AN ECOLOGICAL LAND SURVEY IN THE NORTHEAST PLANNING AREA OF THE NATIONAL PETROLEUM RESERVE – ALASKA, 2003

ADDENDUM TO 2002 REPORT

FINAL REPORT

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INTRODUCTION

This report provides an addendum to the ecological land survey of the northeastern portion of the National Petroleum Reserve–Alaska (NPRA) conducted during 2001–2002 (Jorgenson et al. 2003) by expanding the field survey and mapping area to include the Fish Creek delta. Marine deltas are transitional environments, encompassing coastal, riverine, and terrestrial habitats, and supporting a wide variety of vegetation and wildlife. The Fish Creek delta was added to the previous study area because environmental information is important for ecological and engineering applications including habitat use analysis of subsistence species and facilities placement. The delta also is downstream of areas proposed for oil development and the information is essential to oil spill contingency planning. In this report, we focus on coastal ecosystems that were not adequately described in the 2003 report and refer the reader to the 2003 report for more information on riverine and coastal plain ecosystems. We also conducted a survey for rare plants, focusing on areas of proposed development in the northeastern NPRA. Accordingly, the objectives of this study were to classify and describe coastal geomorphology and vegetation, summarize environmental characteristics of coastal ecosystems and plant species, extend the existing map to the Fish Creek delta, and provide a list of rare plants discovered and their locations. In this report, methods and results are briefly summarized, and we refer the reader to the 2003 report for more complete descriptions.

Marine-influenced terrestrial ecosystems along the Beaufort Sea coast have received relatively little study despite their importance as habitat for subsistence fish and wildlife species and for rural and industrial development. Early vegetation studies focused mostly on floristics and taxonomy of coastal vegetation (Wiggins and Thomas 1962, Britton 1957, Lipkin 1983). More detailed studies on classification and analysis of environmental characteristics are available for the Beaufort Sea Coast (Webber et al. 1980, Taylor 1981, Walker 1985, Meyers 1985, Jorgenson et al. 1997) and Bering Sea Coast (Kinechloe and Stehn 1991, Jorgenson 2000). Aquatic vegetation in nearshore water has been described by Dunton et al. (1982). This study contributes to the growing knowledge of arctic coastal ecosystems by analyzing the geomorphic and vegetation patterns and environmental characteristics of the Fish Creek and Colville River deltas, the greatest concentration of coastal ecosystems along the Beaufort Sea coast.

METHODS

FIELD SURVEYS

Field surveys were conducted within the Fish Creek delta in northeastern NPRA during early August 2003 (Figure 1). Sampling was done primarily along transects (toposequences) that were selected to encompass the range of biophysical environments. Along each transect, 8–12 plots were sampled, each in a distinct vegetation type or spectral signature identifiable on aerial photographs. Data were collected at 84 plots along 9 toposequences. Of these, 61 were classified as coastal physiography. We also collected data at 48 rapid assessment points throughout the delta, which primarily were used for signature verification during mapping. All plots were located on aerial photographs, and coordinates (including approximate elevations) were obtained with a Global Positioning System (GPS) receiver (accuracy ±15 m).

At each plot (~10-m radius), descriptions or measurements of geomorphic units, surface form (micro- and macro-topography), hydrology (depth of water, depth to saturated soil, pH, electrical conductivity), soil stratigraphy, and vegetation cover (visual estimates by growth form and species) were recorded using the same methods as in the 2001–2002 surveys (Jorgenson et al. 2003). Taxonomic nomenclature followed Viereck and Little (1972) for shrubs and Hultén (1968) for other vascular plants. Nomenclature for bryophytes and lichens followed the National Plants Database (NRCS 2001). Nonvascular collections were sent to Mikhail Zhurbenko and Olga Afonina, Komarov Botanical Institute, Russia, for identification. Digital photos were taken at all plots (data and photos are archived at ABR). Data file listings are provided in Appendices 1 and 2.

