussock Meadows generally occur on moderately well-drained portions of slopes and Upland Loamy Dwarf Scrub occurs on more exposed ridges. These higher ice-rich areas then are susceptible to thermokarst and renewal of the thaw-lake cycle.

The ITU map, based in part on these simplified concepts of landscape evolution, also was used for specific evaluations of land capabilities or processes. These include derivation of wildlife habitats for use in evaluating wildlife use and development of a simple model for predicting flood distribution and frequency. For wildlife analyses, the ITUs were combined into 24 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 that would be expected during broad return intervals (i.e., every 3–4 or 5–25 years).

Overall, there are three main benefits from this ecological land survey approach. 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 ecosystem development. Thus, it improves our ability to predict the response of ecosystems to human impacts. The integrated approach also preserves the diversity of environmental characteristics necessary for specialized engineering and environmental applications and analyses, and utilizes a common spatial database. Some of the diverse uses of the ITU map for the Colville studies included analysis of flooding, sedimentation, ice contents, water availability, ecosystem development, wildlife use, and fish use. Finally, it utilizes a systematic approach to aggregating and simplifying ecosystem characteristics that assists in our efforts to understand and manage complicated ecological systems.

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Appendix Table 1. Classification and description of lithofacies observed in the Colville River Delta, Alaska, 1996. Structures < 4 in. (10 cm) thick are not broken out.

Lithofacies Class (and code)	Primary and Secondary Particle Sizes	Sedimentary Structures	Mechanism Interpretation
Gravel, massive (Gm)	Clean gravel (little or no fines)	None visible	Longitudinal bars, lag deposits, sieve deposits
Gravel, horizontal (Gl, was Gh, Gsc)	Clean gravel	Horizontal layers or crudely stratified gravel	Longitudinal bars, lag deposits, sieve deposits
Sands-massive (Sm)	Medium-coarse sands	None visible, medium-coarse, light brown sands, may be pebbly	Uncertain
Sands, massive with trace gravel (Sgm, was Smg)	Medium-coarse sands, loamy sands, with trace gravel	None visible	Coastal plain, reworked coastal environment from coastal or thaw-lake processes
Sands with trace gravel, massive, turbated (Sgmt)	Medium-coarse sands, loamy sands, with trace gravel	Turbated, intermixed massive sand and organics inclusions	Coastal plain, wave-mixed or cryoturbated sediments
Sand, layered (Sl, was Sh)	Medium-coarse sands	Horizontally stratified layers	Planar bed flow (lower and upper flow regime) or eolian
Sands, inclined (Si)	Medium-coarse sands	Undifferentiated wavy-bedded, ripple, or crossbed-stratified layers. Interpretation limited by small size of cores.	Lower flow regime and eolian sand
Sands with organics, inclined (Sdi)	Medium-coarse sands with interbedded detrital peat layers	Undifferentiated wavy-bedded, ripple, or crossbed structure	Lateral accretion deposits during flood stage
Sands, rippled (Sr)	Fine-medium sands	Ripples with variable internal structure, typically 3 cm high, 10-15 cm, internally graded,	Lower flow regime
Sands with organics, rippled (Sor, was Sdr)	Fine-medium-coarse sands with interbedded detrital peat layers	Ripples with variable internal structure	Lateral accretion deposits during flood stage in organic-rich landscapes
Fines, massive (Fm)	Silts and fine sands	None visible	Overbank deposition of sediments or eolian input
Fines with organics, massive (Fom, was Fmo)	Silts and fine sands with well-decomposed organics	None visible,	Soil formation in massive silts
Fines with organics, massive, turbated (Fomt, was Omt, Fmt)	Silts and fine sands with poorly decomposed organic inclusions	Disrupted organic and mineral inclusions due to cryoturbation	Compression and displacement of material during freezing and thawing
Fines with trace gravel, massive, turbated (Fgmt)	Silts and fine sands with trace gravel	Massive, turbated inclusions	Cryoturbation in active layer

Appendix Table 1 (cont.).

Fines, layered (Fl)	Silts and fine sands	Horizontally stratified layers	Proximal overbank deposition of sediments
Fines, rippled (Fr)	Silts and fine sands	Inclined beds or ripples	Lateral accretion deposits along riverbars formed during flood stage
Fines with organics, rippled (For, was Fdr, Fro)	Silts and fine sands with detrital organics	Inclined beds or ripples, interbedded detrital peat	Lateral accretion deposits along riverbars formed during flood stage
Fines with clay, massive (Fcm, was Fsc)	Clay-rich silts and fine sands	None visible to indistinct lamination	Slackwater deposits, lacustrine
Fines with clay, layered (Fcl, was Flc)	Clay-rich silts and fine sands	Horizontally stratified layers	Overbank or tidal flat deposition at flood stage or high tide
Fines with algae (Fa, was Fb)	Benthic algal mat and other limnic material	None visible to horizontal lamination	Lacustrine sediments
Organic, massive (Om)	Undecomposed organics, includes trace silt or sand layers	None visible	Autochthonous organic matter, fluvial sedimentation is rare or lacking
Organic, layered (Ol)	Undecomposed organic and fine mineral layers	Horizontal bedding, some alluvial mineral redistribution in peat	Occasional overbank deposition of suspended sediments
Organic, layered, turbated (Olt, was Olc)	Undecomposed organic and mineral layers	Disrupted inclusions or inclined bedding due to cryoturbation	Interbedded sediments deformed by ice-wedge compression

Appendix Table 2. Some characteristics used in classifying waterbodies in northern Alaska.

Property	Class	Description
Depth	Shallow	< 1.5 m deep, freezes to the bottom during winter
	Deep	> 1.5 m deep, unfrozen water persists during winter
Connectivity	Isolated	No distinct outlet
	Low-water Connection	Outlet has water present throughout year
	High-water Connection	Outlet has water present only during flooding events
Salinity	Saline	
	Brackish	
	Fresh	
Size	Small	Less than 10 ha
	Large	Larger than 10 ha
Emergents	Without	Emergent grasses, sedges or forbs do not form sufficiently large stands to map
	With	Emergent grasses, sedges or forbs form sufficiently large stands to map
Genesis	Riverine	Related to river processes; deltaic, channel, oxbow, point bar, and terrace flank ponds and lakes
	Thaw Lake	Related to melting of ice-rich deposits and impoundment of water
	Bedrock	Shoreline and water level controlled by bedrock
	Kettle Lake	Depressions in glacial deposits related to melting of glacial ice
	Dune	Depressions in dune fields
	Other	Other

Appendix Table 3. Examples of hierarchical approaches to ecosystem differentiation and classification.

Scale				Term			
Level	Sublevel	Typical Map Scale	Typical Region Size	Ecomap 1993	Canadian	Klijn and Udo de Haes	Differentiating Characteristics
Macro-scale	Continent	1: 20,000,000	10^{12} m^2 1,000,000 km^2	Domain		Ecozone	Continents with related climate
		1: 10,000,000	10^{11} m^2 100,000 km^2	Division		Eco-province	Climatic subzones with broad vegetation regions.
	Macro-region	1: 5,000,000	10^{10} m^2 10,000 km^2	Province	Ecoregion	Ecoregion	Climate, a geographic group of landscape mosaics (e.g. Arctic Coastal Plain).
Meso-scale	Meso-region	1: 1,000,000	10^9 m^2 1,000 km^2 100,000 ha	Section	Ecodistrict	Ecodistrict	Major landforms or physiographic units within a climatic region (e.g. Colville River Delta).
	Micro-region	1:250,000	10^8 m^2 100 km^2 10,000 ha	Sub-section		(Ecosubdistricts by ABR)	Physiographic units at larger scale based on associations of geomorphic units (e.g., Inner Colville River Delta).
		1:100,000	10^7 m^2 10 km^2 100 ha	Landtype Association	Ecosection	Ecosection	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).
Micro-scale	Macro-site	1:25,000-50,000	10^4-10^6 1 km^2 10 - 100 ha	Landtype	Ecosite	Ecoseries	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, and assemblages of vegetation types on soil series.
	Meso-site	1:5,000-25,000	10^2-10^4 0.1-10 ha	Landtype Phase	Ecoelement	Ecotope (Ecosite)	Vegetation type or successional stage (e.g., Wet Sedge-Willow Meadow on floodplain cover deposit).
	Micro-site	1:1000-5,000	10^{-2} - 10^2<0.1 ha	Site		Ecoelement	Uniform microsites within stand (e.g., polygon rim vs center).

Appendix Table 4. System for aggregating terrain, surface-form and vegetation codes into ecosystem (ecosite level) classes, for the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Ecosystem Code	Ecosystem Class	ITU (map) code	Terr Code	Terrain Unit	Surf-form Code	Surface Form	Veg Code	Alaska Vegetation Class
2001.0	Nearshore Water	963	963	Nearshore Water	99	Water	99	Water
2010.0	Tidal River	905	905	River, Tidal	99	Water	99	Water
2021.0	Coastal Lake - Isolated	989	989	Brackish Ponds (tidal affected)	99	Water	99	Water
2021.0	Coastal Lake - Isolated	989/96	989	Brackish Ponds (tidal affected)	96	Islands Present	99	Water
2021.0	Coastal Lake - Isolated	989/97	989	Brackish Ponds (tidal affected)	97	Water with Highly Polygonized Margin	99	Water
2022.0	Coastal Lake - Connected	983	983	Deep Tapped Lk w/ Low-water Connect.	99	Water	99	Water
2022.0	Coastal Lake - Connected	986	986	Shallow Tapped Lk w/ Low-water Conn.	99	Water	99	Water
2043.0	Coastal Dwarf Scrub	415/0/295	415	Delta, Active-floodplain Cover Deposit	0	Nonpatterned	295	Halophytic Dwarf Willow (coastal)
2043.0	Coastal Dwarf Scrub	818/0/295	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	295	Halophytic Dwarf Willow (coastal)
2053.0	Coastal Wet Meadow	412/0/346	412	Delta, Riverbed/Riverbars	0	Nonpatterned	346	Halophytic Sedge Wet Meadow
2053.0	Coastal Wet Meadow	413/0/345	413	Delta, High-water Channel	0	Nonpatterned	345	Halophytic Grass Wet Meadow
2053.0	Coastal Wet Meadow	413/0/346	413	Delta, High-water Channel	0	Nonpatterned	346	Halophytic Sedge Wet Meadow
2053.0	Coastal Wet Meadow	413/2/346	413	Delta, High-water Channel	2	Polygons, Disjunct	346	Halophytic Sedge Wet Meadow
2053.0	Coastal Wet Meadow	818/0/345	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	345	Halophytic Grass Wet Meadow
2053.0	Coastal Wet Meadow	818/0/346	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	346	Halophytic Sedge Wet Meadow
2053.0	Coastal Wet Meadow	818/2/346	818	Delta Thaw Basin, Ice-poor	2	Polygons, Disjunct	346	Halophytic Sedge Wet Meadow
2053.0	Coastal Wet Meadow	862/0/346	862	Tidal Flat	0	Nonpatterned	346	Halophytic Sedge Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	413/0/348	413	Delta, High-water Channel	0	Nonpatterned	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	413/2/348	413	Delta, High-water Channel	2	Polygons, Disjunct	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	416/0/348	416	Delta, Inactive-floodplain Cover Deposit	0	Nonpatterned	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	416/2/348	416	Delta, Inactive-floodplain Cover Deposit	2	Polygons, Disjunct	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	416/5/348	416	Delta, Inactive-floodplain Cover Deposit	5	Polygons, Low-cent., Low-relief, Low-dens.	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	417/6/348	417	Delta, Abandoned-floodplain Cover Dep.	6	Polygons, Low-cent., Low-relf, High-dens.	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	818/2/348	818	Delta Thaw Basin, Ice-poor	2	Polygons, Disjunct	348	Salt-killed Wet Meadow
2053.1	Coastal Salt-killed Wet Meadow	818/5/348	818	Delta Thaw Basin, Ice-poor	5	Polygons, Low-cent., Low-relief, Low-dens.	348	Salt-killed Wet Meadow
2090.0	Coastal Barrens	412/0/0	412	Delta, Riverbed/Riverbars	0	Nonpatterned	0	Barren
2090.0	Coastal Barrens	412/0/10	412	Delta, Riverbed/Riverbars	0	Nonpatterned	10	Partially Vegetated
2090.0	Coastal Barrens	818/0/0	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	0	Barren
2090.0	Coastal Barrens	818/0/10	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	10	Partially Vegetated
2090.0	Coastal Barrens	862/0/0	862	Tidal Flat	0	Nonpatterned	0	Barren
2090.0	Coastal Barrens	862/0/10	862	Tidal Flat	0	Nonpatterned	10	Partially Vegetated
3015.0	Lower Perennial River	910	910	River, Lower Perennial	99	Water	99	Water
3015.0	Lower Perennial River	918	918	River, Thermokarst (beaded stream)	99	Water	99	Water
3023.0	Riverine Shallow Lake	943	943	Shallow Isolated Pond, Riverine	99	Water	99	Water
3023.0	Riverine Shallow Lake	987	987	Shallow Tapped Lk w/ High-water Conn.	99	Water	99	Water
3026.0	Riverine Deep Lake	925	925	Deep Isolated Lake, Riverine	99	Water	99	Water
3026.0	Riverine Deep Lake	984	984	Deep Tapped Lk w/ High-water Conn.	99	Water	99	Water
3026.0	Riverine Deep Lake	984/96	984	Deep Tapped Lk w/ High-water Conn.	96	Islands Present	99	Water
3042.0	Riverine Low and Tall Scrub	413/0/242	413	Delta, High-water Channel	0	Nonpatterned	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	415/0/242	415	Delta, Active-floodplain Cover Deposit	0	Nonpatterned	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	416/0/242	416	Delta, Inactive-floodplain Cover Deposit	0	Nonpatterned	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	416/2/242	416	Delta, Inactive-floodplain Cover Deposit	2	Polygons, Disjunct	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	416/2/260	416	Delta, Inactive-floodplain Cover Deposit	2	Polygons, Disjunct	260	Open Low Willow
3042.0	Riverine Low and Tall Scrub	416/5/242	416	Delta, Inactive-floodplain Cover Deposit	5	Polygons, Low-cent., Low-relief, Low-dens.	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	416/5/260	416	Delta, Inactive-floodplain Cover Deposit	5	Polygons, Low-cent., Low-relief, Low-dens.	260	Open Low Willow
3042.0	Riverine Low and Tall Scrub	443/0/242	443	Floodplain, Active-floodplain Cover Dep.	0	Nonpatterned	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	444/0/242	444	Floodplain, Inactive-floodplain Cover Dep.	0	Nonpatterned	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	444/11/242	444	Floodplain, Inactive-floodplain Cover Dep.	11	Polygons, High-centered, Low-relief	242	Closed Low Willow

Appendix Table 4 (cont.).