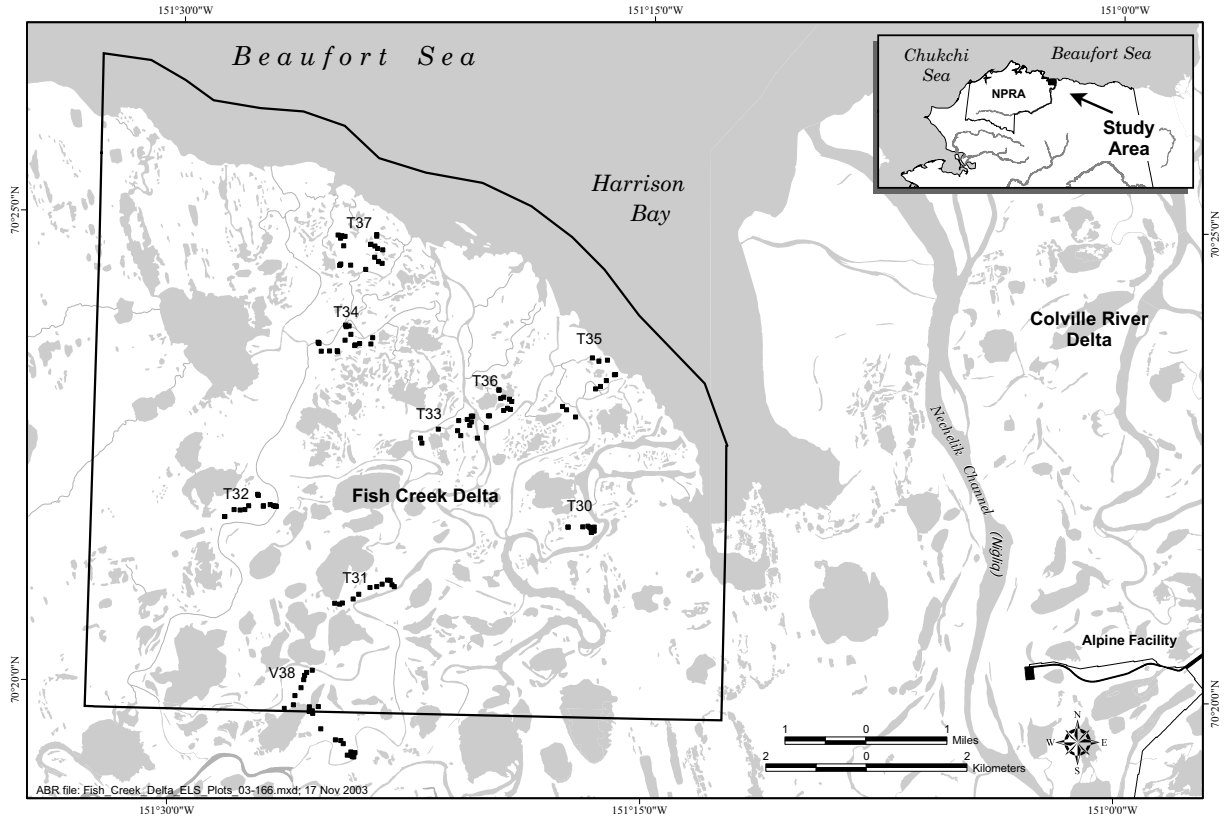


Figure 1. Sampling locations for the ecological land survey on the Fish Creek delta, northeastern NPRA, 2003.

CLASSIFICATION

Classification of coastal ecosystems was undertaken at two levels. First, individual ecological components were classified and coded using standard classification systems developed for Alaska (Table 1). Second, these ecological components were integrated to classify ecotypes (local-scale ecosystems) that best partitioned the range of variation for all the measured components. For this analysis, we included 74 coastal plots from previous surveys in the Colville Delta (Jorgenson et al. 1997) and Fish Creek delta (Jorgenson et al. 2003) and excluded the 23 non-coastal plots from the 2003 dataset, for a total of 144 plots.

Ecological components included geomorphic units, surface forms, and vegetation. Geomorphic (terrain) units were classified according to a system based on landform-soil characteristics for Alaska, originally developed by Kreig and Reger (1982) and the Alaska Division of Geological and Geophysical Survey (1983) and modified for this study. Surface forms were classified according to the periglacial system of Washburn (1973). Vegetation was initially classified in the field using a slightly modified version of the Alaska Vegetation Classification (AVC) developed by Viereck et al. (1992). After fieldwork was completed, plant associations were quantitatively developed using TWINSPAN, sorted table, and Detrended Correspondence Analyses (Mueller-Dombois and Ellenberg 1974, MjM Software Design 1999). Dominant and differential indicator species for each class then were identified and used to name each plant association.

Ecotype classes were developed using contingency tables to sort plots by physiography, soil texture, geomorphic unit, drainage, soil chemistry (pH and salinity), and vegetation type. From these tables, common associations were identified and unusual associations either were lumped with those having similar characteristics or excluded as unusual (outliers). In developing the ecotype classes, we tried to use environmental

Table 1. Coding system for classifying and mapping geomorphology, surface forms and vegetation on the Fish Creek delta, northeastern NPRA, 2003.

Code	Class	Code	Class
	GEOMORPHIC UNIT		SURFACE FORM (cont)
Esa	Eolian Active Sand Deposit	Pd	Disjunct Polygon Rims
Esac	Eolian Active Coastal Sand Deposit (not mapped)	Phh	High-centered, High-relief Polygons
Esi	Eolian Inactive Sand Deposit	Phl	High-centered, Low-relief Polygons
Fdoa	Delta Active Overbank Deposit	Plhh	Low-centered, High-relief, High-density Polygons
Fdob	Delta Abandoned Overbank Deposit	Pllh	Low-centered, Low-relief, High-density Polygons
Fdoi	Delta Inactive Overbank Deposit	Plhl	Low-centered, High-relief, Low-density Polygons
Fdra	Delta Active Channel Deposit	Plll	Low-centered, Low relief, Low-density Polygons
Fdri	Delta Inactive Channel Deposit	Pm	Mixed High- and Low-centered Polygons
Fhl	Lowland Headwater Floodplain	Sb	Bluffs and Streambanks
Fto	Old Alluvial Terrace	Tb	Beads
Ltdn	Delta Thaw Basin, Ice-poor	Tm	Mixed Thaw Pits and Polygons
Ltdi	Delta Thaw Basin, Ice-rich	W	Water
Ltic	Thaw Basin, Ice-rich Center	Wi	Lake with Islands
Ltim	Thaw Basin, Ice-rich Margin	Xb	Basin Complex
Ltip	Thaw Basin Pingo	Xd	Dune Complex
Ltiu	Thaw Basin, Ice-rich Undifferentiated	Xr	Riverine Complex
Ltnm	Thaw Basin, Ice-poor Margin	Dr	Ripples (not mapped)
Ltnc	Thaw Basin, Ice-poor Center		
Ltnu	Thaw Basin, Ice-poor Undifferentiated		VEGETATION CLASS
Mta	Active Tidal Flat		
Mti	Inactive Tidal Flat	Bbg	Barren
Weldc	Brackish Deep Tapped Lake, Connected	Bpv	Partially Vegetated
Weldi	Brackish Deep Lake, Isolated	Habm	Four-leaf Marestail (not mapped)
Welsc	Brackish Shallow Tapped Lake, Connected	Hgdl	Elymus Meadow
Welsi	Brackish Shallow Lake, Isolated	Hgmss	Moist Sedge–Shrub Tundra
Welt	Tidal Lakes	Hgmt	Tussock Tundra
Wert	Tidal River	Hgwfg	Fresh Grass Marsh
Wertg	Tidal Gut	Hgwfs	Fresh Sedge Marsh
Wldcr	Deep Connected Riverine Lake (not mapped)	Hgwhk	Salt-killed Wet Meadow
Wldcrh	Deep Tapped Riverine Lake, High-water Connection	Hgwhsgb	Halophytic Sedge–Grass Wet Meadow, brackish
Wldct	Deep Connected Thaw Lake	Hgwhsgs	Halophytic Sedge–Grass Wet Meadow, saline
Wldir	Deep Isolated Riverine Lake	Hgwhgs	Halophytic Grass Wet Meadow, saline (not mapped)
Wldirt	Deep Isolated Riverine–Thaw Lake	Hgwst	Wet Sedge Meadow Tundra
Wldit	Deep Isolated Thaw Lake	Sddt	Dryas Dwarf Shrub Tundra
Wlscr	Shallow Connected Riverine Lake	Sdwgh	Halophytic Willow–Graminoid Dwarf Shrub Tundra (not mapped)
Wlscrh	Shallow Tapped Riverine Lake, High-water Connection	Sdec	Cassiope Dwarf Shrub Tundra
Wlsirt	Shallow Isolated Riverine–Thaw Lake	Slcw	Closed Low Willow
Wlsir	Shallow Isolated Riverine Lake	Slow	Open Low Willow
Wlsit	Shallow Isolated Thaw Ponds	Stcw	Closed Tall Willow
Wmn	Nearshore Water	Stow	Open Tall Willow
Wrhl	Lowland Headwater Stream	W	Water
		Xbo	Old Basin Wetland Complex
	SURFACE FORM	Xc	Halophytic Wet Meadow Complex
		Xby	Young Basin Wetland Complex
Dt	Water Tracks	Xd	Dune Complex
Es	Small Dune	Xp	Deep Polygon Complex
Ek	Streaked Dune	Xr	Riverine Complex
Lp	Polygonized Pond Margins		
Mg	Gelifluction Lobes		
Ms	Strang		EXAMPLE OF ITU CODING SYSTEM
Mu	Undifferentiated Mounds		Geomorphic Unit/ Surface Form/ Vegetation
N	Nonpatterned		Ltim/Ms/Hgwst or Wsir/W/Hgwfg

characteristics (primarily geomorphology and surface form) and vegetation structure that could be interpreted from aerial photographs. To reduce the number of ecotype classes, we aggregated similar geomorphic units, soil texture classes, drainage classes, and soil chemistry groups. For vegetation, we used the structural levels of the Alaska Vegetation Classification (Viereck et al. 1992), because they are readily identifiable on aerial photographs. Ecotype names were developed based on the dominant characteristics of the aggregated ecological components.

MAPPING

Individual ecological components were mapped simultaneously at 1:10,000 as compound codes called integrated terrain units (ITUs). ITUs were mapped by assigning a three-parameter code to each polygon describing geomorphology, surface form, and vegetation. Delineation was done on-screen using a true color, orthorectified, photo-mosaic developed from 1999 aerial photography and produced by AeroMap, Inc. (Anchorage, AK). We also referred to paper copies of the 1999 color photography (1:14,400 scale) and 1980 CIR photography (1:60,000 scale) using a stereoscope to help improve interpretation of difficult terrain. The minimum mapping size for polygons was 0.25 ha for water bodies, 2.0 ha for complexes, and 0.5 ha for all other classes. For mapping purposes, a 'polygon' is defined as an area delineated on the map as a single unit; it does not refer to polygons in the sense of polygonized landforms. We created six complex surface vegetation classes to map highly heterogeneous areas associated with dynamic geomorphic processes. The complexes were used where at least three vegetation types were present, the dominant cover type occupied <70% of the complex, and individual polygons were below the minimum size for mapping. Separate maps were produced for each of the ecological components used to create the ITUs: geomorphic units, waterbodies (aquatic geomorphic units), surface forms, and vegetation.

Ecotypes were mapped by aggregating the different ITU code combinations, based on relationships among ecological components developed from analysis of field survey data. In many instances, small differences in soil characteristics associated with terrain units or in surface forms could be combined within the broader concept of an ecotype. This approach preserved characteristics related to both geomorphic processes and vegetation development and allowed us to systematically reduce the data to a manageable number of classes.

RARE PLANT SURVEY

We surveyed representative sections of proposed road alignments and drill sites for rare plant species. Specific areas searched included: (1) the proposed road alignment from the Nigliq Channel to the Ublutuoch River; (2) areas around the Spark and CD6 proposed well-site locations, and the proposed Clover mine site; and (3) sections of Fish Creek, Judy Creek, Ublutuoch River, and adjacent coastal plain. Collections were made at 35 locations and voucher specimens for all species collected are maintained at ABR, Inc., replicate material has been offered to the University of Alaska Museum.

RESULTS AND DISCUSSION

ECOLOGICAL COMPONENTS

This report emphasizes the ecological components of the coastal ecosystems of the Fish Creek delta insufficiently sampled during previous field surveys in the northeastern NPRA. A more complete discussion and descriptions of non-coastal ecosystems is presented in Jorgenson et al. 2003.

GEOMORPHIC UNITS

Six terrestrial geomorphic units associated with coastal processes on the Fish Creek delta were differentiated during field surveys and mapping (Table 2, Figure 2). Active and Inactive Tidal Flats were found on the lower delta coast and active channels in the middle delta, in response to slower freshwater currents, tidal fluctuation, tidal surges, and wind-driven high salinity water. Also found on the lower delta are Eolian Active Sand Deposits occurring as active dunes on the tidal flats. On the middle to upper delta, Delta Active Channel Deposits and Delta Active Overbank Deposits replace tidal flats adjacent to river channels where freshwater velocities are higher during flood stages

Table 2. Classification and description of geomorphic units on the Fish Creek delta, northeastern NPRA, 2003.