Ecosystem Code	Ecosystem Class	ITU (map) code	Terr Code	Terrain Unit	Surf-form Code	Surface Form	Veg Code	Alaska Vegetation Class
3042.0	Riverine Low and Tall Scrub	444/2/242	444	Floodplain, Inactive-floodplain Cover Dep.	2	Polygons, Disjunct	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	444/5/242	444	Floodplain, Inactive-floodplain Cover Dep.	5	Polygons, Low-cent., Low-relief, Low-dens.	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	818/0/231	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	231	Open Tall Willow
3042.0	Riverine Low and Tall Scrub	818/0/242	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	818/0/260	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	260	Open Low Willow
3042.0	Riverine Low and Tall Scrub	818/2/242	818	Delta Thaw Basin, Ice-poor	2	Polygons, Disjunct	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	818/2/260	818	Delta Thaw Basin, Ice-poor	2	Polygons, Disjunct	260	Open Low Willow
3042.0	Riverine Low and Tall Scrub	818/5/242	818	Delta Thaw Basin, Ice-poor	5	Polygons, Low-cent., Low-relief, Low-dens.	242	Closed Low Willow
3042.0	Riverine Low and Tall Scrub	819/35/260	819	Delta Thaw Basin, Ice-rich	35	Pingos	260	Open Low Willow
3042.0	Riverine Low and Tall Scrub	819/5/242	819	Delta Thaw Basin, Ice-rich	5	Polygons, Low-cent., Low-relief, Low-dens.	242	Closed LowWillow
3042.0	Riverine Low and Tall Scrub	819/5/260	819	Delta Thaw Basin, Ice-rich	5	Polygons, Low-cent., Low-relief, Low-dens.	260	Open Low Willow
3043.0	Riverine Dwarf Scrub	444/0/270	444	Floodplain, Inactive-floodplain Cover Dep.	0	Nonpatterned	270	Dryas Tundra
3052.0	Riverine Moist Meadow	413/2/320	413	Delta, High-water Channel	2	Polygons, Disjunct	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	416/0/320	416	Delta, Inactive-floodplain Cover Deposit	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	416/2/320	416	Delta, Inactive-floodplain Cover Deposit	2	Polygons, Disjunct	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	416/5/320	416	Delta, Inactive-floodplain Cover Deposit	5	Polygons, Low-cent., Low-relief, Low-dens.	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	444/0/320	444	Floodplain, Inactive-floodplain Cover Dep.	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	444/11/320	444	Floodplain, Inactive-floodplain Cover Dep.	11	Polygons, High-centered, Low-relief	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	444/12/320	444	Floodplain, Inactive-floodplain Cover Dep.	12	Polygons, High-centered. High-relief	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	444/2/320	444	Floodplain, Inactive-floodplain Cover Dep.	2	Polygons, Disjunct	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	444/5/320	444	Floodplain, Inactive-floodplain Cover Dep.	5	Polygons, Low-cent., Low-relief, Low-dens.	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	818/0/320	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
3052.0	Riverine Moist Meadow	818/2/320	818	Delta Thaw Basin, Ice-poor	2	Polygons, Disjunct	320	Moist Sedge–Shrub Tundra
3053.0	Riverine Wet Meadow	413/0/334	413	Delta, High-water Channel	0	Nonpatterned	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	413/2/334	413	Delta, High-water Channel	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	413/5/334	413	Delta, High-water Channel	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	416/0/334	416	Delta, Inactive-floodplain Cover Deposit	0	Nonpatterned	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	416/2/334	416	Delta, Inactive-floodplain Cover Deposit	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	416/5/334	416	Delta, Inactive-floodplain Cover Deposit	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	443/0/334	443	Floodplain, Active-floodplain Cover Dep.	0	Nonpatterned	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	444/0/334	444	Floodplain, Inactive-floodplain Cover Dep.	0	Nonpatterned	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	444/2/334	444	Floodplain, Inactive-floodplain Cover Dep.	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	444/5/334	444	Floodplain, Inactive-floodplain Cover Dep.	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	818/0/334	818	Delta Thaw Basin, Ice-poor	0	Nonpatterned	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	818/2/334	818	Delta Thaw Basin, Ice-poor	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	818/5/334	818	Delta Thaw Basin, Ice-poor	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	819/2/334	819	Delta Thaw Basin, Ice-rich	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
3053.0	Riverine Wet Meadow	819/5/334	819	Delta Thaw Basin, Ice-rich	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
3054.0	Riverine Marsh	416/5/336	416	Delta, Inactive-floodplain Cover Deposit	5	Polygons, Low-cent., Low-relief, Low-dens.	336	Fresh Sedge Marsh
3054.0	Riverine Marsh	987/0/337	987	Shallow Tapped Lk w/ High-water Conn.	0	Nonpatterned	337	Fresh Grass Marsh
3073.0	Riverine Deep-polygon Complex	416/7/336	416	Delta, Inactive-floodplain Cover Deposit	7	Polygons, Low-cent., High-relf, Low-dens.	336	Fresh Sedge Marsh
3073.0	Riverine Deep-polygon Complex	819/7/336	819	Delta Thaw Basin, Ice-rich	7	Polygons, Low-cent., High-relf, Low-dens.	336	Fresh Sedge Marsh
3090.0	Riverine Barrens	413/0/10	413	Delta, High-water Channel	0	Nonpatterned	10	Partially Vegetated
3090.0	Riverine Barrens	441/0/0	441	Floodplain, Riverbed Deposit	0	Nonpatterned	0	Barren
3090.0	Riverine Barrens	441/0/10	441	Floodplain, Riverbed Deposit	0	Nonpatterned	10	Partially Vegetated
4052.0	Lacustrine Moist Meadow	816/0/320	816	Thaw Basin, Ice-poor	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
4052.0	Lacustrine Moist Meadow	816/2/320	816	Thaw Basin, Ice-poor	2	Polygons, Disjunct	320	Moist Sedge–Shrub Tundra
4052.0	Lacustrine Moist Meadow	816/31/320	816	Thaw Basin, Ice-poor	31	Mounds, Undifferentiated, Dense	320	Moist Sedge–Shrub Tundra

Appendix Table 4 (cont.).

Ecosystem Code	Ecosystem Class	ITU (map) code	Terr Code	Terrain Unit	Surf-form Code	Surface Form	Veg Code	Alaska Vegetation Class
4053.0	Lacustrine Wet Meadow	816/0/334	816	Thaw Basin, Ice-poor	0	Nonpatterned	334	Wet Sedge–Willow Meadow
4053.0	Lacustrine Wet Meadow	816/2/334	816	Thaw Basin, Ice-poor	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
4054.0	Lacustrine Marsh	941/0/336	941	Shallow Isolated Pond	0	Nonpatterned	336	Fresh Sedge Marsh
4054.0	Lacustrine Marsh	941/0/337	941	Shallow Isolated Pond	0	Nonpatterned	337	Fresh Grass Marsh
4054.0	Lacustrine Marsh	941/96/336	941	Shallow Isolated Pond	96	Islands Present	336	Fresh Sedge Marsh
4054.0	Lacustrine Marsh	941/96/337	941	Shallow Isolated Pond	96	Islands Present	337	Fresh Grass Marsh
4054.0	Lacustrine Marsh	943/0/337	943	Shallow Isolated Pond, Riverine	0	Nonpatterned	337	Fresh Grass Marsh
4054.0	Lacustrine Marsh	950/0/337	950	Shallow Connected Pond	0	Nonpatterned	337	Fresh Grass Marsh
4054.0	Lacustrine Marsh	950/96/336	950	Shallow Connected Pond	96	Islands Present	336	Fresh Sedge Marsh
4071.0	Lacustrine Thaw Complex	816/101/411	816	Thaw Basin, Ice-poor	101	Basin Complex	411	Basin Wetland Complex, Young
4090.0	Lacustrine Barrens	816/0/10	816	Thaw Basin, Ice-poor	0	Nonpatterned	10	Partially Vegetated
5023.0	Lowland Shallow Lake	941	941	Shallow Isolated Pond	99	Water	99	Water
5023.0	Lowland Shallow Lake	941/96	941	Shallow Isolated Pond	96	Islands Present	99	Water
5023.0	Lowland Shallow Lake	941/97	941	Shallow Isolated Pond	97	Water with Highly Polygonized Margin	99	Water
5023.0	Lowland Shallow Lake	948	948	Shallow Ioslated Pond, Dune Depression	99	Water	99	Water
5023.0	Lowland Shallow Lake	950	950	Shallow Connected Pond	99	Water	99	Water
5023.0	Lowland Shallow Lake	950/96	950	Shallow Connected Pond	96	Islands Present	99	Water
5023.0	Lowland Shallow Lake	950/97	950	Shallow Connected Pond	97	Water with Highly Polygonized Margin	99	Water
5026.0	Lowland Deep Lake	922	922	Deep Isolated Lake	99	Water	99	Water
5026.0	Lowland Deep Lake	922/96	922	Deep Isolated Lake	96	Islands Present	99	Water
5026.0	Lowland Deep Lake	922/97	922	Deep Isolated Lake	97	Water with Highly Polygonized Margin	99	Water
5026.0	Lowland Deep Lake	930	930	Deep Connected Lake	99	Water	99	Water
5026.0	Lowland Deep Lake	930/96	930	Deep Connected Lake	96	Islands Present	99	Water
5042.0	Lowland Low Scrub	417/6/242	417	Delta, Abandoned-floodplain Cover Dep.	6	Polygons, Low-cent., Low-relf, High-dens.	242	Closed Low Willow
5042.0	Lowland Low Scrub	417/6/260	417	Delta, Abandoned-floodplain Cover Dep.	6	Polygons, Low-cent., Low-relf, High-dens.	260	Open Low Willow
5042.0	Lowland Low Scrub	545/11/242	545	Alluvial Terrace (ancient floodplain)	11	Polygons, High-centered, Low-relief	242	Closed Low Willow
5042.0	Lowland Low Scrub	545/11/260	545	Alluvial Terrace (ancient floodplain)	11	Polygons, High-centered, Low-relief	260	Open Low Willow
5042.0	Lowland Low Scrub	545/12/242	545	Alluvial Terrace (ancient floodplain)	12	Polygons, High-centered. High-relief	242	Closed Low Willow
5042.0	Lowland Low Scrub	817/5/260	817	Thaw Basin, Ice-rich	5	Polygons, Low-cent., Low-relief, Low-dens.	260	Open Low Willow
5052.0	Lowland Moist Meadow	417/6/320	417	Delta, Abandoned-floodplain Cover Dep.	6	Polygons, Low-cent., Low-relf, High-dens.	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	545/0/320	545	Alluvial Terrace (ancient floodplain)	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	545/11/320	545	Alluvial Terrace (ancient floodplain)	11	Polygons, High-centered, Low-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	545/12/320	545	Alluvial Terrace (ancient floodplain)	12	Polygons, High-centered. High-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	595/0/320	595	Alluvial Plain Deposit (undiff. fluvial)	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	595/11/320	595	Alluvial Plain Deposit (undiff. fluvial)	11	Polygons, High-centered, Low-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	817/11/320	817	Thaw Basin, Ice-rich	11	Polygons, High-centered, Low-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	817/12/320	817	Thaw Basin, Ice-rich	12	Polygons, High-centered. High-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	817/5/320	817	Thaw Basin, Ice-rich	6	Polygons, Low-cent., Low-relief, Low-dens.	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	860/0/320	860	Alluvial-Marine Terrace	0	Nonpatterned	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	860/11/320	860	Alluvial-Marine Terrace	11	Polygons, High-centered, Low-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	860/12/320	860	Alluvial-Marine Terrace	12	Polygons, High-centered. High-relief	320	Moist Sedge–Shrub Tundra
5052.0	Lowland Moist Meadow	860/2/320	860	Alluvial-Marine Terrace	2	Polygons, Disjunct	320	Moist Sedge–Shrub Tundra
5053.0	Lowland Wet Meadow	380/62/334	380	Eolian Sand Dunes	62	Dunes, Streaked	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	417/6/334	417	Delta, Abandoned-floodplain Cover Dep.	6	Polygons, Low-cent., Low-relf, High-dens.	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	545/0/334	545	Alluvial Terrace (ancient floodplain)	0	Nonpatterned	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	545/2/334	545	Alluvial Terrace (ancient floodplain)	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	545/5/334	545	Alluvial Terrace (ancient floodplain)	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	595/5/334	595	Alluvial Plain Deposit (undiff. fluvial)	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow

Appendix Table 4 (cont.).

Ecosystem Code	Ecosystem Class	ITU (map) code	Terr Code	Terrain Unit	Surf-form Code	Surface Form	Veg Code	Alaska Vegetation Class
5053.0	Lowland Wet Meadow	817/5/334	817	Thaw Basin, Ice-rich	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	860/0/334	860	Alluvial-Marine Terrace	0	Nonpatterned	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	860/2/334	860	Alluvial-Marine Terrace	2	Polygons, Disjunct	334	Wet Sedge–Willow Meadow
5053.0	Lowland Wet Meadow	860/5/334	860	Alluvial-Marine Terrace	5	Polygons, Low-cent., Low-relief, Low-dens.	334	Wet Sedge–Willow Meadow
5071.0	Lowland Thaw Complex	817/101/412	817	Thaw Basin, Ice-rich	101	Basin Complex	412	Basin Wetland Complex, Old
5073.0	Lowland Deep-polygon Complex	417/7/336	417	Delta, Abandoned-floodplain Cover Dep.	7	Polygons, Low-cent., High-relf, Low-dens.	336	Fresh Sedge Marsh
5073.0	Lowland Deep-polygon Complex	417/8/336	417	Delta, Abandoned-floodplain Cover Dep.	8	Polygons, Low-cent., High-relf, High-dens.	336	Fresh Sedge Marsh
7058.0	Upland Tussock Meadow	545/0/314	545	Alluvial Terrace (ancient floodplain)	0	Nonpatterned	314	Tussock Tundra
7058.0	Upland Tussock Meadow	545/11/314	545	Alluvial Terrace (ancient floodplain)	11	Polygons, High-centered, Low-relief	314	Tussock Tundra
7058.0	Upland Tussock Meadow	545/12/314	545	Alluvial Terrace (ancient floodplain)	12	Polygons, High-centered. High-relief	314	Tussock Tundra
7058.0	Upland Tussock Meadow	595/11/314	595	Alluvial Plain Deposit (undiff. fluvial)	11	Polygons, High-centered, Low-relief	314	Tussock Tundra
7058.0	Upland Tussock Meadow	817/11/314	817	Thaw Basin, Ice-rich	11	Polygons, High-centered, Low-relief	314	Tussock Tundra
7058.0	Upland Tussock Meadow	817/12/314	817	Thaw Basin, Ice-rich	12	Polygons, High-centered. High-relief	314	Tussock Tundra
7058.0	Upland Tussock Meadow	817/35/314	817	Thaw Basin, Ice-rich	35	Pingos	314	Tussock Tundra
7058.0	Upland Tussock Meadow	860/11/314	860	Alluvial-Marine Terrace	11	Polygons, High-centered, Low-relief	314	Tussock Tundra
7058.0	Upland Tussock Meadow	860/12/314	860	Alluvial-Marine Terrace	12	Polygons, High-centered. High-relief	314	Tussock Tundra
7443.0	Upland Loamy Dwarf Scrub	545/11/270	545	Alluvial Terrace (ancient floodplain)	11	Polygons, High-centered, Low-relief	270	Dryas Tundra
7443.0	Upland Loamy Dwarf Scrub	545/98/320	545	Alluvial Terrace (ancient floodplain)	98	Cliff or Bluff	320	Moist Sedge–Shrub Tundra
7443.0	Upland Loamy Dwarf Scrub	817/35/270	817	Thaw Basin, Ice-rich	35	Pingos	270	Dryas Tundra
7443.0	Upland Loamy Dwarf Scrub	818/35/270	818	Delta Thaw Basin, Ice-poor	35	Pingos	270	Dryas Tundra
7443.0	Upland Loamy Dwarf Scrub	860/11/270	860	Alluvial-Marine Terrace	11	Polygons, High-centered, Low-relief	270	Dryas Tundra
7443.0	Upland Loamy Dwarf Scrub	860/98/320	860	Alluvial-Marine Terrace	98	Cliff or Bluff	320	Moist Sedge–Shrub Tundra
7642.0	Upland Sandy Low Scrub	380/62/242	380	Eolian Sand Dunes	62	Dunes, Streaked	242	Closed Low Willow
7642.0	Upland Sandy Low Scrub	380/62/260	380	Eolian Sand Dunes	62	Dunes, Streaked	260	Open Low Willow
7643.0	Upland Sandy Dwarf Scrub	380/62/270	380	Eolian Sand Dunes	62	Dunes, Streaked	270	Dryas Tundra
7652.0	Upland Sandy Moist Meadow	380/11/320	380	Eolian Sand Dunes	11	Polygons, High-centered, Low-relief	320	Moist Sedge–Shrub Tundra
7652.0	Upland Sandy Moist Meadow	380/62/320	380	Eolian Sand Dunes	62	Dunes, Streaked	320	Moist Sedge–Shrub Tundra
7690.0	Upland Sandy Barrens	380/62/10	380	Eolian Sand Dunes	62	Dunes, Streaked	10	Partially Vegetated
12000.0	Human Modified	860/0/10	860	Alluvial-Marine Terrace	0	Nonpatterned	10	Partially Vegetated
12000.0	Human Modified	872/0/0	872	Fill, Gravel	0	Nonpatterned	0	Barren
12000.0	Human Modified	874/17/320	874	Fill, Peat (peat roads)	17	Mixed Pits and Polygons	320	Moist Sedge–Shrub Tundra
12000.0	Human Modified	995	995	Drainage Impoundment	99	Water	99	Water
12000.0	Human Modified	996	996	Sewage Lagoon	99	Water	99	Water
12000.0	Human Modified	997	997	Reserve Pit	99	Water	99	Water

Appendix Table 5. Habitat classification system for Alaska's north slope (modified from Jorgenson et al. 1989).

Class	Codes	Class	Codes
MARINE WATERS	**100 O**	**MEADOWS**	**500 M**
Inshore waters	110 On	Wet Meadows	510 Mw
Offshore waters	120 Oo	Nonpatterned	511 Mwn
Sea Ice	130 Oi	sedge (*Carex, Erioph.*)	512 Mwns
COASTAL ZONE	**200 C**	sedge-grass (*Carex, Dupontia*)	516 Mwng
Nearshore Water (estuarine)	201 Cn	Low relief	521 Mwl
Open nearshore water	205 Cno	sedge	522 Mwls
Brackish ponds (deep or shallow)	210 Cnp	High relief (sedge-willow)	531 Mwh
Deep	211 Cnpd	sedge	532 Mwhs
without islands	212 Cnpdw	Moist Meadows	540 Mm
with islands	213 Cnpdi	Low relief	541 Mml
with polygonized margins	214 Cnpdp	sedge-dwarf shrub tundra	542 Mmls
Shallow	221 Cnps	tussock tundra	546 Mmlt
Tapped Lakes (deltas only)	230 Cnt	herb	548 Mmlh
Deep	231 Cntd	High relief	551 Mmh
Low-water connection	232 Cntdl	sedge-dwarf shrub tundra	552 Mmhd
High-water connection	235 Cntdh	tussock tundra	556 Mmht
Shallow	241 Cnts	Dry Meadows	560 Md
Low-water connection	242 Cntsl	Grass	561 Mdg
High-water connection	245 Cntsh	Herb	566 Mdh
Coastal Wetland Complex	250 Cw	**SHRUBLANDS**	**600 S**
Salt Marsh	251 Cwm	Riverine Shrub	610 Sr
Halophytic sedge	252 Cwms	Riverine low shrub	611 Srl
Halophytic grass	253 Cwmg	willow	612 Srlw
Halophytic herb	254 Cwmh	birch	615 Srlb
Halophytic dwarf willow scrub	257 Cws	alder	618 Srla
Barren	260 Cb	Riverine dwarf shrub	621 Srd
Coastal islands	261 Cbi	*Dryas*	622 Srdd
Coastal beaches	271 Cbb	Upland Shrub	630 Su
cobble-gravel	272 Cbbc	Upland low shrub	631 Sul
sand	273 Cbbs	mixed shrub tundra	632 Sulm
Coastal rocky shores	275 Cbr	willow	635 Sulw
low	276 Cbrl	alder	638 Sula
cliffs	277 Cbrc	Upland dwarf shrub	641 Sud
Tidal flats	280 Cbt	*Dryas*	642 Sudd
Salt-killed tundra	285 Cbk	ericaceous	645 Sude
Causeway	291 Cbc	Shrubby Bogs	650 Sb
FRESH WATERS	**300 W**	Low shrub bog	651 Sbl
Open Water	305 Wo	mixed shrub	652 Sblm
Deep open lakes	310 Wod	Dwarf shrub bog	661 Sbd
isolated	311 Wodi	ericaceous	662 Sble
without islands	312 Wodiw	**PARTIALLY VEGETATED**	**800 P**
with islands	313 Wodii	Riverine Barrens (including deltas)	810 Pf
with polygonized margins	314 Wodip	Barren	811 Pfb
connected	315 Wodc	Partially vegetated	815 Pfp
Shallow open water (isolated or connected)	320 Wos	Eolian Barrens	820 Pe
without islands	322 Wosw	Barren	821 Peb
with islands	323 Wosi	Partially vegetated	825 Pep
with polygonized margins	324 Wosp	Upland Barrens (talus, ridges, etc.)	830 Pu
Rivers and Streams	330 Wr	Barren	831 Pub
Tidal	331 Wrt	Partially vegetated	835 Pup
Lower perennial	341 Wrl	Lacustrine Barrens (shore bottoms, margins)	840 Pl
Upper perennial	351 Wru	Barren	841 Plb
deep pools	352 Wrud	Partially vegetated	845 Plp
shallow	353 Wrup	Alpine	860 Pa
riffles	354 Wrur	Cliffs (rocky)	871 Pc
falls	355 Wruf	Bluffs (unconsolidated)	875 Pb
Intermittent	356 Wri	Barren (unstable)	876 Pbb
Water with Emergents (shallow, isol. or conn.)	360 We	Partially vegetated (stable)	877 Pbv
Aquatic sedge	361 Wes	Burned Areas (barren)	880 Pr
without islands	362 Wesw	**ARTIFICIAL**	**900 A**
with islands	363 Wesi	Fill	910 Af
deep polygon centers	364 Wesp	Gravel	911 Afg
Aquatic grass	371 Weg	barren or partially vegetated	912 Afgb
without islands	372 Wegw	vegetated	913 Afgv
with islands	373 Wegi	Medium-grained	920 Afm
Aquatic herb	381 Weh	barren or partially vegetated	921 Afmb
without islands	382 Wehw	vegetated	925 Afmv
with islands	383 Wehi	Sod (organic-mineral)	930 Afs
Impoundment	390 Wi	barren or partially vegetated	931 Afsb
Drainage impoundment	391 Wid	vegetated	935 Afsv
Effluent reservoir	395 Wie	Excavations	940 Ae
		Gravel	941 Aeg
BASIN WETLAND COMPLEXES	**400 B**	Barren or Partially vegetated	942 Aegb
Young (non-ice rich)	401 By	Vegetated	945 Aegv
Old (ice-rich)	405 Bo	Structure and Debris	950 As

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Appendix Table 6. Summary of ecological characteristics of sample plots on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

Plot	Date	Degrees Latitude NAD27	Degrees Long. NAD27	Depth Surf Organic (cm)	Sum Organics (30 cm)	Drainage*	Depth Active Layer	Soil pH	Soil EC	Water EC	Water Temp (C)	Elev (1996 survey) (m)	Relative Elev. (m)	Elev Ratio (plot / inactive)	AK Vegetation Class	Dominant Species	Map Terrain Unit Code	Surf-form Code	Map Veg Code	Ecosite Code	Ecosite Code Name
G1.01	08/12/95	70.34124N	150.97483W	0	0	v poor	38	7.9	966			nd	nd	nd	Wet sedge-willow meadow	caraqu-dupfis-salova-eriang	818	0	334	3053	Riverine Wet Meadow
G1.02	08/12/95	70.35104N	150.98186W	0	0	sw poor	57	nd	nd			nd	nd	nd	Open low willow-sedge	sallan-salova-carbig-arclat	415	0	260	3042	Riverine Low and Tall Scrub
G1.03	08/12/95	70.35032N	150.97543W	0	0		nd	8.4	2180			nd	nd	nd	Halophytic sedge wet meadow	carsub-pucphr-carurs	818	0	346	2053	Coastal Wet Meadow
G1.04a	08/12/95	70.34766N	150.94928W	0	0		44	7.1	4600			nd	nd	nd	Halophytic dwarf willow-graminoid	salova-carsub-poaalp-carurs-caraqu	818	0	295	2043	Coastal Dwarf Scrub
G1.04b	08/12/95	nd	nd	nd	nd		nd	nd	nd			nd	nd	nd	Halophytic sedge wet meadow	carsub-poaarc-pucphr-carurs	818	0	346	2053	Coastal Wet Meadow
G1.05	08/06/96	70.34197N	150.95222W	0	0	poor	34			240		nd	nd	nd	Ericaceous dwarf scrub	castet-salpla/mosses	417	9	320	5052	Lowland Moist Meadow
G1.06	08/06/96	70.34394N	150.95229W	0	0	poor	56					nd	nd	nd	Halophytic dwarf willow	salova-carsub	818	0	295	2043	Coastal Dwarf Scrub
G1.07	08/06/96	70.34488N	150.93927W	8	8	poor	57	6.4				nd	nd	nd	Open low willow-sedge	salgla-carbib/dryint-castet/mosses	380	0	320	7652	Upland Sandy Moist Meadow
G11.01	08/10/96	70.31877N	150.41023W	0	0	excessive	nd			118	4.5	nd	nd	nd	Barren	Artemisia spp.	441	0	0	3090	Riverine Barrens
G11.02	08/10/96	70.32005N	150.41055W	0	0	well	nd			119	5.3	nd	nd	nd	*Dryas* tundra	dryint-salret-astalp	444	0	270	3043	Riverine Dwarf Scrub
G11.03	08/10/96	70.3197N	150.40726W	0	0	well	nd			43	5.4	nd	nd	nd	*Dryas* -lichen tundra	dryint-castet/lichens	444	11	270	3043	Riverine Dwarf Scrub
G11.04	08/10/96	70.3226N	150.40711W	0	0	well	nd	8.3	74			nd	nd	nd	*Dryas* tundra	dryint-salrot	860	98	270	7443	Upland Loamy Dwarf Scrub
G11.05	08/10/96	70.32343N	150.39675W	3	8	v poor	29	5.7	57	93		nd	nd	nd	Tussock tundra	erivag-ledpal/castet	817	12	314	7058	Upland Tussock Meadow
G11.06	08/10/96	70.32373N	150.40179W	7	7	v poor	41			317	8	nd	nd	nd	Barren (pond - no emergents)		941	0	0	5023	Lowland Shallow Lake
G11.07	08/10/96	70.31498N	150.3797W	8	8	sw poor	34	6.7	120	167	5	nd	nd	nd	*Dryas* -sedge tundra	dryint-erivag-eriang-salpla	860	12	314	7058	Upland Tussock Meadow
G11.08	08/10/96	70.31563N	150.38504W	10	10	v poor	41	6.5	212	164	4	nd	nd	nd	Sedge-*Dryas* tundra	eriang-carmem-erivag/dryint	860	11	320	5052	Lowland Moist Meadow
G11.29	07/22/92	70.3213N	151.05815W	0	0	excessive	nd	7.9				nd	nd	nd	Open tall willow	salale-salgla-elyare	380	62	10	7690	Upland Sandy Barrens
G11.30	07/22/92	70.32189N	151.04061W	0	2	sw poor	nd	6.9				nd	nd	nd	Wet sedge-willow meadow	nd	417	8	334	5053	Lowland Wet Meadow
G11.31	07/22/92	70.29426N	151.00233W	0	0	nd	70					nd	nd	nd	Open low willow	salgla-sallan	415	0	260	3042	Riverine Low and Tall Scrub
G12.01	08/07/95	70.2801N	150.99872W	0	0		64	nd	nd			nd	nd	nd	Dry hair-grass	descae-equarv-chrbip	411	0	10	2090	Coastal Barrens
G12.02	08/07/95	70.2748N	150.99264W	2	20	v poor	40	6.9	220			nd	nd	nd	Wet sedge-willow meadow	caraqu-sallan-luparc	416	5	334	3053	Riverine Wet Meadow
G12.03	08/07/95	70.2655N	150.99801W	nd	nd		nd	nd	nd			nd	nd	nd	Closed low willow	salgla-arcrub-astarc-mosses	415	0	242	3042	Riverine Low and Tall Scrub
G12.04	08/04/96	70.26655N	150.95243W	2	15	v poor	43			230		nd	nd	nd	Wet sedge meadow	caraqu-potpal-sallan/mosses	818	0	334	3053	Riverine Wet Meadow