Unit	Description
Eolian Active Coastal Sand Deposits	Fine to very fine, well-sorted sand containing abundant quartz with minor dark minerals. Sand is stratified with large-scale cross bedding in places. Active dunes are barren or partially vegetated and are undergoing active accretion and deflation. Active dunes usually occur adjacent to exposed sandy channel deposits.
Delta Active Channel Deposits	Silty and sandy channel or lateral accretion deposits laid down from the bed load of a river in a deltaic setting under low water velocities. This unit includes point bars, lateral bars, mid-channel bars, unvegetated high-water channels, and broad sandbars exposed during low water. Generally, sediment texture becomes finer in a seaward direction along the distributaries. Detrital organic matter usually is interbedded with the sediments. Only those riverbed deposits that are exposed at low water are mapped, but they also occur under rivers and cover deposits. Frequent flooding (every 1–2 yr) prevents the establishment of permanent vegetation.
Delta Active Overbank Deposits	Thin (10-50 cm) fine-grained, horizontally stratified cover deposits (primarily silt) that are laid down over sandier channel deposits during flood stages. Relatively frequent (every 3–4 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 Channel Deposits	Delta deposits in channels that are only flooded during periods of high flow. Because of river meandering these "high-water" channels are no longer active during low-flow conditions. Generally, there is little indication of ice-wedge development, although a few older channels have begun to develop polygon rims. Very old channels with well-developed low-centered polygons are not included in this unit.
Delta Inactive Overbank Deposits	Fine-grained cover or vertical accretion deposits laid down over coarser channel deposits during floods. The surface layers are a sequence (20–60 cm thick) of interbedded organic and silt horizons, indicating occasional flood deposition. Under the interbedded organic horizons is a thick layer (0.3–2 m thick) of silty cover deposits overlying channel deposits. Surface forms range from nonpatterned to disjunct or 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 Overbank Deposits	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.
Delta Thaw Basin, Ice-Poor	Deposits in thaw lakes within deltaic deposits. They usually are connected to a river or to nearshore water (tapped lake). Most connections occur when a meandering distributary cuts through a lake's bank; once connected, the lake is influenced by changes in river level. During breakup, large quantities of sediment-laden water flow into the lake, forming a lake delta at the point of breakthrough. Sediments generally consist of brackish fine sands, silts, and clays.
Active Tidal Flats	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters and undergoing active sedimentation. Tidal flats occur on seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal flats frequently are associated with lagoons and estuaries and may vary widely in salinity, depending on the flow of saline nearshore water and freshwater from tidal rivers. Similar to delta active channel deposits, but are differentiated by their occurrence as triangular shaped mudflats along the fringe of the delta.
Inactive Tidal Flats	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters but sedimentation is infrequent allowing the build up of organic material. The surface is vegetated with halophytic vegetation.
Nearshore Water	Shallow, brackish (800–15,000 µS/cm) to saline (>15,000 µS/cm) 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 through October.
Tidal Lakes	Coastal lakes and ponds that are flooded periodically with saltwater during high tides or storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate frequently is silt with some clay and fine sand and occasionally contains peat. Connected and isolated ponds were not differentiated from each other.
Tidal Gut	Inlet or channel with a permanent connection to marine water. Tidal guts are maintained by the action of tides and marine currents and receive minimal influence from freshwater sources.
Tidal River	Permanently flooded channels in deltas that are affected by daily tidal fluctuations and have 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.
Brackish Deep Tapped Lakes, Low-water Connection	Deep (≥1.5 m), brackish waterbodies that have been partially drained through erosion of banks by adjacent river channels, and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish because the lakes are usually within the delta and subject to flooding every year. Because water levels have dropped after tapping, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shores. Lakes do not freeze to the bottom during the winter.

Table 2. Continued

Unit	Description
Brackish Shallow Tapped Lake, Connected	Shallow (<1.5 m), brackish waterbodies that have been partially drained through erosion of banks by adjacent river channels, and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish because the lakes are usually within the delta and subject to flooding every year. Because water levels have dropped after tapping, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shores.
Brackish Deep Lake, Isolated	Deep (?1.5 m), isolated brackish to saline waterbodies along the outer delta that are subject to frequent flooding from high tides and storm surges. The lakes freeze to the bottom during the winter.
Brackish Shallow Isolated Lakes	Shallow (<1.5 m), isolated brackish to saline waterbodies along the outer delta that are subject to frequent flooding from high tides and storm surges. The lakes freeze to the bottom during the winter.

and the effects of salinity are diminished. Ice-poor Delta Thaw Basins form within recently drained brackish lakes and along the shores of tapped lakes on the middle delta. The most abundant coastal geomorphic units were Active and Inactive Tidal Flats (Table 3). An additional 8 geomorphic units were found on non-coastal portions of the delta and the adjacent coastal plain. The most common of these include Delta Inactive Overbank Deposits, Ice-rich Thaw Basins, Old Alluvial Terrace, and Eolian Inactive Sand Deposits.

Eight coastal waterbody classes have been identified within the delta (Table 2, Figure 3). Waterbodies common on the outer delta included Nearshore Water, Tidal River, Tidal Gut, and Tidal Lakes. On the upper delta Tidal River and Brackish Lakes (connected and isolated) were prevalent. The most abundant coastal lake classes within the delta were Brackish Deep Tapped Lake, Connected and Tidal Lakes (Table 3). On freshwater portions of the delta and adjacent coastal plain, an additional 9 waterbody classes were mapped, the most common of which were Deep Isolated Riverine Lakes, Deep Isolated Thaw Lakes, and Shallow Isolated Thaw Lakes.

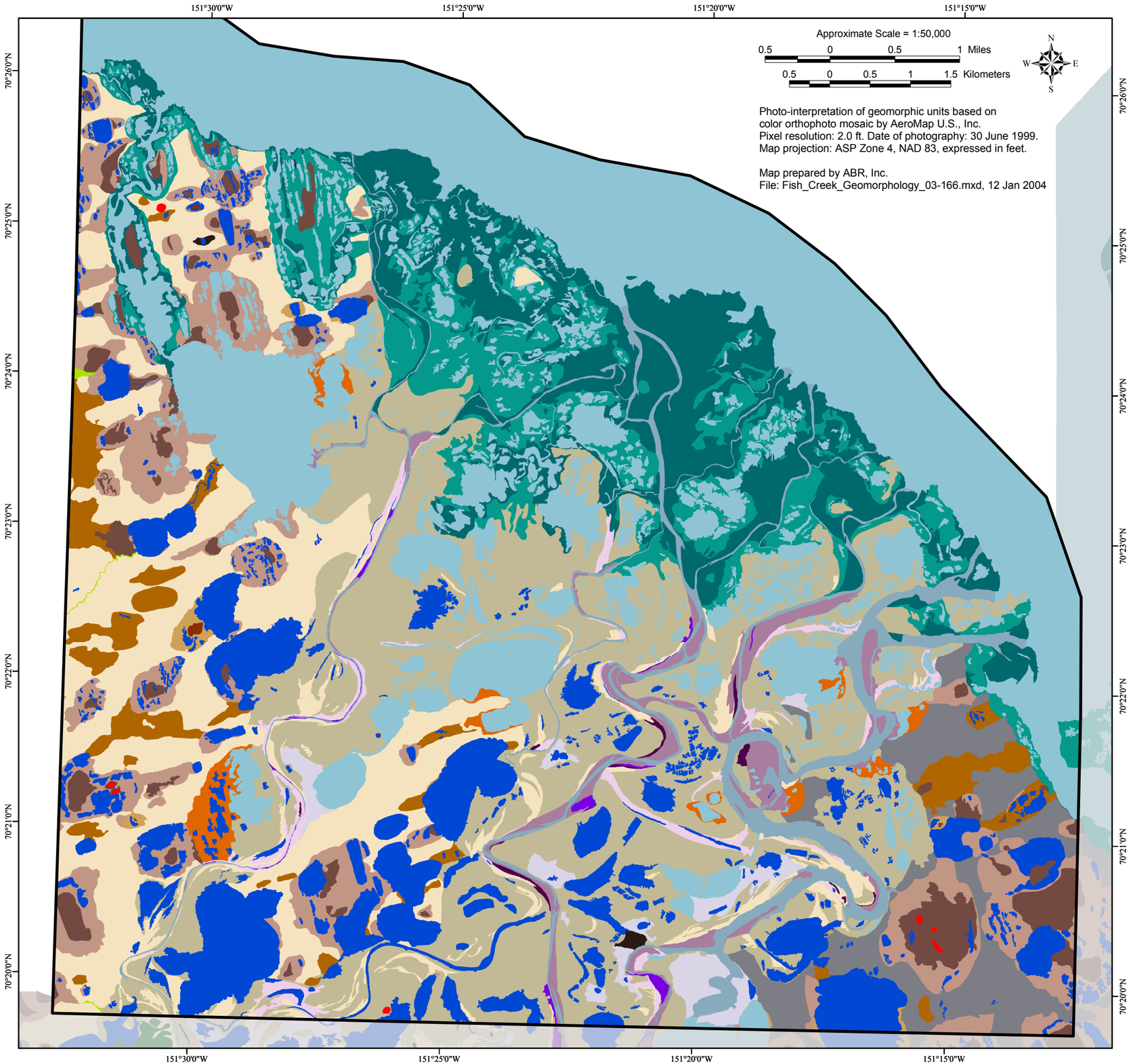
Geomorphic units are ecologically important because they represent areas with different erosional and depositional environments and, therefore, experience different types of naturally occurring disturbances. Terrestrial units, such as Active Tidal Flats, are frequently flooded with high salinity water. This frequent flooding and sediment deposition restricts the vegetation to a few salt-tolerant species, inhibits development of a moss layer, and increases the active layer depth. In contrast, Delta Abandoned Overbank Deposits are not affected by flooding or high salinity, but are subject to disturbance associated with cryoturbation and thermokarst of ice wedges. The waterbody classification (aquatic geomorphic units) differentiated numerous characteristics that affect habitat use by invertebrates, fish, and wildlife (Burgess et al. 2003). Shallow lakes tend to melt earlier and become warmer than deep water, connected lakes allow better fish passage than isolated lakes, and tapped lakes and brackish lakes have widely varying salinity levels.

SURFACE FORMS

Eight surface forms were commonly associated with coastal ecosystems on the delta (Table 4, Figure 4). The most common were Nonpatterned ground, Water, and Lakes with Islands (Table 3). Polygonized ground also was observed in association with Salt-killed Wet Meadow on Delta Inactive Overbank Deposits. Nonpatterned ground on the lower and mid-delta typically had small surface undulations, particularly on Inactive Tidal Flats, which lead to variation in dominant plant species and soil salinity. Polygonized ground was more common on non-coastal portions of the delta and adjacent coastal plain; some of the most common classes included High-centered, Low-relief Polygons; Low-centered, Low-relief, Low-density Polygons; and Mixed High- and Low-centered Polygons.

VEGETATION

Eleven vegetation classes (Viereck et al. 1992) specific to coastal communities were recognized within the Fish Creek delta (Table 5, Figure 5). Of these, 3 were not mapped because they occurred in very small patches (Four-leaf Marestail, Halophytic Willow–Graminoid Dwarf Shrub Tundra) or were not reliably distinguishable from other classes (Halophytic Grass Wet Meadow, saline). Common coastal vegetation types included Barrens; Partially Vegetated; Halophytic



Geomorphic Unit

- Active Tidal Flat
- Inactive Tidal Flat
- Delta Active Channel Deposit
- Delta Inactive Channel Deposit
- Delta Active Overbank Deposit
- Delta Inactive Overbank Deposit
- Delta Abandoned Overbank Deposit
- Delta Thaw Basin, Ice-poor
- Eolian Active Sand Deposit
- Eolian Inactive Sand Deposit
- Old Alluvial Terrace
- Thaw Basin, Ice-poor Center
- Thaw Basin, Ice-poor Margin
- Thaw Basin, Ice-poor Undifferentiated
- Thaw Basin, Ice-rich Center
- Thaw Basin, Ice-rich Margin
- Thaw Basin Pingo
- Thaw Basin, Ice-rich Undifferentiated
- Lowland Headwater Floodplain
- Fresh Water
- Coastal Water