G12.05	08/04/96	70.267N	150.95066W	1	1	v poor	35			425		nd	nd	nd	Wet sedge-willow meadow	eriang-salpla-caraqu	819	5	334	3053	Riverine Wet Meadow
G12.06	08/04/96	70.26786N	150.94999W	14	14	v poor	46			134		nd	nd	nd	Fresh grass marsh	arcful/hipvul	818	0	337	3054	Riverine Marsh
G12.07	08/04/96	70.27055N	150.94704W	13	17	v poor	41			220		nd	nd	nd	Sedge-*Dryas* tundra	caraqu-carcho-salpla/castet-dryint	417	8	320	5052	Lowland Moist Meadow
G12.08	08/04/96	70.27465N	150.94259W	0	0	well	nd	6.7	50			nd	nd	nd	*Dryas* -lichen tundra	dryint-sallan/lichens	380	62	270	7643	Upland Sandy Dwarf Scrub
G12.09	08/06/95	70.3356N	151.04972W	nd	nd		nd					nd	nd	nd	Open low willow-sedge	caraqu-sallan	416	2	334	3053	Riverine Wet Meadow
G12.10	08/06/95	70.33601N	151.04663W	nd	nd		nd					nd	nd	nd	Wet sedge-grass meadow	eriang-dupfis-caraqu-sallan	416	5	334	3053	Riverine Wet Meadow
G12.11	08/06/95	70.34119N	151.04804W	nd	nd		nd					nd	nd	nd	*Dryas* tundra	sallan-arclat-dryint-carbig-salret	416	5	270	3043	Riverine Dwarf Scrub
G12.12	08/06/95	70.34305N	151.03906W	nd	nd		nd					nd	nd	nd	Open low willow-sedge	salpla-sallan-carbig	417	6	260	5042	Lowland Low Scrub
G12.24	07/22/92	70.34696N	151.07283W	0	0	sw poor	80	5.9				nd	nd	nd	Open low willow-sedge	sallan-caraqu-eriang-salpul/dryint	416	0	334	3053	Riverine Wet Meadow
G12.25	07/22/92	70.34457N	151.07947W	0	24	poor	30					nd	nd	nd	Wet sedge-willow meadow	caraqu-erisch-sallan	416	5	334	3053	Riverine Wet Meadow
G12.26	07/22/92	70.34079N	151.04762W	0	0	sw poor	48	8				nd	nd	nd	Open low willow	salgla-salova-dryint	415	0	260	3042	Riverine Low and Tall Scrub
G12.27	07/22/92	70.34159N	151.04597W	1	1	sw poor	32					nd	nd	nd	Wet sedge-willow meadow	caraqu-dupfis-salova-eriang	416	0	334	3053	Riverine Wet Meadow
G12.28	07/22/92	70.33221N	151.06678W	0	0	moderate	60	8.1				nd	nd	nd	Barren	descae-elyare	411	0	0	2090	Coastal Barrens
G13.01A	08/09/96	70.24193N	150.73167W	10	18	poor	30	6.6	135			nd	nd	nd	Tussock tundra	erivag-salpla-carbig/dryint	817	5	314	7058	Upland Tussock Meadow
G13.01B	08/09/96	70.24233N	150.7311W	22	22	v poor	58			450		nd	nd	nd	Wet sedge meadow	carsax-caraqu-eriang/scosco	817	101	334	5053	Lowland Wet Meadow
G13.02	08/09/96	70.24449N	150.72073W	11	11	poor	35	6.8	75			nd	nd	nd	Mixed shrub-sedge tussock	salret-erivag-castet-salpla	545	11	314	7058	Upland Tussock Meadow
G13.03	08/09/96	70.24597N	150.71441W	9	21	v poor	38			340		nd	nd	nd	Wet sedge meadow	caraqu-eriang	816	2	334	4053	Lacustrine Wet Meadow
G13.04	08/09/96	70.24681N	150.71228W	2	20	poor	29	4.8	5.6??			nd	nd	nd	Vaccinium tundra	vacvit-ledpal-castet-carbig-eriang	817	12	270	7443	Upland Loamy Dwarf Scrub
G13.05	08/09/96	70.2465N	150.70859W	4	4	poor	56			755		nd	nd	nd	Mesic sedge-shrub tundra	eriang-erivag/castet-dryint/mosses	545	11	320	5052	Lowland Moist Meadow
G13.06	08/09/96	70.24551N	150.70924W	12	12	v poor	92					nd	nd	nd	Fresh sedge marsh	caraqu	816	0	336	4054	Lacustrine Marsh
G2.01	08/13/95	70.26906N	150.86551W	8	21	v poor	40	7.1	790			nd	nd	nd	Open low willow-sedge	caraqu-sallan-mosses	416	2	334	3053	Riverine Wet Meadow
G2.02	08/13/95	70.27132N	150.85532W	0	0	well	nd					nd	nd	nd	Closed low willow	salgla-arcrub	380	62	242	7642	Upland Sandy Low Scrub
G2.03	08/13/95	70.27101N	150.85086W	0	0		nd					nd	nd	nd	Open low willow	salgla-astsp-bropum	380	62	260	7642	Upland Sandy Low Scrub
G2.04	08/13/95	70.27593N	150.85803W	0	0	poor	38	7.4	878			nd	nd	nd	Open low willow-sedge	caraqu-sallan-luparc-mosses	417	11	320	5052	Lowland Moist Meadow
G2.05	08/13/95	70.27776N	150.88466W	0	2	sw poor	49	nd	nd			nd	nd	nd	Closed low willow	sallan-arcrub-salret-dryint-mosses	818	0	242	3042	Riverine Low and Tall Scrub
G2.18	07/16/92	70.39146N	150.87297W	1	1	sw poor	nd	7.4				nd	nd	nd	Open low willow	dryint-salgla-salret-astrag sp.	416	6	270	3043	Riverine Dwarf Scrub
G2.25	07/18/92	70.39504N	150.88018W	17	17	poor	29	6.4				nd	nd	nd	Wet sedge meadow	caraqu-erisch-hiepau	416	2	334	3053	Riverine Wet Meadow
G2.26	07/18/92	70.39923N	150.87622W	0	0	moderate	nd	7				nd	nd	nd	Open low willow	dryint-salgla-salret-lichen	380	0	260	7642	Upland Sandy Low Scrub
G2.27	07/18/92	70.39384N	150.86129W	0	0	moderate	nd					nd	nd	nd	Open low willow	salgla-dryint-luparc	416	5	260	3042	Riverine Low and Tall Scrub
G3.01	08/13/95	70.27941N	150.97779W	0	0	poor	48	7.1	698			nd	nd	nd	Open low willow-sedge	sallan-caraqu-dupfis-eriang-mosses	818	0	260	3042	Riverine Low and Tall Scrub
G3.02	08/13/95	70.28227N	150.97682W	0	23	sw poor	41	6.6	260			nd	nd	nd	Open low willow-sedge	caraqu-sallan-luparc-mosses	416	6	334	3053	Riverine Wet Meadow
G4.01	08/14/95	70.25468N	150.66445W	17	24	poor	47	7.5	164			nd	nd	nd	Wet sedge-willow meadow	caraqu-eriang-carmem-salix	545	0	334	5053	Lowland Wet Meadow
G4.02	08/14/95	70.25595N	150.70216W	5	5	sw poor	30	nd	nd			nd	nd	nd	Mixed shrub-sedge tussock	erivag-salpla-salret-castet-ledpal	545	11	314	7058	Upland Tussock Meadow
G4.03	08/02/92	nd	nd	0	0	nd	nd	7.8				nd	nd	nd	Open low willow	sallan-salgla-arcalp-caraqu	380	62	260	7642	Upland Sandy Low Scrub
G4.04	08/03/92	nd	nd	0	0	nd	nd	8				nd	nd	nd	nd		380	62		nd	nd
G4.23	07/22/92	70.36458N	151.05511W	0	0	sw poor	nd	7.4				nd	nd	nd	Wet sedge-willow meadow	caraqu-erisch-salix sp.-scosco	416	8	334	3053	Riverine Wet Meadow
G5.01	08/14/95	70.31633N	150.2815W	3	3	sw poor	69	8	610			nd	nd	nd	Mesic sedge-willow tundra	eriang-caraqu-carsax-salret-mosses	816	0	320	4052	Lacustrine Moist Meadow
G5.02	08/14/95	70.31793N	150.28696W	14	14	sw poor	34	nd	nd			nd	nd	nd	Mesic sedge-willow tundra	carmis-caratr-salpla-salret-mosses	860	39	320	5052	Lowland Moist Meadow
G5.03	08/14/95	70.31758N	150.28512W	4	9		35	8.6	229			nd	nd	nd	Mesic sedge-willow tundra	caraqu-eriang-salpla-salret-mosses	444	0	320	3052	Riverine Moist Meadow
G6.01	08/14/95	70.24809N	150.20428W	8	13	nd	43	nd	nd			nd	nd	nd	Mixed shrub-sedge tussock	erivag-castet-dryint-salret-carbig-mosses	860	11	314	7058	Upland Tussock Meadow
G6.02	08/14/95	70.25014N	150.21101W	20	22	nd	36		460			nd	nd	nd	Sedge-*Dryas* tundra	carmem-carmis-caratr-eriang-dryint-salret-moses	860	0	320	5052	Lowland Moist Meadow
G6.03	08/14/95	70.25182N	150.21096W	21	21	nd	38		307			nd	nd	nd	Mesic sedge-willow tundra	caraqu-carmis-salpla-salret-mosses	860	0	320	5052	Lowland Moist Meadow
G6.04	08/01/96	70.1705N	150.90736W	0	0	sw poor	70			1620		nd	nd	nd	Closed low willow	sallan/equarv/mosses	818	0	242	3042	Riverine Low and Tall Scrub
G6.18	07/20/92	70.40238N	151.10581W	0	0	well	130	8.4				nd	nd	nd	Dry *Elymus*	elyare	380	0	10	2090	Coastal Barrens
G6.19	07/20/92	70.40151N	151.10779W	0	0	moderate	60	8				nd	nd	nd	Fresh grass marsh	arcful-dupfis-carsub	862	0	337	2053	Coastal Wet Meadow
G6.20	07/20/92	70.40158N	151.10644W	0	0	sw poor	54	8				nd	nd	nd	Halophytic sedge wet meadow	carsub	862	0	346	2053	Coastal Wet Meadow
G6.21	07/20/92	70.40109N	151.10938W	0	0	sw poor	nd	8.2				nd	nd	nd	Halophytic dwarf willow	salova-elyare-descae	862	0	295	2043	Coastal Dwarf Scrub
G6.32	07/22/92	70.39329N	151.12276W	0	9	nd	25					nd	nd	nd	Halophytic dwarf willow	salova-elyare-dupfis	862	0	295	2043	Coastal Dwarf Scrub
G6.33	07/22/92	70.39097N	151.1289W	0	0	nd	23					nd	nd	nd	Halophytic sedge wet meadow	carsub-pucphr-dupfis-stehum	862	0	346	2053	Coastal Wet Meadow
G7.01	08/05/96	70.44564N	150.86926W	0	0	poor	46			4980	6	nd	nd	nd	Halophytic sedge wet meadow	carsub-dupfis/salova	862	0	346	2053	Coastal Wet Meadow
G7.02	08/05/96	70.44681N	150.87828W	0	4	poor	42			17670	5	nd	nd	nd	Halophytic grass wet meadow	puccinspp-stehum	416	0	348	2053.1	Coastal Salt-killed Wet Meadow
G7.03	08/05/96	70.44493N	150.89074W	0	15	poor	55			16750	6	nd	nd	nd	Halophytic grass wet meadow	pucphr-carurs	416	0	345	2053	Coastal Wet Meadow