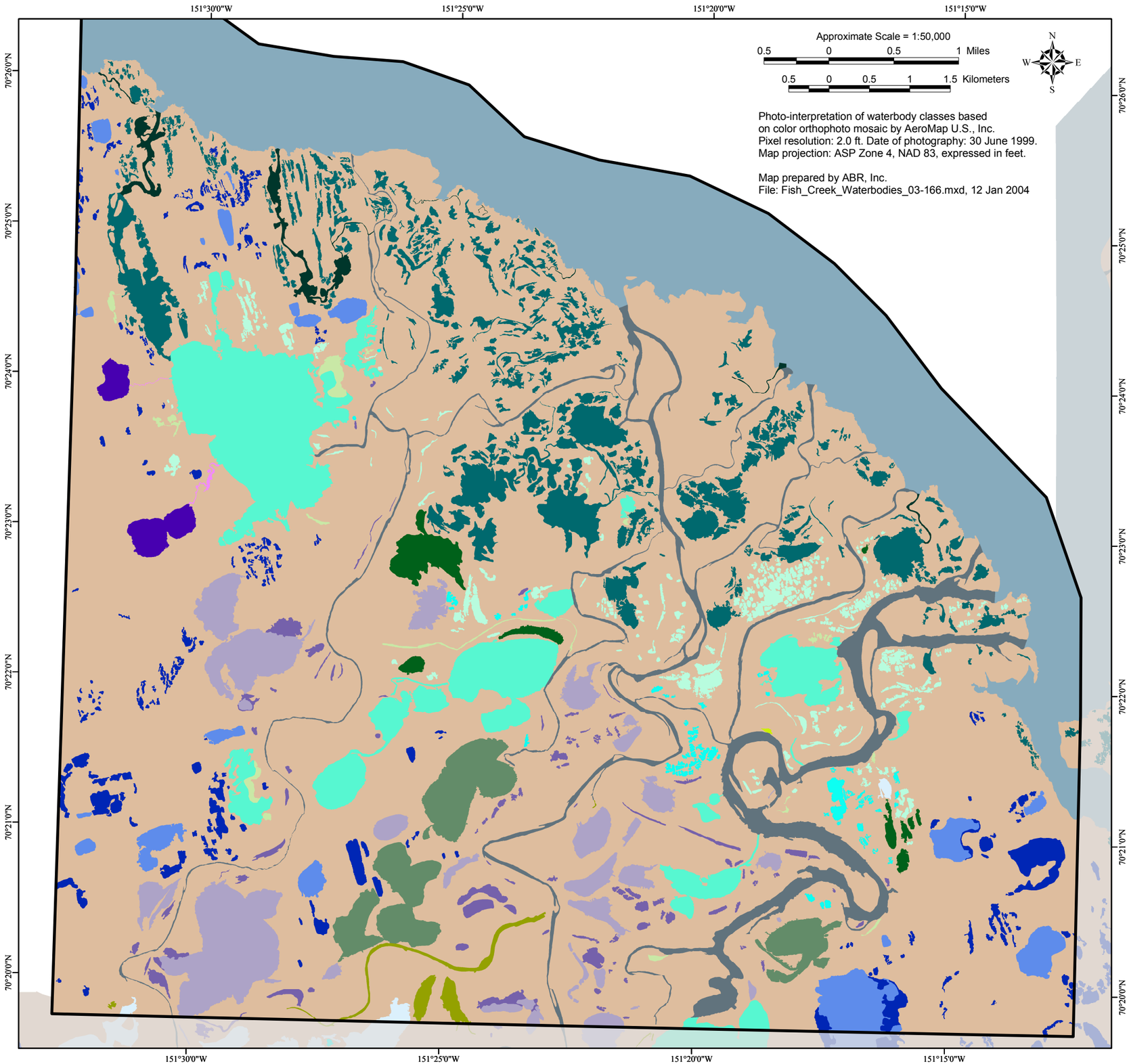
Note: Areas mapped outside the study area boundary are shown in muted colors.

Geomorphology

Ecological Land Survey

Fish Creek Delta,
Northeastern NPRA

Figure 2



Waterbody Class

- Tidal Lake
- Brackish Shallow Tapped Lake, Connected
- Brackish Deep Tapped Lake, Connected
- Brackish Shallow Lake, Isolated
- Brackish Deep Lake, Isolated
- Shallow Connected Riverine Lake
- Shallow Tapped Riverine Lake, High-water Connection
- Deep Tapped Riverine Lake, High-water Connection
- Shallow Isolated Riverine Lake
- Deep Isolated Riverine Lake
- Shallow Isolated Riverine–Thaw Lake
- Deep Isolated Riverine–Thaw Lake
- Shallow Isolated Thaw Lake
- Deep Isolated Thaw Lake
- Deep Connected Thaw Lake
- Lowland Headwater Stream
- Tidal Gut
- Tidal River
- Nearshore Water

Note: Areas mapped outside the study area boundary are shown in muted colors.

Waterbodies

Ecological Land Survey

Fish Creek Delta, Northeastern NPRA

Figure 3

Table 3. Areal extent of geomorphic units, surface forms, and vegetation classes on the Fish Creek delta, northeastern NPRA, 2003.

	Area		
Geomorphic Unit	Acres	Ha	%
Active Tidal Flat	2629	1064	8.0
Brackish Deep Lake, Isolated	168	68	0.5
Brackish Deep Tapped Lake, Connected	1634	661	5.0
Brackish Shallow Lake, Isolated	350	142	1.1
Brackish Shallow Tapped Lake, Connected	74	30	0.2
Deep Connected Thaw Lake	76	31	0.2
Deep Isolated Riverine Lake	1039	420	3.2
Deep Isolated Riverine–Thaw Lake	30	12	0.1
Deep Isolated Thaw Lake	486	197	1.5
Deep Tapped Riverine Lake, High-water Connection	539	218	1.6
Delta Abandoned Overbank Deposit	343	139	1.0
Delta Active Channel Deposit	482	195	1.5
Delta Active Overbank Deposit	45	18	0.1
Delta Inactive Channel Deposit	316	128	1.0
Delta Inactive Overbank Deposit	6079	2460	18.5
Delta Thaw Basin, Ice-poor	210	85	0.6
Eolian Active Sand Deposit	36	14	0.1
Eolian Inactive Sand Deposit	3665	1483	11.2
Inactive Tidal Flat	1964	795	6.0
Lowland Headwater Floodplain	11	4	<0.1
Lowland Headwater Stream	5	2	<0.1
Nearshore Water	4609	1865	14.1
Old Alluvial Terrace	1020	413	3.1
Shallow Connected Riverine Lake	1	0	<0.1
Shallow Isolated Riverine Lake	225	91	0.7
Shallow Isolated Riverine–Thaw Lake	85	34	0.3
Shallow Isolated Thaw Ponds	463	187	1.4
Shallow Tapped Riverine Lake, High-water Connection	88	36	0.3
Thaw Basin Pingo	12	5	<0.1
Thaw Basin, Ice-poor Center	7	3	<0.1
Thaw Basin, Ice-poor Margin	69	28	0.2
Thaw Basin, Ice-poor Undifferentiated	18	7	0.1
Thaw Basin, Ice-rich Center	728	295	2.2
Thaw Basin, Ice-rich Margin	1918	776	5.9
Thaw Basin, Ice-rich Undifferentiated	740	299	2.3
Tidal Gut	126	51	0.4
Tidal Lakes	1484	600	4.5
Tidal River	1000	405	3.1
Total	32,771	13,263	100.0