Appendix Table 6 (cont.).

Plot	Date	Degrees Latitude NAD27	Degrees Long. NAD27	Depth Surf Organic (cm)	Sum Organics (30 cm)	Drainage*	Depth Active Layer	Soil pH	Soil EC	Water EC	Water Temp (C)	Elev (1996 survey) (m)	Relative Elev. (m)	Elev Ratio (plot / inactive)	AK Vegetation Class	Dominant Species	Map Terrain Unit Code	Surf-form Code	Map Veg Code	Ecosite Code	Ecosite Code Name
G7.04	08/05/96	70.44228N	150.88887W	1	17	poor	41			2180		nd	nd	nd	Wet sedge meadow	eriang-caraqu-erirus-dupfis/salova	416	8	334	3053	Riverine Wet Meadow
G7.05	08/05/96	70.44105N	150.88987W	0	10	poor	30			10001	5	nd	nd	nd	Salt-killed wet meadow	stehum-carsub	416	5	348	2053.1	Coastal Salt-killed Wet Meadow
P1.01	08/12/95	70.2588N	150.65209W	11	11	poor	36	6.5	930			nd	0.80	0.80	Open low willow-sedge	eriang-salpla-betnan-salret	444	0	260	3042	Riverine Low and Tall Scrub
P1.02	08/12/95	70.25859N	150.64835W	3	17	sw poor	30	nd	nd			nd	3.21	3.22	Tussock tundra	erivag-salpla-dryint-castet-carbig	545	0	314	7058	Upland Tussock Meadow
P1.03	08/12/95	70.25852N	150.6444W	3	3	well	63	nd	nd			nd	2.24	2.25	*Dryas* tundra	dryint-equvar-salret-moss	816	0	270	7443	Upland Loamy Dwarf Scrub
P1.04	08/12/95	70.25856N	150.64066W	12	12	v poor	52	6.2	260			nd	2.15	2.15	Wet sedge meadow	caraqu-eriang-mosses	816	0	334	4053	Lacustrine Wet Meadow
P1.05	08/12/95	70.25858N	150.63543W	30	30	sw poor	34	nd	nd			nd	3.81	3.82	Mixed shrub-sedge tussock	salplan-betnan-erivag-carbig/castet-dryint	545	11	314	7058	Upland Tussock Meadow
P1.06	08/12/95	70.25857N	150.62988W	30	30	poor	35	5.9	19			nd	2.66	2.66	Sedge-*Dryas* tundra	eriang-carbig-dryint-salpla	545	9	320	5052	Lowland Moist Meadow
P2.01	08/13/95	70.26439N	150.53808W	0	0	excessive	nd	7.3	260			nd	0.25	0.13	Barren	gravel bar	441	0	0	3090	Riverine Barrens
P2.02	08/13/95	70.26496N	150.53828W	1	1	moderate	nd	6.5	110			nd	1.14	0.60	Open low willow-sedge	salpla-carbig-dryint-arclat	443	21	260	3042	Riverine Low and Tall Scrub
P2.03	08/13/95	70.26541N	150.53748W	4.5	4.5	well	nd	nd	nd			nd	1.89	1.00	*Dryas* -lichen tundra	dryint-castet-lichens	444	0	270	3043	Riverine Dwarf Scrub
P2.04	08/13/95	70.26563N	150.53456W	29	29	poor	40	6.2	400			nd	1.39	0.73	Mesic sedge-willow tundra	eriang-salpla	444	5	320	3052	Riverine Moist Meadow
P2.05	08/13/95	70.26619N	150.53261W	2	2	well	42	nd	nd			nd	3.66	1.93	*Dryas* -lichen tundra	dryint-castet/sauang/lichens-tomnit	545	21	270	7443	Upland Loamy Dwarf Scrub
P2.06	08/13/95	70.26707N	150.53189W	7	12	well	33	nd	nd			nd	5.06	2.67	Tussock tundra	erivag-castet-dryint-salpla-eriang	545	11	314	7058	Upland Tussock Meadow
P2.07	08/13/95	70.26899N	150.52951W	22	22	v poor	52	6.9	450			nd	4.78	2.53	Wet sedge meadow	caraqu-eriang-carbig	816	2	334	4053	Lacustrine Wet Meadow
P2.08	08/13/95	70.26988N	150.52617W	nd	nd	nd	nd	nd	nd	nd	nd	nd	4.80	2.54	Wet sedge meadow	caraqu-eriang-carbig	816	2	334	4053	Lacustrine Wet Meadow
P3.01	08/14/95	70.27623N	150.1519W	1	20.5	v poor	43	6.2	290			nd	2.22	na	Wet sedge meadow	eriang-carsax-caraqu-drepano	817	11	334	5053	Lowland Wet Meadow
P3.02	08/14/95	70.27691N	150.15013W	5	23	sw poor	29	nd	nd			nd	2.65	na	Mixed shrub-sedge tussock	erivag-castet-carbig-salpla-dryint-salret	817	11	314	7058	Upland Tussock Meadow
P3.03	08/14/95	70.27737N	150.14834W	2	28	nd	30	7.2	390			nd	2.77	na	Wet sedge meadow	eriang-caraqu-scosco-dryas	817	39	334	5053	Lowland Wet Meadow
P3.04	08/14/95	70.27774N	150.14587W	0	0	sw poor	64	nd	nd			nd	3.93	na	Mixed shrub-sedge tussock	erivag-carbig-dryint-tomnit	860	11	314	7058	Upland Tussock Meadow
P3.05	08/14/95	70.27777N	150.14324W	5	17	sw poor	34	nd	nd			nd	4.84	na	*Dryas* -sedge tundra	dryint-eriang-erivag-carbig	860	11	320	5052	Lowland Moist Meadow
P3.06	08/14/95	70.27783N	150.14123W	0	11	well	45	nd	nd			nd	4.52	na	*Dryas* -sedge tundra	dryint-carbig-tomnit	860	11	270	7443	Upland Loamy Dwarf Scrub
P3.07	08/14/95	70.27785N	150.13599W	1	1	sw poor	85	6.8	750			nd	1.80	na	Mesic sedge-willow tundra	caraqu-equvar-salova	816	0	320	4052	Lacustrine Moist Meadow
P3.08	08/14/95	70.27784N	150.134W	0	0	sw poor	55	nd	nd			nd	1.08	na	Dwarf willow tundra	salixspp-dryint-equvar-caraqu-lichens	816	31	270	7443	Upland Loamy Dwarf Scrub
P3.09	08/14/95	70.27805N	150.13217W	10	10	v poor	64	7.4	320			nd	0.01	na	Fresh sedge marsh	caraqu-utrvul	816	0	336	4054	Lacustrine Marsh
S3.0	07/30/96	nd	nd	0	10		56					nd	nd	nd	Open low willow	sallan-salgla-salpla-luparc-arclat	416	5	260	3042	Riverine Low and Tall Scrub
S3.100	07/31/96	nd	nd	2	21	poor	38			208		nd	nd	nd	Wet sedge-willow meadow	eriang-caraqu-salix spp.-luparc	416	5	334	3053	Riverine Wet Meadow
S3.20	07/30/96	nd	nd	4	18		43					nd	nd	nd	Open low willow-sedge	sallan-salpla-caraqu-luparc	416	5	260	3042	Riverine Low and Tall Scrub
S3.200	07/31/96	nd	nd	2	22	poor	42			178		nd	nd	nd	Mesic sedge-willow tundra	eriang-salix spp.-luparc/dryint	416	5	320	3052	Riverine Moist Meadow
S3.50	07/30/96	nd	nd	1	5		38					nd	nd	nd	na	na	416	5	na	nd	nd
S4.20	07/30/96	nd	nd	nd	nd		nd					nd	nd	nd	Open low willow-sedge	sallan-caraqu-luparc	417	8	334	5053	Lowland Wet Meadow
S4.50	07/30/96	nd	nd	nd	nd		nd					nd	nd	nd	Wet sedge-willow meadow	caraqu-sallan-dupfis/potpal	417	8	334	5053	Lowland Wet Meadow
T1.01	07/17/92	70.3915N	150.85958W	0	13	sw poor	23	6.6				nd	3.10	0.96	Wet sedge-willow meadow	caraqu-sallan-carbig-pedsud	416	5	334	3053	Riverine Wet Meadow
T1.02	07/17/92	70.3912N	150.86236W	0	0	sw poor	56	8.0				nd	1.60	0.50	Halophytic dwarf willow	salova-dupfis-arclat	415	0	295	2043	Coastal Dwarf Scrub
T1.03	07/17/92	70.39119N	150.86295W	0	0	sw poor	47	7.8				nd	1.40	0.43	Dry *Elymus*	elyare-descae-pucand	411	0	302	2053	Coastal Wet Meadow
T1.04	07/17/92	70.39119N	150.86343W	0	0	sw poor	55	7.4				nd	1.40	0.43	Halophytic sedge wet meadow	pucphy	411	0	346	2053	Coastal Wet Meadow
T1.05	07/17/92	70.39109N	150.86401W	0	1	sw poor	55	7.2				nd	0.80	0.25	Barren		411	0	0	2090	Coastal Barrens
T1.06	07/18/92	70.39082N	150.86497W	0	0	moderate	47	7.5				nd	2.10	1.03	Halophytic dwarf willow	salova-dupfis-arclat	415	0	295	2043	Coastal Dwarf Scrub
T1.07	07/18/92	70.39074N	150.86554W	0	0	well	40	7.6				nd	2.00	0.98	Open low willow	sallan-salret-arcrub-	415	0	260	3042	Riverine Low and Tall Scrub
T1.08	07/18/92	70.39064N	150.86592W	0	0	well	39	7.5				nd	2.70	1.33	*Dryas* -sedge tundra	dryint-salret-salgla-sallan-carbig-tomnit	416	0	270	3043	Riverine Dwarf Scrub
T1.09	07/18/92	70.39008N	150.86839W	10	28	sw poor	29	6.4				nd	3.00	1.48	Wet sedge meadow	caraqu-erisch	416	5	334	3053	Riverine Wet Meadow
T1.11	07/18/92	70.38959N	150.87023W	0	0	nd	38	6.8				nd	3.80	1.87	*Dryas* -sedge tundra	dryint-carbig-salret-tomnit	416	9	270	3043	Riverine Dwarf Scrub
T10.01	08/01/95	70.33024N	151.03485W	0	0	v poor	73	7	3710			1.14	1.14	0.39	Barren		818	0	0	2090	Coastal Barrens
T10.02	08/01/95	70.33047N	151.03289W	0	0	sw poor	62	6.6	8970			1.51	1.51	0.51	Halophytic grass wet meadow	pucphr-arcful-salarc	818	0	345	2053	Coastal Wet Meadow
T10.03	08/01/95	70.33146N	151.02714W	0	15	v poor	46	6.9	640			3.06	3.06	1.04	Wet sedge-grass meadow	caraqu-eriang-dupfis	416	5	334	3053	Riverine Wet Meadow
T10.04	08/01/95	70.33207N	151.02496W	0	3	sw poor	48	6.9	780			3.10	3.10	1.05	Open low willow-sedge	salpla-arclat-eriang-carbig-polbis	416	21	260	3042	Riverine Low and Tall Scrub
T10.05	08/01/95	70.33207N	151.02496W	0	13	v poor	43	6.9	600			3.13	3.13	1.06	Wet sedge-grass meadow	dupfis-caraqu	416	5	334	3053	Riverine Wet Meadow
T10.06	08/01/95	70.33576N	151.02063W	0	12	v poor	37	6.9	1420			2.95	2.95	1.00	Wet sedge-grass meadow	dupfis-caraqu-eriang	416	5	334	3053	Riverine Wet Meadow
T10.07	08/01/95	70.33728N	150.99731W	0	2	v poor	43	6.4	270			3.76	3.76	1.27	Wet sedge-willow meadow	eriang-caraqu-salixspp.-dryint	417	6	334	5053	Lowland Wet Meadow
T11.01	08/06/95	70.32321N	151.06529W	4	6	poor	46	6.3	765			2.40	2.70	0.99	Open low willow-sedge	caraqu-sallan-mosses	416	5	320	3052	Riverine Moist Meadow
T11.02	08/06/95	70.32302N	151.06774W	10	16	poor	38	6.6	520			2.60	2.90	1.07	Wet sedge-willow meadow	caraqu-dupfis-sallan-mosses	416	5	334	3053	Riverine Wet Meadow
T11.03	08/06/95	70.32194N	151.06738W	0	23	poor	36	6.6	285			2.83	3.13	1.17	Wet sedge-willow meadow	caraqu-eriang-salpla	417	6	334	5053	Lowland Wet Meadow
T11.04	08/06/95	70.32079N	151.07361W	3	3	v poor	32	6.4	760			2.01	2.31	0.83	Open low willow-sedge	sallan-caraqu-eriang-dryint-mosses	416	2	320	3052	Riverine Moist Meadow
T11.05	08/06/95	70.31924N	151.07865W	0	25	poor	37	6.9	530			2.40	2.70	0.99	Wet sedge-willow meadow	caraqu-salpla-dryint-mosses	416	5	334	3053	Riverine Wet Meadow
T11.06	08/06/95	70.31797N	151.08284W	7	7	sw excess	64	nd	nd			6.02	6.32	2.48	*Dryas* -sedge tundra	dryint-castet-carbib-tomnit	380	21	270	7643	Upland Sandy Dwarf Scrub
T11.07	08/06/95	70.3147N	151.09374W	3	23	poor	36	6.9	383			2.70	3.01	1.12	Open low willow-sedge	caraqu-salpla-sallan-eriang-mosses	416	5	334	3053	Riverine Wet Meadow
T12.01	07/31/95	70.26052N	151.01147W	0	1	well	90	7	1500			0.81	0.94	0.20	Barren		411	0	0	2090	Coastal Barrens
T12.02	07/31/95	70.26059N	151.00772W	0	0	nd	85	nd	nd			3.51	3.64	0.87	Closed tall willow	salala-equarv-bropum	415	0	221	3042	Riverine Low and Tall Scrub
T12.03	07/31/95	70.2607N	151.00426W	0	0	nd	95	nd	nd			2.34	2.47	0.58	Wet sedge-grass meadow	aloalp-descae-equarv	413	0	334	3053	Riverine Wet Meadow
T12.03b	08/04/96	70.26083N	151.00117W	2	2	poor	75					3.86	3.99	0.95	Closed low willow	sallan/equvar/mosses	415	0	242	3042	Riverine Low and Tall Scrub
T12.04	07/31/95	70.26086N	150.99923W	0	0	poor	75	7.2	1260			3.97	4.10	0.98	Open low willow-sedge	sallan-equcsi-caraqu-eriang-mosses	416	0	260	3042	Riverine Low and Tall Scrub
T12.05	07/31/95	70.26093N	150.9975W	0	0	nd	39	7.5	770			4.99	5.12	1.23	Open low willow	salgla-luparc-dryint-salret	416	21	260	3042	Riverine Low and Tall Scrub
T12.06	07/31/95	70.26102N	150.99484W	4	26	sw poor	45	6.6	325			4.45	4.58	1.10	Wet sedge-willow meadow	caraqu-eriang-equsci-sallan-moses	416	5	334	3053	Riverine Wet Meadow
T12.07	07/31/95	70.26119N	150.98845W	3	26	nd	40	6.6	350			4.17	4.30	1.03	Wet sedge-willow meadow	carcho-equsci-caraqu-carrar-sallan-mosses	416	2	334	3053	Riverine Wet Meadow
T12.08	07/31/95	70.26131N	150.98541W	2	5	sw poor	30	nd	nd			4.70	4.83	1.16	Open low willow-sedge	carbig-luparc-salixspp-dryint-arcalp-mosses	416	5	260	3042	Riverine Low and Tall Scrub
T12.09	07/31/95	70.26159N	150.97875W	5	24	poor	36	6.6	320			4.30	4.43	1.06	Wet sedge-willow meadow	caraqu-eriang-sallan-moses	416	5	334	3053	Riverine Wet Meadow
T12.10	08/04/96	70.26444N	150.95705W	1	1	moderate	34					nd	*4.80*	0.96	*Dryas* tundra	dryint-luparc-salpla-castet-salret	417	12	270	5042	Lowland Low Scrub
T13.01	08/08/95	70.28214N	150.92986W	0	0	nd	91	nd	nd			0.88	1.01	0.21	Barren		411	0	0	2090	Coastal Barrens
T13.02	08/08/95	70.28218N	150.92909W	0	0	well	40	nd	nd			3.23	3.36	0.76	Closed tall willow	salala-sallan-petfri-astalp	415	0	221	3042	Riverine Low and Tall Scrub
T13.03	08/08/95	70.2823N	150.92828W	0	0	well	88	nd	nd			3.74	3.87	0.88	Closed tall willow	salala-sallan-hedysar-equarv	415	0	221	3042	Riverine Low and Tall Scrub
T13.05	08/08/95	70.28254N	150.92644W	0	15	v poor	44	7.1	443			4.12	4.25	0.97	Wet sedge-willow meadow	caraqu-dupfis-sallan-mosses	416	2	334	3053	Riverine Wet Meadow
T13.06	08/08/95	70.28451N	150.91402W	3	21	v poor	39	6.5	178			4.70	4.83	1.10	Wet sedge meadow	caraqu-carsax-carbig-eriang-mosses	416	5	334	3053	Riverine Wet Meadow
T13.07	08/08/95	70.28618N	150.90418W	30	30	poor	43	6.9	590			4.73	4.86	1.11	Mesic sedge-willow tundra	carbig-eriang-carsax-salixspp.-mosses	417	5	320	5052	Lowland Moist Meadow
T14.01	08/17/96	70.18841N	150.86932W	0	nd	v poor	nd					nd	-0.43	-0.08	Barren		411	0	0	2090	Coastal Barrens
T14.02	08/17/96	70.18831N	150.86877W	0	2	v poor	93			920	8	nd	-0.07	-0.01	Seral herb	eqisci-descae	411	0	10	2090	Coastal Barrens
T14.03	08/17/96	70.18968N	150.86616W	0	0	moderate	115					nd	0.09	0.02	Open tall willow	salala/sallan/equarv	415	0	231	3042	Riverine Low and Tall Scrub

Appendix Table 6 (cont.).

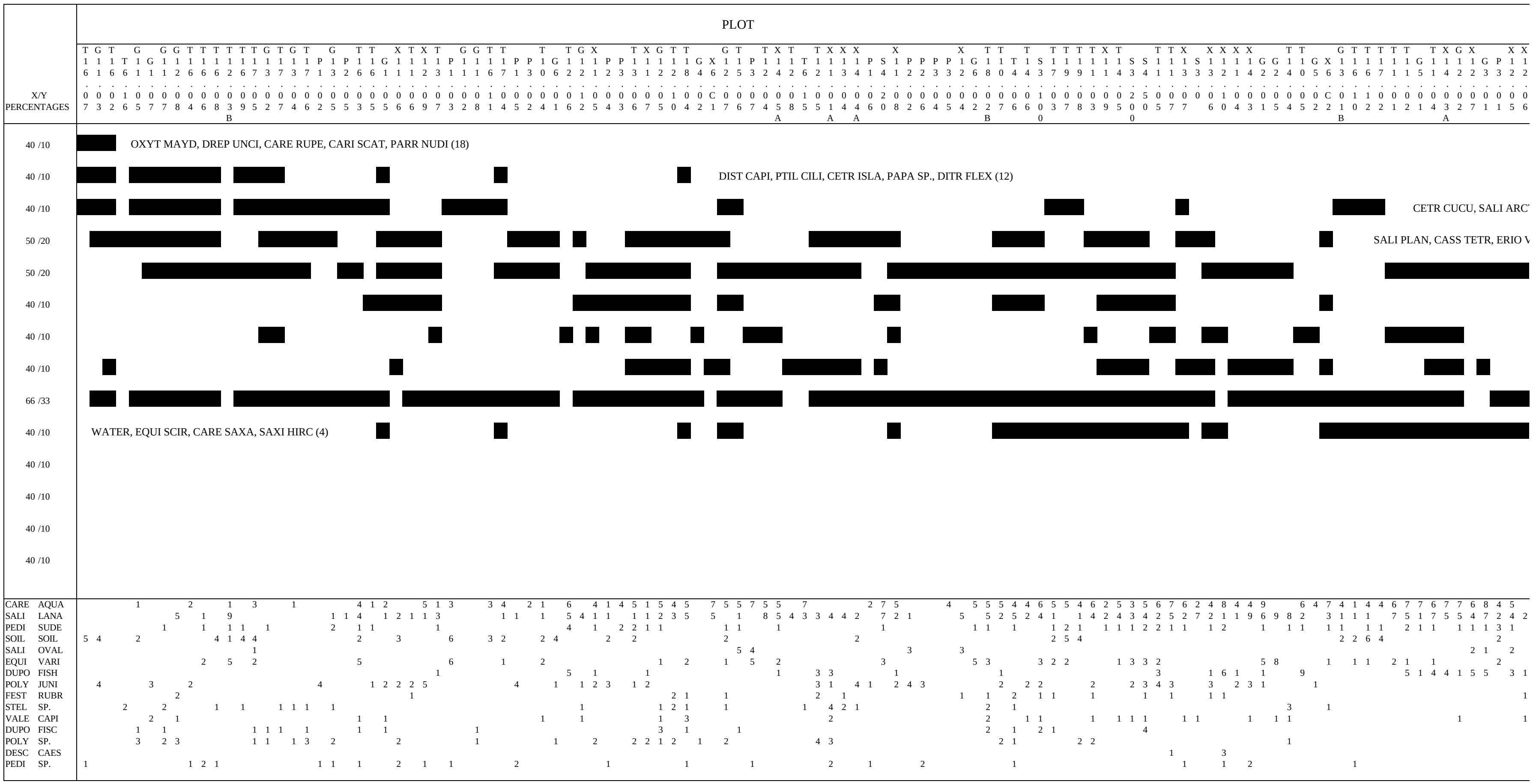
Plot	Date	Degrees Latitude NAD27	Degrees Long. NAD27	Depth Surf Organic (cm)	Sum Organics (30 cm)	Drainage*	Depth Active Layer	Soil pH	Soil EC	Water EC	Water Temp (C)	Elev (1996 survey) (m)	Relative Elev. (m)	Elev Ratio (plot / inactive)	AK Vegetation Class	Dominant Species	Map Terrain Unit Code	Surf-form Code	Map Veg Code	Ecosite Code	Ecosite Code Name
T14.04	08/17/96	70.18818N	150.86774W	4	5.5	poor	48					nd	1.14	0.23	Open low willow	sallan-luparc-salgla/arcrub-dryint	416	6	260	3042	Riverine Low and Tall Scrub
T14.05	08/01/96	70.18803N	150.84601W	2	17	poor	43			262	11.8	nd	5.19	1.03	Wet sedge meadow	caraqu-luparc-carcho/scosco	416	5	334	3053	Riverine Wet Meadow
T14.06	08/01/96	70.18783N	150.84371W	3	19	poor	35			76	11.1	nd	5.32	1.06	Mesic sedge-willow tundra	eriang-carbig/equsci/tomnit	417	8	320	5052	Lowland Moist Meadow
T15.02	08/14/96	70.43955N	150.6773W	0	0	moderate	85	8.3	1700			nd	1.58	0.84	Halophytic grass wet meadow	puccin spp.-salova-agrbor	415	0	345	2053	Coastal Wet Meadow
T15.03	08/14/96	70.43919N	150.68221W	1	1	v poor	79	7.1	1090	>1999		nd	1.34	0.72	Halophytic dwarf willow	salova-dupfis	415	0	295	2043	Coastal Dwarf Scrub
T15.04	08/14/96	70.43781N	150.69177W	1	1.5	moderate	86	8.9	190			nd	2.99	1.60	*Dryas* tundra	dryint-astalp-salova	380	62	270	7643	Upland Sandy Dwarf Scrub
T15.05	08/14/96	70.43811N	150.69538W	1	16	v poor	41			1180	4	nd	1.82	0.97	Halophytic dwarf willow	salova-carsub/depan sp.	416	2	295	2043	Coastal Dwarf Scrub
T15.06	08/14/96	70.43826N	150.69798W	6	6	v poor	41			590	6	nd	1.90	1.02	Wet sedge meadow	eriang-caraqu/salova-Salarc/mosses	416	6	336	3073	Riverine Deep-polygon Complex
T15.07	08/14/96	70.43808N	150.70039W	0	17	v poor	46			>1999	4	nd	1.18	0.63	Halophytic grass wet meadow	dupfis-carsub-eriang	416	2	345	2053	Coastal Wet Meadow
T15.08	08/14/96	70.43833N	150.70274W	0	18	v poor	44			>1999	7	nd	1.10	0.59	Wet sedge-grass meadow	dupfis-eriang-erirus	416	2	345	2053	Coastal Wet Meadow
T15.09	08/14/96	70.4389N	150.70554W	1	16	v poor	45			>1999	7	nd	1.17	0.63	Halophytic dwarf willow	salova-dupfis-eriang	416	0	295	2043	Coastal Dwarf Scrub
T15.10	08/14/96	70.43894N	150.70894W	1	9	v poor	33			1510		nd	0.83	0.44	Wet sedge-grass meadow	dupfis-caraqu-arcful	413	0	337	3054	Riverine Marsh
T16.00	08/02/96	70.23738N	150.26961W	0	0	well	nd				12	nd	-0.22	-0.11	River	caraqu	910	0	0	3090	Riverine Barrens
T16.01	08/02/96	70.23711N	150.26961W	0	0	well	nd	8.3	30			nd	1.72	0.84	Open low willow	salgla-sallan-salale/astalp	380	62	260	7642	Upland Sandy Low Scrub
T16.02	08/02/96	70.23671N	150.26998W	1	4	well	89					nd	2.50	1.23	*Dryas* tundra	dryint-salret/mosses	444	3	270	3043	Riverine Dwarf Scrub
T16.03	08/02/96	70.23638N	150.27071W	3	3	moderate	99			270	7	nd	1.90	0.93	*Dryas* -sedge tundra	dryint-equvar-salret-carex spp./mosses	444	0	320	3052	Riverine Moist Meadow
T16.04	08/02/96	70.23589N	150.27139W	5	16	poor	28	6.8	90			nd	2.47	1.21	*Dryas* -sedge tundra	dryint-carbig-erivag/mosses	452	11	320	5052	Lowland Moist Meadow
T16.05	08/02/96	70.23538N	150.27212W	30	30	poor	44			260		nd	2.52	1.24	Wet sedge meadow	eriang-carmem-carsax	452	0	334	5053	Lowland Wet Meadow
T16.06	08/02/96	70.235N	150.27283W	6	6	sw poor	49	7.6	60			nd	3.44	1.69	*Dryas* -sedge tundra	dryint-carbig-eriang/mosses	330	54	270	7443	Upland Loamy Dwarf Scrub
T16.07	08/02/96	70.23485N	150.2732W	2	5	moderate	nd	8.3	80			nd	5.70	2.79	*Dryas* -lichen tundra	dryint-castet/lichens	860	98	270	7443	Upland Loamy Dwarf Scrub
T16.08	08/03/96	70.23464N	150.27349W	6	6	sw poor	55	7.6	80			nd	8.58	4.21	*Dryas* -sedge tundra	dryint-carbig-salarc/tomnit	860	23	270	7443	Upland Loamy Dwarf Scrub
T16.09	08/03/96	70.23353N	150.27486W	10	10	poor	41	6.5	88			nd	9.87	4.84	Sedge-*Dryas* tundra	eriang-erivag-carbig/dryint	860	21	320	5052	Lowland Moist Meadow
T16.10	08/03/96	70.23311N	150.27576W	17	17	poor	46	6.5	59.8			nd	10.02	4.91	Sedge-*Dryas* tundra	carsax-carmis-carmem/dryint	860	21	320	5052	Lowland Moist Meadow
T16.11	08/03/96	70.23256N	150.27666W	22	22	poor	45	6.5	344			nd	10.09	4.95	Sedge-*Dryas* tundra	carmem-eriang/dryint	817	39	320	5052	Lowland Moist Meadow
T16.12	08/03/96	70.23178N	150.27742W	30	30	v poor	46			548	12.8	nd	10.04	4.92	Wet sedge meadow	carmem-carsax-caraqu	817	9	336	5071	Lowland Thaw Complex
T17.01	08/08/96	70.24535N	150.37411W	9	9	poor	44			249	7	nd	0.63	na	Wet sedge meadow	erirus-eriang-caraqu	816	0	334	4053	Lacustrine Wet Meadow
T17.02	08/08/96	70.24539N	150.37296W	30	30	v poor	42			282	6	nd	0.52	na	Wet sedge meadow	caraqu-eriang	816	0	334	4053	Lacustrine Wet Meadow
T17.03	08/08/96	70.24544N	150.3686W	17	17	v poor	66			659	8	nd	0.61	na	Wet sedge meadow	eriang-carsax-caraqu	816	2	334	4053	Lacustrine Wet Meadow
T17.04	08/08/96	70.24567N	150.3612W	19	19	v poor	84			793	7	nd	1.05	na	Wet sedge meadow	caraqu-carmem	816	2	334	4053	Lacustrine Wet Meadow
T17.05	08/08/96	70.24581N	150.35863W	3	3	poor	88			658		nd	1.61	na	Sedge-*Dryas* tundra	carbig-eriang/castet-dryint	817	3	320	5052	Lowland Moist Meadow
T17.06	08/08/96	70.24624N	150.35669W	6	18	poor	34					nd	2.22	na	Mixed shrub-sedge tussock	erivag-salpla-eriang/dryint-castet	860	3	314	7058	Upland Tussock Meadow
T17.07	08/08/96	70.24766N	150.35291W	15	15	poor	30					nd	2.23	na	*Dryas* -sedge tundra	erivag-eriang/dryint	860	11	320	5052	Lowland Moist Meadow
T18.01	08/15/96	70.29478N	150.72934W	0	0	moderate	90					2.27	2.27	0.59	Dry hair-grass	descae/equvar-stellaria sp.	411	0	10	2090	Coastal Barrens
T18.01b	08/15/96	70.2951N	150.7296W	3	3	moderate	99	7.9	130			3.93	3.93	1.02	Closed tall willow	salala/astumb-astabo	415	0	221	3042	Riverine Low and Tall Scrub
T18.02	08/15/96	70.29534N	150.72979W	1	2	poor	65					3.84	3.84	1.00	Open low willow	sallan/equvar-eriang	415	0	260	3042	Riverine Low and Tall Scrub
T18.02b	08/15/96	70.29612N	150.73608W	1	4	v poor	49			960		3.80	3.80	0.99	Mesic sedge-willow tundra	eriang-sallan-caraqu/equarv	416	0	320	3052	Riverine Moist Meadow
T18.03	08/15/96	70.29617N	150.73036W	2	6	v poor	40					3.79	3.79	0.98	Wet sedge meadow	caraqu-eriang-dupfis	416	0	334	3053	Riverine Wet Meadow
T18.04	08/15/96	70.29928N	150.73268W	10	12	v poor	40					4.34	4.34	1.13	Wet sedge meadow	caraqu-sallan-eriang/potpal-equsci	417	8	334	5053	Lowland Wet Meadow
T19.01	08/11/96	70.34431N	150.90804W	0	3	poor	82			>1999	5	0.15	0.13	0.06	Seral grass	pucphr	411	0	10	2090	Coastal Barrens
T19.02	08/11/96	70.34436N	150.90859W	0	0	poor	82	8	1220			0.81	0.79	0.31	Seral grass	pucphr	411	0	10	2090	Coastal Barrens
T19.03	08/11/96	70.34444N	150.9093W	0	0	poor	66	8.2	410			1.14	1.12	0.44	Midgrass-forb	poaalp-petfri	411	0	10	2090	Coastal Barrens
T19.04	08/11/96	70.34448N	150.90996W	0	0	sw poor	75	8	120			1.18	1.16	0.46	Open tall willow	salala/salova	415	0	231	3042	Riverine Low and Tall Scrub
T19.05	08/10/96	70.34448N	150.91029W	0	0	moderate	52	7.2	130			2.31	2.29	0.90	Open low willow	sallan/equsci/tomnit	415	0	260	3042	Riverine Low and Tall Scrub
T19.06	08/11/96	70.34455N	150.91148W	10	17	v poor	44			350	5	2.44	2.42	0.95	Wet sedge meadow	caraqu-erirus/mosses	416	2	334	3053	Riverine Wet Meadow
T19.07	08/11/96	70.345N	150.91556W	18	22	v poor	46			330	8	3.11	3.09	1.21	Wet sedge meadow	eriang-caraqu/drepanocladus sp.	416	5	334	3053	Riverine Wet Meadow
T19.08	08/11/96	70.34524N	150.91948W	30	30	v poor	43			310	8	3.35	3.33	1.30	Wet sedge meadow	eriang-caraqu/scosco	417	6	334	5053	Lowland Wet Meadow
T2.12	07/17/92	nd	nd	0	0	sw poor	52	7.6				nd	0.50	0.16	Barren	barren	411	0	0	2090	Coastal Barrens
T2.13	07/17/92	nd	nd	0	0	moderate	63	8.2				nd	2.00	0.62	Dry *Elymus*	elyare-artarc-descae-chrbip	411	0	10	2090	Coastal Barrens
T2.14	07/18/92	70.39396N	150.86456W	0	0	moderate	58	7.7				nd	2.50	0.78	Closed low willow	salgla-arcrub-salret-astalp	415	0	242	3042	Riverine Low and Tall Scrub
T2.15	07/18/92	70.39406N	150.86669W	1	1	moderate	42	7.3				nd	2.90	0.90	*Dryas* -sedge tundra	dryint-salret-arclat-carbig-tomnit	416	0	270	3043	Riverine Dwarf Scrub
T2.16	07/18/92	70.39397N	150.86931W	0	28	sw poor	29	6.8				nd	3.10	0.97	Wet sedge-willow meadow	caraqu-erisch-eriang-sallan-salpla-scosco	416	5	334	3053	Riverine Wet Meadow
T2.17	07/18/92	70.39408N	150.87259W	30	30	nd	33	5.7				nd	3.60	1.12	Wet sedge meadow	caraqu-erisch	416	5	334	3053	Riverine Wet Meadow
T4.01	07/21/92	70.36424N	151.06989W	0	2	moderate	67	7.6				nd	0.60	0.21	Halophytic grass wet meadow	pucphr	411	0	0	2090	Coastal Barrens
T4.02	07/21/92	70.36418N	151.07248W	0	0	moderate	56	7.4				nd	2.10	0.72	Halophytic dwarf willow	salova-descae	415	0	295	2043	Coastal Dwarf Scrub
T4.03	07/21/92	70.36423N	151.07432W	0	0	v poor	nd	6.2				nd	1.50	0.52	Fresh grass marsh	arcful-hipvul	413	0	337	3054	Riverine Marsh
T4.04	07/21/92	70.3635N	151.07887W	6	6	poor	36	5.1				nd	2.30	0.79	Wet sedge-willow meadow	caraqu-eriang-sallan	413	0	334	3053	Riverine Wet Meadow
T4.05	07/21/92	70.36264N	151.08375W	2	11	sw poor	39	5.2				nd	2.90	1.00	Wet sedge-willow meadow	caraqu-salpla-eriang	416	8	334	3053	Riverine Wet Meadow
T4.06	08/09/96	70.36397N	151.08605W	1	9	poor	36			530	5	nd	2.25	0.77	Mesic sedge-willow tundra	eriang-sallan-caraqu-salpla	417	6	334	5053	Lowland Wet Meadow
T5.06	07/21/92	70.39888N	151.08529W	0	5	sw poor	68	7.2				nd	0.20	0.19	Barren		411	0	0	2090	Coastal Barrens
T5.08	07/21/92	70.39896N	151.08288W	0	2	moderate	27	7.6				nd	1.40	1.32	Halophytic dwarf willow	salova-caraqu	415	0	295	2043	Coastal Dwarf Scrub
T5.09	07/21/92	70.39888N	151.08102W	0	4	poor	30	6.4				nd	1.10	1.04	Salt-killed wet meadow	pucphr-stehum	818	0	348	2053.1	Coastal Salt-killed Wet Meadow
T5.10b	07/21/92	nd	nd	nd	nd	moderate	nd					nd	0.90	0.85	Seral herb	polbis-poalan-stellaria sp.	416	0	10	3090	Riverine Barrens
T5.11	07/21/92	70.39886N	151.07765W	5	5	sw poor	20	5.4				nd	2.50	2.37	Tussock tundra	eriang-betnan-salpla-carbig	545	12	314	7058	Upland Tussock Meadow
T6.12	07/20/92	70.39863N	151.10768W	0	0	poor	58	8				nd	0.60	nd	Halophytic grass wet meadow	pucphr	862	0	0	2090	Coastal Barrens
T6.13	07/20/92	70.39879N	151.10774W	0	0	well	77	7.6				nd	2.60	nd	*Dryas* tundra	dryint-salret-salgla	380	0	270	7643	Upland Sandy Dwarf Scrub
T6.14	07/20/92	70.39875N	151.10823W	0	0	well	87	7.9				nd	3.10	nd	Open low willow	salgla-elyare-arclat	380	0	260	7642	Upland Sandy Low Scrub
T6.15	07/20/92	70.3981N	151.10808W	0	2	nd	24	7.4				nd	2.40	nd	Sedge-*Dryas* tundra	caraqu-dryint-salret/tomnit	545	11	320	5052	Lowland Moist Meadow
T6.16	07/20/92	70.3964N	151.10708W	0	0	moderate	26	6				nd	3.70	nd	Tussock tundra	eriang/dryint-salret-salpla/tomnit	545	6	314	7058	Upland Tussock Meadow
T6.17	07/20/92	70.39879N	151.10849W	0	0	sw poor	64	8.6				nd	1.10	nd	Dry *Elymus*	elyare	411	0	10	2090	Coastal Barrens
X1.00	07/28/92	70.33106N	150.74766W	0	0	excessive	nd	7.5				0.83	0.88	0.11	Barren		411	0	0	2090	Coastal Barrens
X1.01	07/28/92	70.33143N	150.74889W	0	0	excessive	nd	nd				1.86	1.92	0.24	Dry *Elymus*	elyare-chrbip	411	0	10	2090	Coastal Barrens
X1.02	07/28/92	70.33177N	150.75065W	0	0	sw excess	118	7.7				2.75	2.81	0.35	Dry *Elymus*	elyare-chrbip-salale	380	0	10	2090	Coastal Barrens
X1.02a	07/28/92	nd	nd	0	0	well	62	7.9				3.17	3.23	0.41	Dry hair-grass	descae-chybip-salale-stecra	380	0	10	2090	Coastal Barrens
X1.03	07/27/92	70.332N	150.752W	0	0	excessive	51	7.8				3.69	3.75	0.47	Open tall willow	salale/equvar-junarc	415	0	231	3042	Riverine Low and Tall Scrub
X1.04	07/27/92	nd	nd	0	0	nd	nd	7.8				4.06	4.12	0.52	Open tall willow	salale/sallan-salgla	380	62	231	7642	Upland Sandy Low Scrub
X1.05	07/27/92	70.33345N	150.75646W	3	3	v poor	50	7.1				2.35	2.41	0.30	Wet sedge-willow meadow	caraqu-eriang-sallan	413	0	334	3053	Riverine Wet Meadow

Appendix Table 6 (cont.).