	Area		
Surface Form	Acres	Ha	%
Basin Complex	909	368	2.8
Beads	7	3	<0.1
Bluffs and Streambanks	36	15	0.1
Disjunct Polygon Rims	954	386	2.9
Dune Complex	103	42	0.3
Gelifluction Lobes	32	13	0.1

	Area		
Surface Form (cont')	Acres	Ha	%
High-centered, High-relief Polygons	69	28	0.2
High-centered, Low-relief Polygons	4496	1820	13.7
Lake with Islands	5527	2237	16.9
Low-centered, High-relief, High-density Polygons	566	229	1.7
Low-centered, High-relief, Low-density Polygons	763	309	2.3
Low-centered, Low relief, Low-density Polygons	2595	1050	7.9
Low-centered, Low-relief, High-density Polygons	9	4	<0.1
Mixed High- and Low-centered Polygons	1786	723	5.4
Mixed Thaw Pits and Polygons	1132	458	3.5
Nonpatterned	5917	2395	18.1
Polygonized Pond Margins	284	115	0.9
Riverine Complex	17	7	0.1
Small Dune	600	243	1.8
Strang	115	46	0.4
Streaked Dune	1	0	<0.1
Undifferentiated Mounds	171	69	0.5
Water	6671	2700	20.4
Water Tracks	11	4	<0.1
Total	32,771	13,263	100.0

	Area		
Vegetation Class	Acres	Ha	%
Barren	1462	592	4.5
Cassiope Dwarf Shrub Tundra	200	81	0.6
Closed Low Willow	3	1	<0.1
Closed Tall Willow	2	1	<0.1
Deep Polygon Complex	14	6	<0.1
Dryas Dwarf Shrub Tundra	571	231	1.7
Dune Complex	103	42	0.3
Elymus Meadow	53	21	0.2
Fresh Grass Marsh	124	50	0.4
Fresh Sedge Marsh	498	201	1.5
Halophytic Sedge–Grass Wet Meadow, brackish	67	27	0.2
Halophytic Sedge–Grass Wet Meadow, saline	637	258	1.9
Coastal Complex	2591	1049	7.9
Moist Sedge–Shrub Tundra	3425	1386	10.5
Old Basin Wetland Complex	873	353	2.7
Open Low Willow	264	107	0.8
Open Tall Willow	15	6	<0.1
Partially Vegetated	1078	436	3.3
Riverine Complex	24	10	0.1
Salt-killed Wet Meadow	1573	637	4.8
Tussock Tundra	3312	1340	10.1
Water	12,317	4985	37.6
Wet Sedge Meadow Tundra	3529	1428	10.8
Young Basin Wetland Complex	36	15	0.1
Total	32,771	13,263	100.0

Table 4. Classification and description of surface form classes on the Fish Creek delta, northeastern NPRA, 2003.