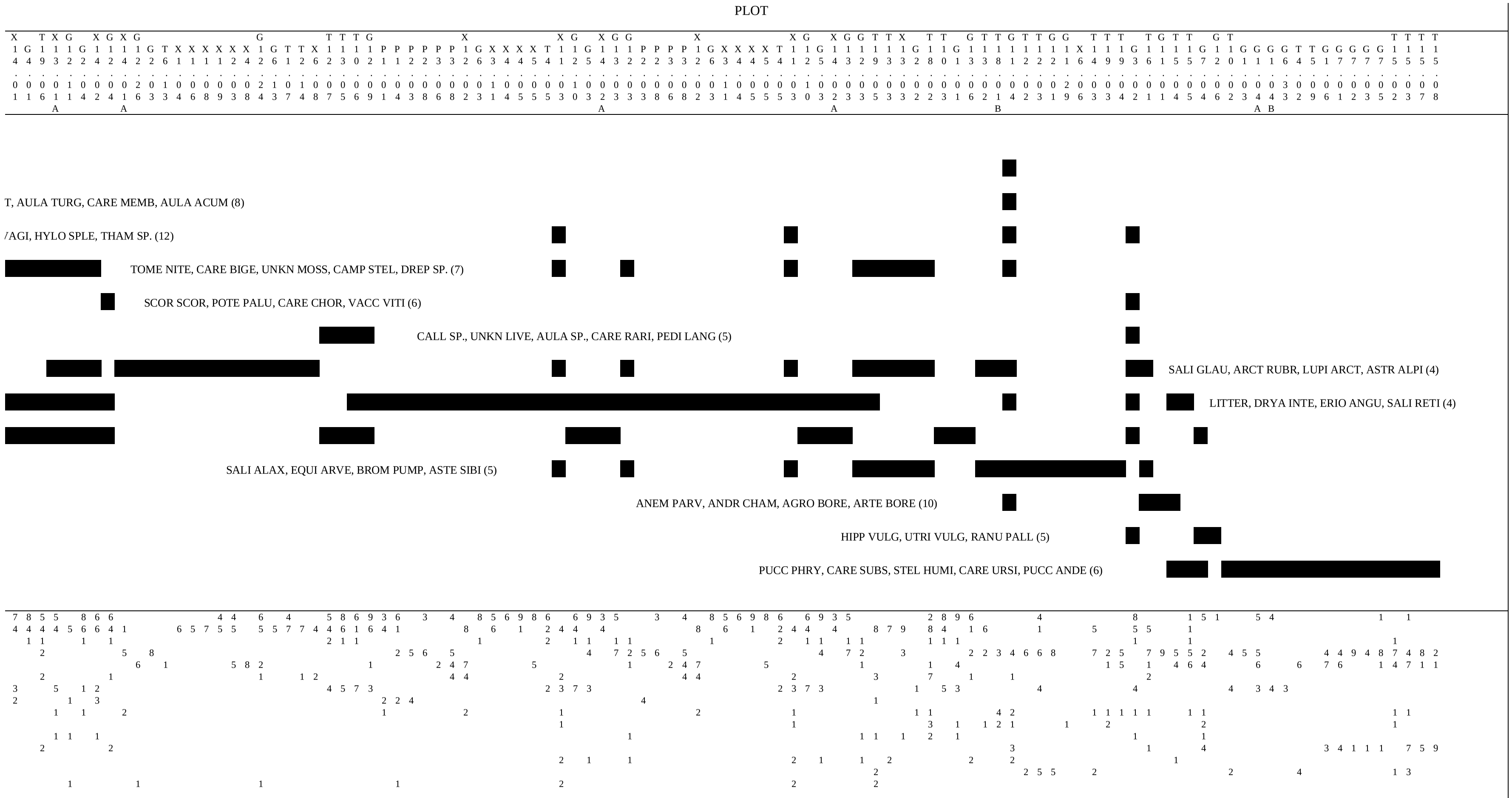
Plot	Date	Degrees Latitude NAD27	Degrees Long. NAD27	Depth Surf Organic (cm)	Sum Organics (30 cm)	Drainage*	Depth Active Layer	Soil pH	Soil EC	Water EC	Water Temp (C)	Elev (1996 survey) (m)	Relative Elev. (m)	Elev Ratio (plot / inactive)	AK Vegetation Class	Dominant Species	Map Terrain Unit Code	Surf-form Code	Map Veg Code	Ecosite Code	Ecosite Code Name
X1.06	07/27/92	70.33407N	150.76055W	0	0	sw excess	71	8.2				9.43	9.49	1.21	*Dryas* tundra	dryint-arcrub-sallan-astalp	380	62	270	7643	Upland Sandy Dwarf Scrub
X1.07	07/27/92	70.33453N	150.76263W	3	3	moderate	30	7.4				7.78	7.84	1.00	Open low willow-sedge	sallan-caraqu-eriang	416	2	334	3053	Riverine Wet Meadow
X1.08	07/25/92	70.33515N	150.76693W	0	0	excessive	nd					6.10	6.16	0.78	Open low willow	sallan/dryint-arcrub-salret-poa sp.	380	62	260	7642	Upland Sandy Low Scrub
X1.09	07/25/92	70.3484N	150.76832W	nd	nd	poor	nd	8				6.16	6.22	0.79	Wet sedge-willow meadow	carex sp.-sallan-eriang-caraqu-carbig	416	2	334	3053	Riverine Wet Meadow
X1.10	07/28/92	nd	nd	0	0	sw poor	45	5.9				3.20	3.26	0.41	insufficient data		416	8	334	3053	Riverine Wet Meadow
X11.01	08/05/95	70.324N	150.88759W	0	4	sw poor	74					0.82	0.91	0.10	Barren		411	0	0	2090	Coastal Barrens
X11.01a	08/11/95	nd	nd	5	5	well	38	nd	nd			3.25	3.34	0.42	Open low willow	salpla-salgla-dryint-salret-luparc	416	5	242	3042	Riverine Low and Tall Scrub
X11.02	08/05/95	70.324N	150.88759W	0	6	sw poor	68					1.21	1.30	0.15	Dry hair-grass	descae-equarv-stelhum-chrbip	411	0	10	2090	Coastal Barrens
X11.03	08/05/95	70.32445N	150.88797W	0	2	nd	56	nd	nd			3.67	3.76	0.47	Open low willow	sallan-luparc-salgla-dryint-tomnit	415	0	260	3042	Riverine Low and Tall Scrub
X11.04	08/05/95	70.32502N	150.88932W	2	6	poor	34	nd	nd			3.25	3.34	0.42	*Dryas* -sedge tundra	caraqu-carbig-eriang-dryint-salret	416	5	320	3052	Riverine Moist Meadow
X11.05	08/05/95	70.32646N	150.8925W	30	30	v poor	40	nd	nd			3.71	3.80	0.48	Wet sedge meadow	carsax-caraqu-eriophspp-scisci	416	5	334	3053	Riverine Wet Meadow
X11.06	08/05/95	70.32729N	150.89699W	1	1	well	90	nd	nd			8.73	8.82	1.12	*Dryas* tundra	dryint-castet-salret-carbig-mosses	380	21	270	7643	Upland Sandy Dwarf Scrub
X11.07	08/05/95	70.3283N	150.90232W	2	2	sw poor	32	nd	nd			8.20	8.29	1.05	Sedge-*Dryas* tundra	carbig-dryint-mosses	380	5	320	5052	Lowland Moist Meadow
X11.08	08/05/95	70.32967N	150.91078W	5	24	poor	37	nd	nd			4.24	4.33	0.54	Sedge-*Dryas* tundra	caraqu-dryint-mosses	416	6	320	3052	Riverine Moist Meadow
X11.09	08/05/95	70.33056N	150.91679W	0	0	poor	45	nd	nd			3.92	4.01	0.50	Sedge-*Dryas* tundra	carbig-eriang-dryint-mosses	417	8	320	5052	Lowland Moist Meadow
X11.10	08/05/95	70.32463N	150.90467W	0	0	sw poor	85	nd	nd			0.82	0.91	0.10	Dry hair-grass	descae-pucphr	411	0	10	2090	Coastal Barrens
X12.01	08/02/95	70.34436N	151.06198W	0	0	nd	95	nd	nd			0.30	0.43	0.13	Barren		411	0	0	2090	Coastal Barrens
X12.01a	08/06/95	nd	nd	0	16	v poor	39		715			nd	nd	nd	Wet sedge-willow meadow	caraqu-eriang-sallan	416	2	334	3053	Riverine Wet Meadow
X12.02	08/03/95	70.34458N	151.06004W	1	2	well	60	nd	nd			2.48	2.61	1.03	Closed low willow	sallan-salova	415	0	242	3042	Riverine Low and Tall Scrub
X12.03	08/03/95	70.34379N	151.05919W	2	2	nd	40	6.9	1810			1.78	1.91	0.74	Halophytic dwarf willow	salova-caraqu-dupfis-equvar	413	0	295	2043	Coastal Dwarf Scrub
X12.04	08/03/95	70.34384N	151.05748W	1	1	sw poor	45	nd	nd			2.69	2.82	1.12	*Dryas* tundra	dryint-sallan-salret-equsci	416	0	270	3043	Riverine Dwarf Scrub
X12.05	08/03/95	70.34383N	151.05519W	2	10	v poor	37	7	600			2.35	2.48	0.98	Wet sedge meadow	caraqu-eriang-equsci-sallan	416	0	334	3053	Riverine Wet Meadow
X12.06	08/03/95	70.34364N	151.05561W	0	2	sw poor	48	7.3	757			2.59	2.72	1.07	*Dryas* -sedge tundra	dryint-carbig-equsci-tomnit	416	0	270	3043	Riverine Dwarf Scrub
X12.07	08/03/95	70.34359N	151.04913W	3	19	v poor	36	6.6	670			2.12	2.25	0.88	Wet sedge-grass meadow	caraqu-dupfis-sallan-equsci-mosses	416	2	334	3053	Riverine Wet Meadow
X12.09	08/06/95	70.34373N	151.05514W	1	27	v poor	40	6.2	199			2.79	2.92	1.16	Open low willow-sedge	salpla-carbig-eriang-castet-tomnit	417	6	334	5053	Lowland Wet Meadow
X12.10	08/06/95	70.34359N	151.03581W	3	24	nd	36	nd	nd			2.23	2.36	0.93	Wet sedge-willow meadow	caraqu-dupfis-salpul/camste	416	5	334	3053	Riverine Wet Meadow
X13.01	08/10/95	70.33305N	150.82646W	0	1.5	sw poor	43	nd	nd			1.02	1.02	0.24	Barren		411	0	0	2090	Coastal Barrens
X13.01a	08/10/95	70.33327N	150.8317W	1	1	poor	55	7.3	746			6.64	6.64	1.55	*Dryas* -sedge tundra	caraqu-dupfis-dryint-sallan-mosses	416	5	320	3052	Riverine Moist Meadow
X13.03	08/10/95	70.33311N	150.82485W	0	0	sw poor	78	nd	nd			2.89	2.89	0.68	Closed low willow	salgla-salala-astalp	415	0	242	3042	Riverine Low and Tall Scrub
X13.04	08/10/95	70.33349N	150.82249W	5	5	sw poor	44	nd	nd			3.87	3.87	0.91	*Dryas* tundra	dryint-salret-hylspl-tomnit	416	0	270	3043	Riverine Dwarf Scrub
X13.05	08/10/95	70.33376N	150.82023W	30	30	v poor	37	7.1	340			4.05	4.05	0.95	Wet sedge-willow meadow	caraqu-eriang-sallan	416	5	334	3053	Riverine Wet Meadow
X13.06	08/10/95	70.33456N	150.81311W	0	0	poor	40	7.3	184			4.54	4.88	1.06	Wet sedge-willow meadow	carsax-caraqu-salret-scosco	416	5	334	3053	Riverine Wet Meadow
X13.07	08/05/96	nd	nd	9	13	poor	42			260		4.35	4.69	1.02	*Dryas* -sedge tundra	dryint-caraqu-eriang-salret/mosses	417	8	320	5052	Lowland Moist Meadow
X14.01	08/04/95	70.24665N	150.82264W	2	19.5	poor	36	6.7	1560			5.24	5.47	0.89	Wet sedge meadow	caraqu-eqisci-dryint-mosses	416	5	334	3053	Riverine Wet Meadow
X14.01a	08/09/95	70.24471N	150.85483W	0	0	well	48	nd	nd			7.36	7.59	1.25	Open low willow	salgla-arcrub-dryint	380	62	242	7642	Upland Sandy Low Scrub
X14.02	08/04/95	70.24496N	150.82263W	1	21	poor	49	6.4	499			5.65	5.88	0.96	Wet sedge-willow meadow	caraqu-sallan-eriang-luparc	417	6	334	5053	Lowland Wet Meadow
X14.02a	08/09/95	70.24432N	150.85784W	0	15	nd	54	7.6	1098			5.72	5.95	0.97	Wet sedge-willow meadow	caraqu-eriang-sallan-equsci	416	5	334	3053	Riverine Wet Meadow
X14.03	08/04/95	70.24713N	150.82572W	0	13	nd	63	nd	nd			5.24	5.47	0.89	Closed low willow	sallan-oxyarc-dryint	416	5	242	3042	Riverine Low and Tall Scrub
X14.03a	08/09/95	70.24401N	150.85991W	10	15	sw poor	44	6.9	615			6.05	6.28	1.03	*Dryas* -sedge tundra	caraqu-sallan-dryint-salret-tomnit	416	5	320	3052	Riverine Moist Meadow
X14.04a	08/09/95	70.24379N	150.86201W	4	4	well	43	nd	nd			6.64	6.87	1.13	Open low willow	dryint-salgla-tomnit	380	62	260	7642	Upland Sandy Low Scrub
X14.05a	08/09/95	70.24349N	150.86413W	20	20	v poor	38	7.2	432			4.13	4.36	0.70	wet sedge-willow	caraqu-sallan-eriang-mosses	818	0	334	3053	Riverine Wet Meadow
X2.01	07/27/92	70.36535N	150.62791W	0	0	moderate	58	7.8				nd	nd	nd	Open low willow-sedge	sallan-caraqu/equvar/salova	416	0	260	3042	Riverine Low and Tall Scrub
X2.03	07/28/92	70.36426N	150.62481W	0	0	excessive	80	8.4				4.63	4.76	1.45	Open low willow	salgla-sallan/salova-caraqu-salale	380	62	260	7642	Upland Sandy Low Scrub
X2.04	07/28/92	70.36366N	150.62306W	0	0	excessive	nd					3.86	4.00	1.21	Dry *Elymus*	elyare-salale	380	62	10	7690	Upland Sandy Barrens
X2.05	07/29/92	70.36319N	150.62178W	0	0	excessive	nd					1.79	1.92	0.56	Dry *Elymus*	elyare	380	62	10	7690	Upland Sandy Barrens
X2.08	07/29/92	70.36267N	150.62024W	0	0	well	nd					0.60	0.73	0.19	Barren		411	0	0	2090	Coastal Barrens
X2.09	07/29/92	70.35757N	150.6055W	0	0	sw poor	47	7.8				3.86	4.00	1.21	Mesic sedge-willow tundra	caraqu-sallan-eriang-salgla-salpla	545	11	320	5052	Lowland Moist Meadow
X3.01	07/30/92	70.38786N	150.65452W	0	0	poor	65	7.4				0.48	0.61	0.28	Barren		411	0	0	2090	Coastal Barrens
X3.04	07/30/92	70.38964N	150.66278W	0	0	sw excess	72	8.1				1.54	1.68	0.89	Dry *Elymus*	elyare-descae/salova	380	62	10	7690	Upland Sandy Barrens
X3.06	07/30/92	70.38194N	150.64911W	0	0	sw excess	67	7.7				1.67	1.80	0.96	Seral grass	arclat-descae-chrbip	411	0	10	2090	Coastal Barrens
X3.07	07/30/92	70.38157N	150.64888W	0	0	moderate	55	7.8				2.06	2.20	1.19	Halophytic dwarf willow	salova-stehum-chrbip-descae-arttil	415	0	295	2043	Coastal Dwarf Scrub
X3.08	07/30/92	70.37992N	150.6471W	0	0	poor	56	7.9				1.00	1.13	0.58	Wet sedge-grass meadow	erisch-dupfis-hiepau-aloalp	413	0	345	3053	Riverine Wet Meadow
X3.09	07/30/92	70.37924N	150.64656W	0	0	moderate	49	7.9				1.67	1.80	0.96	Halophytic dwarf willow	salova-Calamagrostis sp.	415	0	295	2043	Coastal Dwarf Scrub
X3.10	07/30/92	70.37907N	150.64631W	nd	nd	nd	nd					1.76	1.89	1.02	Wet sedge meadow	eriang-hiepau	416	0	334	3053	Riverine Wet Meadow
X3.11	07/30/92	70.37865N	150.64599W	0	4	poor	40	6.9				1.76	1.89	1.02	Open low willow-sedge	sallan-eriang-caraqu/salret-dryint	416	2	320	3052	Riverine Moist Meadow
X4.03	07/31/92	70.42981N	150.58524W	0	0	sw poor	39	6.5				1.82	1.62	1.13	Wet sedge-grass meadow	hiepau-eriang-caraqu	416	0	334	3053	Riverine Wet Meadow
X4.04	07/31/92	70.43032N	150.58593W	0	0	moderate	30	7.1				1.91	1.71	1.19	Sedge-*Dryas* tundra	caraqu-Carex spp.-eriang/dryint	416	2	320	3052	Riverine Moist Meadow
X4.05	07/31/92	70.43086N	150.58623W	0	0	sw poor	32	6.4				2.09	1.89	1.30	Wet sedge meadow	caraqu-eriang	416	5	334	3053	Riverine Wet Meadow
X4.06a	07/31/92	nd	nd	0	0	poor	55	7.4				0.42	0.21	0.26	Barren		411	0	0	2090	Coastal Barrens
X4.08	07/31/92	70.42652N	150.58038W	0	0	well	53	7.9				1.79	1.59	1.11	Halophytic dwarf willow	salova-astalp	415	0	295	2043	Coastal Dwarf Scrub
X5.02	08/01/92	70.46421N	150.72673W	0	0	nd	63	7.3				0.57	0.37	0.35	Barren		862	0	0	2090	Coastal Barrens
X5.03	08/01/92	70.46583N	150.72508W	0	0	nd	49	7.6				1.12	0.92	0.69	Halophytic dwarf willow	salova-eriang-unknown grass	862	0	295	2043	Coastal Dwarf Scrub
X5.04	08/01/92	70.46603N	150.72492W	0	15	nd	nd	6.2				1.58	1.37	0.98	Salt-killed wet meadow	stehum-descae-salova-hiepau	416	2	348	2053.1	Coastal Salt-killed Wet Meadow
X5.05	08/01/92	70.46746N	150.72302W	nd	nd	nd	nd					3.50	3.29	2.17	Mesic sedge-willow tundra	caraqu-eriang/salova-dryint	416	6	320	3052	Riverine Moist Meadow
X5.08	08/01/92	70.46059N	150.73488W	0	0	nd	56					1.36	1.16	0.85	Salt-killed wet meadow	pucphr	416	5	348	2053.1	Coastal Salt-killed Wet Meadow
X6.02	07/24/92	70.16402N	150.92865W	0	0	well	92	7.7				2.83	2.56	0.45	Barren		411	0	0	2090	Coastal Barrens
X6.06	07/25/92	70.16243N	150.91295W	0	0	sw excess	nd	7.8				9.85	9.58	1.57	Open tall willow	salale/salgla-Poa sp.	380	62	10	7690	Upland Sandy Barrens
X6.08	07/25/92	70.16238N	150.91238W	0	0	sw excess	nd	7.8				8.29	8.02	1.32	Open low willow	salgla-sallan/arcrub-astalp	380	62	242	7642	Upland Sandy Low Scrub
X6.11	07/25/92	70.16219N	150.91057W	2	7	sw poor	44	6.9				6.13	5.86	0.98	Wet sedge-willow meadow	caraqu-eriang-sallan/equvar	416	0	334	3053	Riverine Wet Meadow
X6.12	07/25/92	70.16493N	150.9397W	2	20	sw poor	40	7.5				6.06	5.80	0.97	Wet sedge-willow meadow	eriang-unknown grass-sallan/pedsud	416	5	334	3053	Riverine Wet Meadow
X6.13	07/25/92	70.16529N	150.94347W	2	10	sw poor	25	7.2				6.58	6.31	1.05	*Dryas* tundra	dryint-arcrub-salret-luparc-sallan	416	5	320	3052	Riverine Moist Meadow
X6.C1	07/29/96	70.16505N	150.91013W	0	6		36					nd	nd	nd	Mesic sedge-willow tundra	caraqu-luparc-sallan-carbig	417	8	320	5052	Lowland Moist Meadow
X6.C2	07/29/96	nd	nd	9	9	poor	28					nd	nd	nd	Mesic sedge-willow tundra	caraqu-luparc-salpul-eriang	417	8	320	5052	Lowland Moist Meadow
Y1.00	07/30/95	70.23993N	150.97775W	0	1	nd	80					nd	nd	nd	Closed low willow	sallan	416	5	242	3042	Riverine Low and Tall Scrub

*Drainage classes: excessive, somewhat excessive, well, moderate, somewhat poor, poor, very poor

Appendix Table 7. Results of sorted-table analysis performed for vegetation plots on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996. The left column ratios are the "inside (X) and outside (Y) percentages." All species belonging to a species group have to occur in at least X% of the plots that form the corresponding plot group, and in not more than Y% of the plots outside the plot group.



Appendix Table 7 (cont.).



Appendix Table 8. Frequency of occurrence of surface forms within terrain units on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

	Surface Form Code																
Terrain Unit Code	0	2	5	6	7	8	11	12	17	31	35	62	96	97	98	101	Total
380							1					204					205
412	523																523
413	113	72	1														186
415	186																186
416	109	192	465		150												916
417				243	13	5											261
441	119																119
443	84																84
444	74	77	53				12	10									226
545	33	10	23				293	62							6		427
595	3		2				14										19
816	136	213								2						111	462
817			122				211	8			29					233	603
818	333	96	10								4						443
819		1	43		2						1						47
860	36	14	18				580	25							33		706
862	140																140
872	9																9
874									3								3
922													25	49			74
930													8				8
941	32												295	28			323
950	6												11	1			12
987	15																0
989													5	80			85
Total	1957	675	737	243	165	5	1111	105	3	2	34	204	345	158	39	344	6067

Appendix Table 9. Frequency of occurrence of vegetation types within terrain units on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

	Vegetation Code																
Terrain Unit Code	0	10	231	242	260	270	295	314	320	334	336	337	345	346	348	411	Total
380		43		1	142	7			11	1							205
412	279	197												47			523
413		13		17					5	129			1	10	11		186
415				162			24										186
416				25	91				45	500	151				104		916
417				27	35				25	148	18				8		261
441	111	8															119
443				83						1							84
444				24		12			107	83							226
545				3	3	1		173	210	37							427
595								7	10	2							19
816		6							146	199						111	462
817					1	12		78	165	114							603
818	88	57	1	26	4	4	3		14	174			18	46	8		443
819				8	2					35	2						47
860		3				14		349	308	32							706
862	66	46												28			140
872	9																9
874									3								3
941											25	36					61
943												6					6
950											2	6					8
987												15					15
Total	553	373	1	376	278	50	27	607	1049	1455	198	63	19	131	131	111	5655

Appendix Table 10. Frequency of occurrence of vegetation types within surface forms on the Colville River Delta and adjacent coastal plain, northern Alaska, 1996.

	Vegetation Code																
Surface Form Code	0	10	231	242	260	270	295	314	320	334	336	337	345	346	348	411	Total
0	553	330	1	293	3	12	27	3	156	354	4	55	19	123	24		1957
2				12	13				158	446				8	38		675
5				34	81				54	506	1				61		737
6				27	35				25	148					8		243
7											165						165
8											5						5
11				8	3	15		570	515								1111
12				1				17	87								105
17									3								3
31									2								2
35					1	16		17									34
62		43		1	142	7			10	1							204
96											23	8					31
97																	0
98									39								39
101																111	344
Total	553	373	1	376	278	50	27	607	1049	1455	198	63	19	131	131	111	5655

Appendix Table 11. List of vascular plant species found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992-96. Unless otherwise indicated, voucher specimens were collected and are available at ABR, Inc. Species in parentheses are without voucher specimens. Nomenclature follows Hulten (1968).

Agropyron boreale
Agropyron macrourum
Alnus crispa
Alopecurus alpinus alpinus
Andromeda polifolia
Androsace chamaejasme lehmanniana
Androsace septentrionalis
Anenome parviflora
Antennaria friesiana friesiana
Arabis arenicola pubescens
(Arabis lyrata)
Arctagrostis latifolia latifolia
Arctophila fulva
Arctostaphylos alpina
Arctostaphylos rubra
Armeria maritima arctica
Arnica alpina angustifolia
(Arnica lessingii)
Artemisia arctica comata
Artemisia borealis
Artemisia glomerata
Artemisia tilesii tilesii
Aster sibiricus
Astragalus aboriginum
Astragalus alpinus alpinus
Astragalus eucosmus sealei
Astragalus umbellatus
Betula glandulosa
Betula nana exilis
Bromus pumpellianus arcticus
Bupleurum triradiatum arcticum
Calamagrostis canadensis canadensis
Calamagrostis deschampsioides
Calamagrostis holmii
Caltha palustris
Campanula uniflora
(Cardamine bellidifolia)
Cardamine hyperborea
Cardamine pratensis angustifolia
Carex aquatilis
Carex atrofusca
Carex bigelowii
Carex capillaris
Carex chordorrhiza
Carex glareosa glareosa
Carex krausei
Carex lugens
Carex maritima
Carex membranacea
Carex misandra
Carex nardina
Carex ramenskii
Carex rariflora
Carex rotundata
Carex rupestris
Carex saxatilis
Carex scirpoidea
Carex subspathacea
Carex ursina
Carex vaginata
Carex williamsii
Cassiope tetragona
Castilleja caudata
Cerastium beeringianum beeringianum
Chrysanthemum bipinnatum bipinnatum
(Chrysanthemum arcticum)
Chrysanthemum integrifolium
Cochlearia officinalis arctica
Comarum palustre
Deschampsia caespitosa caespitosa
Deschampsia caespitosa orientalis
Draba cinerea
Draba hirta
Draba macrocarpa
Dryas integrifolia
Dupontia fisheri psilosantha
Elymus arenarius mollis villosissimus
Empetrum nigrum
Epilobium latifoliium
Equisetum arvense
Equisetum scirpoides
Equisetum variegatum variegatum
Erigeron purpuratus
Eriophorum angustifolium subarcticum
Eriophorum russeolum
Eriophorum scheuchzeri
Eriophorum vaginatum
Festuca brachyphylla
Festuca rubra
Gentiana propinqua arctophila
Gentiana propinqua propinqua
Hedysarum alpinum americanum
Hedysarum mackenzii
Hierochloë alpina
Hierochloë odorata
Hierochloë pauciflora
Hippuris vulgaris
Juncus arcticus alaskanus
Juncus biglumis
(Juncus castaneus)
Juncus triglumis albescens
Kobresia myosuroides
Kobresia sibirica
Lagotis glauca
Ledum palustre decumbens
Lupinus arcticus
Luzula arctica
(Luzula arcuata)
Luzula confusa
Luzula multiflora multiflora
Luzula tundricola
Lycopodium selago

Appendix Table 11 (cont.).

Melandrium affine
Melandrium apetalum arcticum
Menyanthes trifoliata
Minuartia arctica
Minuartia rossii
Minuartia rubella
Oxytropis arctica
Oxytropis borealis
Oxytropis campestris
Oxytropis maydelliana
Oxytropis viscida
Papaver macounii
Parnassia kotzebuei
Parrya nudicaulis
Pedicularis capitata
Pedicularis kanei
Pedicularis langsdorffii arctica
Pedicularis sudetica albolabiata
Pedicularis sudetica interior
Pedicularis verticillata
Petasites frigidus
Petasites hyperboreus
Plantago canescens
Poa abbreviata
Poa alpigena
Poa alpina
Poa arctica arctica
Poa arctica caespitans
Poa glauca
Poa lanata
Poa pseudoabbreviata
Poa vivipara
Polemonium boreale boreale
Polygonum bistorta plumosum
Polygonum viviparum
Potentilla hookeriana chamissonis
Potentilla palustris
Potentilla pulchella
Potentilla virgulata
Puccinellia andersonii
Puccinellia arctica
Puccinellia borealis
(Puccinellia langeana)
(Puccinellia vaginata)
Puccinellia phryganodes
Pyrola grandifolia
Pyrola secunda obtusata
Ranunculus gmelini gmelini
Ranunculus hyperboreus hyperboreus
Ranunculus lapponicus
Ranunculus pallasii
Ranunculus parviflora
Ranunculus pedatifidus affinis
Rhodiola integrifolia
Rubus chamaemorus
Rumex arcticus
Salix alaxensis
Salix arctica
Salix brachycarpa niphoclada
(Salix fuscescens)
Salix glauca
Salix hastata
Salix lanata richardsonii
Salix ovalifolia ovalifolia
Salix phlebophylla
Salix planifolia planifolia
Salix planifolia pulchra
Salix polaris pseudopolaris
Salix reticulata reticulata
(Salix rotundifolia)
Saussurea angustifolia
Saxifraga bronchialis
Saxifraga caespitosa
Saxifraga cernua
Saxifraga foliosa
Saxifraga hieracifolia
Saxifraga hirculus
Saxifraga oppositifolia oppositifolia
Saxifraga punctata nelsoniana
Sedum rosea integrifolium
Senecio atropurpureus frigidus
Senecio congestus
Senecio lugens
Senecio resedifolius
Silene acaulis acaulis
Sparganium hyperboreum
(Stellaria crassifolia)
Stellaria humifusa
Stellaria laeta
Taraxacum ceratophorum
Tofieldia coccinea
Tofieldia pusilla
Trisetum spicatum spicatum
Utricularia vulgaris macrorhiza
Vaccinium uliginosum
Vaccinium vitis-idaea
Valeriana capitata
Wilhelmsia physodes

Appendix Table 12. List of mosses and lichens found on the Colville River Delta and adjacent coastal plain, northern Alaska, 1992-96. Voucher specimens on file at ABR, Inc.

Bryophytes	**Bryophytes (cont.)**
Abietinella abietina (Hedw.) Fleisch., *(=Thuidium abietinum)*	*Pohlia sp.*
Aulacomnium acuminatum	*Polytrichum hyperboreum* R. Br.
Aulacomnium palustre (Hedw.) Schwaegr.	*Polytrichum juniperinum*
Aulacomnium sp.	*Polytrichum sp.*
Aulacomnium turgidum Wahlenb.	*Polytrichum strictum* Sm.
Barbula sp.	*Ptilidium ciliare*
Blindia acuta	*Rhacomitrium lanuginosum* (Hedw.) Brid.
Brachytheceaceae (cf. B.albicans Hedw.*)*	*Rhizomnium magnifolium* (Horik.) Kop.
Brachytheceaceae (cf. B.plumosum Hedw.*)*	*Rhizomnium sp.*
Brachytheceaceae (cf. B.salebrosum Web. et Mohr*)*	*Rhytidium rugosum* (Hedw.) Kindb.
Brachythecium sp.	*Scorpidium scorpioides* (Hedw.) Limpr.
Brachythecium turgidum Hartm.	*Sphagnum (cf. platyphyllum* (Braithw.) Sull.)
Bryum sp.	*Sphagnum nemoreum* Scop.
Calliergon cordifollium Hedw.	*Sphagnum sp.*
Calliergon giganteum Schimp.	*Sphagnum squarrosum* Crome.
Calliergon sp.	*Sphagnum subsecundum* Nees.
Calliergon stramineum (Brid.) Kindb.	*Tomenthypnum sp.*
Campyllium stellatum Hedw.	*Tomentypthum nitens* (Hedw.) Loeske.
Catoscopium nigritum Hedw.	*Tortella tortuosa* (Hedw.) Limpr.
Cinclidium sp.	
Climacium dendroides	
Desmatodon randii Kennedy.	
Dicranella (cf. schreberiana var. robusta Schimp.*)*	**Lichens**
Dicranella sp.	
Dicranum (cf. fulvum Hook.*)*	*Alectoria nigricans*
Dicranum elongatum Schleich.	*Alectoria sp.*
Dicranum sp.	*Cetraria cucullata*
Distichium capillaceum (Hedw.) B.S.G.	*Cetraria islandica*
Distichium sp.	*Cetraria nivalis*
Ditricum flexicaule (Schleich.) Hampe	*Cetraria sp.*
Drepanocladus (cf. aduncas (Hedw.)) Warnst.	*Cladina sp.*
Drepanocladus brevifolius	*Cladonia sp.*
Drepanocladus revolvens (Sm.) Warnst.	*Coleocolon sp.*
Drepanocladus sp.	*Cornicularia divergens*
Drepanocladus uncinatus (Hedw.) Warnst	*Dactylina arctica*
Fissidens adiantoides Hedw.	*Dactylina sp.*
Hylocomium splendens Hedw.	*Masonhalea richardsonii*
Hypnum sp.	*Nephroma arcticum*
Lophozia sp.	*Parmelia sp.*
Marchantia polymorpha	*Peltigera aphthosa*
Meesia triquetra Richt.	*Peltigera canina*
Mnium sp.	*Peltigera malacea*
Myurella julacea (Schwaegr.) B.S.G.	*Peltigera sp.*
Oncophorus wahlenbergii Brid.	*Pertusaria sp.*
Orthothecium chryseum	*Sphaerophorus globosus*
Palludella squarrosa	*Sphaerophorus sp.*
Plagiomnium medium (B.S.G.) Kop.	*Stereocaulon sp.*
Pleurozium schreberi	*Thamnolia subuliformis*
Pohlia cruda (Hedw.) Lindb.	*Thamnolia sp.*

Appendix Table 13. Correlation matrices of environmental variables for each of the three data subsets used in canonical correspondence analysis. Correlations are weighted by row totals from the corresponding vegetation matrix (sum of percent cover of vegetation per plot), variables are defined below.

WEIGHTED CORRELATIONS AMONG VARIABLES IN ENVIRONMENTAL MATRIX 1

	TopOrg	SumOrg	Drain0	Drain1	Drain2	Permaf	ElevRa
TopOrg	1.000	.627	-.118	-.094	.265	-.265	.446
SumOrg	.627	1.000	-.276	-.248	.433	-.470	.286
Drain0	-.118	-.276	1.000	-.243	-.396	.222	.021
Drain1	-.094	-.248	-.243	1.000	-.579	.088	.049
Drain2	.265	.433	-.396	-.579	1.000	-.306	.019
Permaf	-.265	-.470	.222	.088	-.306	1.000	-.205
ElevRa	.446	.286	.021	.049	.019	-.205	1.000

WEIGHTED CORRELATIONS AMONG VARIABLES IN ENVIRONMENTAL MATRIX 2

	TopOrg	SumOrg	Drain0	Drain1	Drain2	EC	pH
TopOrg	1.000	.575	-.180	-.174	.328	-.179	-.222
SumOrg	.575	1.000	-.302	-.265	.412	-.133	-.447
Drain0	-.180	-.302	1.000	-.152	-.372	-.008	.254
Drain1	-.174	-.265	-.152	1.000	-.668	-.043	.214
Drain2	.328	.412	-.372	-.668	1.000	.016	-.440
EC	-.179	-.133	-.008	-.043	.016	1.000	-.176
pH	-.222	-.447	.254	.214	-.440	-.176	1.000

WEIGHTED CORRELATIONS AMONG VARIABLES IN ENVIRONMENTAL MATRIX 3

	TopOrg	SumOrg	Drain0	Drain1	Drain2	Zwater	Permaf
TopOrg	1.000	.580	-.094	-.114	.183	.198	-.125
SumOrg	.580	1.000	-.213	-.207	.268	.498	-.362
Drain0	-.094	-.213	1.000	-.151	-.331	-.280	.065
Drain1	-.114	-.207	-.151	1.000	-.642	-.413	.117
Drain2	.183	.268	-.331	-.642	1.000	.573	-.090
Zwater	.198	.498	-.280	-.413	.573	1.000	-.235
Permaf	-.125	-.362	.065	.117	-.090	-.235	1.000

VARIABLES
TopOrg= surface organic-horizon depth
SumOrg= cumulative organic-horizon 0-30 cm
Drain0= well drained
Drain1= moderately drained
Drain2= poorly drained
Permaf= thaw depth
ElevRa= elevation ratio (elevation of plot/elevation of first inactive parcel)
Zwater= depth to ground (-) or depth of surface (+) water

Appendix Table 14. Flood-frequency classes associated with terrain units within three flooding regions, Colville River Delta, 1996.

Terrain Unit	Flooding Region 1 (Delta head, Upper East Channel)	2 (Central Delta)	3 (Outer Delta)	4 (Alluvial Terraces on Both Sides of Delta)
Eolian Sand Dunes	5	5	5	5
Alluvial Terrace Deposit	5	5	5	5
Gravel Fill	5	5	5	5
Delta Abandoned-floodplain Cover Deposit	3	4	3	4
Delta Inactive-floodplain Cover Deposit	3	3	2	3
Shallow Isolated and Connected Ponds	3	3	2	5
Deep Isolated and Connected Lakes	3	3	2	5
Thaw Basin Deposit, Ice-rich	3	3	2	5
Delta Active-floodplain Cover Deposit	2	2	2	3
Tapped Lake, High-Water Connection	2	2	2	2
Deep Thaw Lake, Connected	2	2	2	2
Delta Thaw Basin Deposit, Ice-rich	2	2	2	2
Thaw Basin Deposit, Ice-poor	2	2	2	5
Delta Thaw Basin Deposit, Ice-poor	1	1	1	1
Shallow Riverine Pond	1	1	1	1
Tapped Lake, Low-water Connection	1	1	1	1
Delta Riverbed/Riverbar Deposit	1	1	1	1
Tidal Flat Deposit	1	1	1	1
Tidal River	1	1	1	1
Nearshore Water	1	1	1	1

Flood frequency classes: 1 (every 1–2 yr), 2 (every 3–4 yr), 3 (every 5–25 yr), 4 (every 26–150 yr), 5 (non-flooded).