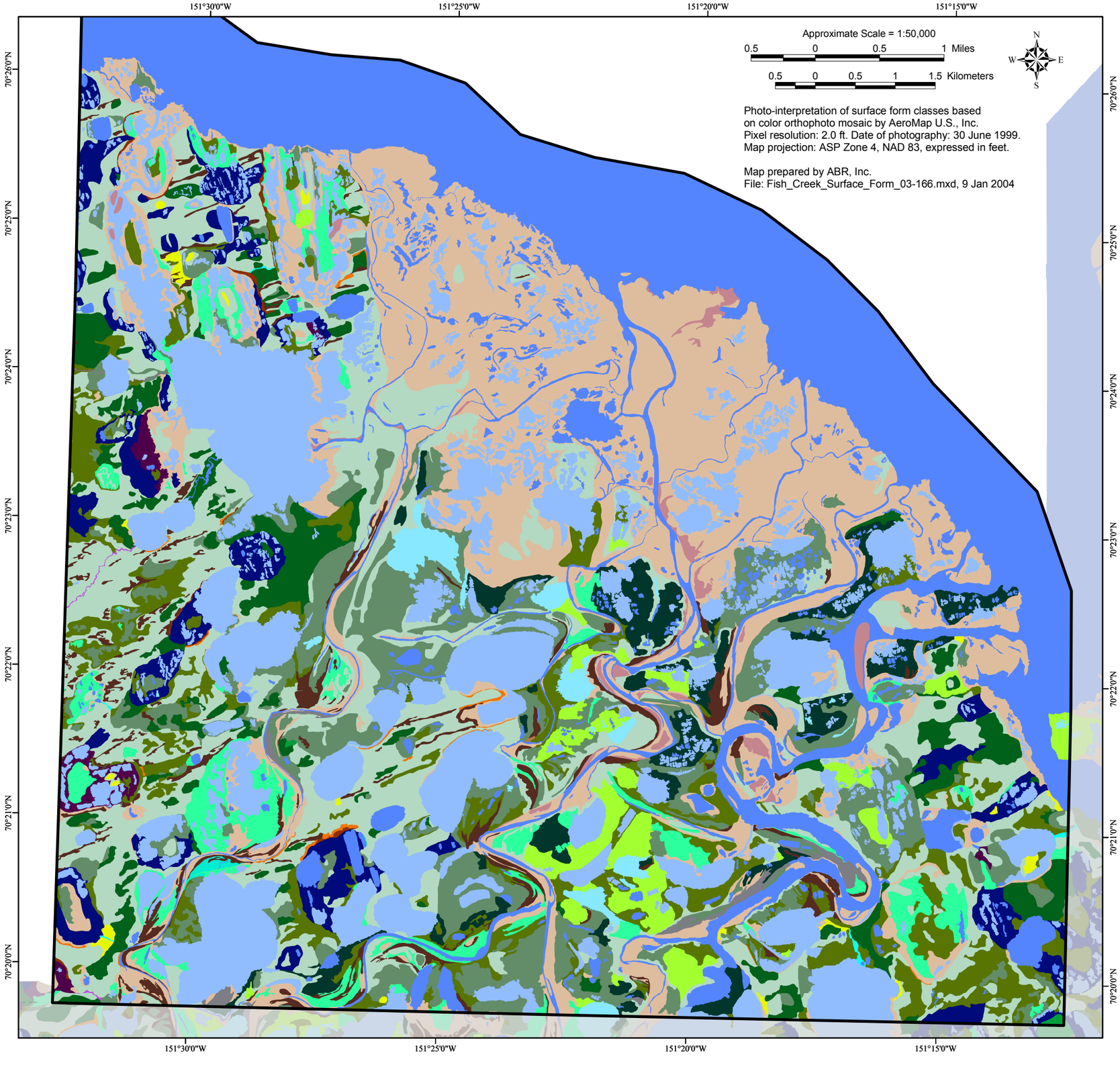
Class	Description
Small Dune	Elongated mounds or low ridges composed of wind-blown sand.
Undifferentiated Mounds	Isolated but repeating low mounds that are not attributed to specific geomorphic or periglacial processes. In the study area, it was used for low mounds on point bars and tidal flats that are formed partly by eolian and fluvial or tidal processes.
Nonpatterned	These flat areas show no evidence of polygonal rims caused by the development of ice wedges. Ice wedges may be present but are not expressed in the surface form. Small, elevated microsites are common on Inactive Tidal Flats, these generally are < 30 cm high and form no regular pattern or density. Non-patterned ground is typical of tidal flats where salt intrusion discourages ice formation.
Disjunct Polygon Rims	Disjunct polygon rims are found where ice-wedge development is evident but not sufficient to create closed polygons. This surface form is common on inactive delta deposits and in relatively recently drained thaw basins and isolated depressions in older basins where ice wedges are actively developing.
High-centered, Low-relief Polygons	High-centered polygons are composed of a raised "center" and a relatively low "trough" between centers of adjacent polygons and no rim. Most high-centered polygons range between 5 and 10 m in diameter. Generally, high-centered polygons result from the melting of ice wedges in the troughs between polygons. The centers are only slightly raised (< 50 cm) with respect to the trough or crack areas. This class also includes “flat-centered” polygons where the relief between centers and troughs is barely noticeable. This surface form is common on old surfaces such as abandoned delta deposits, alluvial–marine terraces, or older ice-rich drained basins, and was frequently associated with Salt-killed Wet Meadow.
Low-centered, Low-relief, Low-density Polygons	Well-developed polygons with a central low "basin," a raised "rim," and (frequently) a "trough" between polygons. Typically, polygons range from 15 to 30 m across and rims are less than 50 cm tall. Larger polygons often are partially bisected by newly forming rims. The polygons are formed by the development of a polygonal network of ice wedges in the permafrost.
Polygonized Pond Margins	A distinctive feature of pond shorelines formed when polygon centers merge with the adjacent pond leaving the elevated rims as peninsulas extending into the water body. This class is appropriate when at least 10% of the shore is polygonized, islands also may be present.
Lakes with Islands	Lakes with one or more islands present. Islands must be at least 1 m across and 3 m from the shore to be included in this class.
Water	Areas covered by permanent water.

Sedge–Grass Wet Meadow, saline; Salt-killed Wet Meadow; and Coastal Complex (Table 3). Barrens and Partially Vegetated classes were most frequently found on Active Tidal Flats and channel margins; Halophytic Sedge–Grass Wet Meadow, saline was the dominant type on vegetated Active Tidal Flats; and Coastal Complex was common on Inactive Tidal Flats. Ponds too small to map were common to all tidal flat deposits. The vegetation types on the Fish Creek delta are similar to classes that were developed for the Colville Delta (Jorgenson et al. 1997). For both areas, the combination of short growing season, low average temperature, and high salinity produce a restricted flora. Sixteen additional classes were mapped on the upper delta and adjacent coastal plain, the most abundant of which were Wet Sedge Meadow Tundra, Moist Sedge–Shrub Tundra, Tussock Tundra, and Old Basin Wetland Complex.

ECOTYPES

HIERARCHICAL ORGANIZATION OF ECOLOGICAL COMPONENTS

We developed hierarchical relationships among ecological components for the coastal ecosystems in this study by successively grouping data from 144 survey plots (including coastal plots from the Colville Delta) by soil texture, geomorphology, surface form, drainage, soil



Surface Form Class

- Small Dune
- Streaked Dune
- Bluffs and Streambanks
- Gelifluction Lobes
- Nonpatterned
- Disjunct Polygon Rims
- Low-centered, Low-relief, Low-density Polygons
- Low-centered, Low-relief, High-density Polygons
- Low-centered, High-relief, Low-density Polygons
- Low-centered, High-relief, High-density Polygons
- High-centered, Low-relief Polygons
- High-centered, High-relief Polygons
- Mixed High- and Low-centered Polygons
- Mixed Thaw Pits and Polygons
- Strang
- Undifferentiated Mounds
- Beads
- Water Tracks
- Polygonized Pond Margins
- Lake with Islands
- Basin Complex
- Dune Complex
- Riverine Complex
- Water

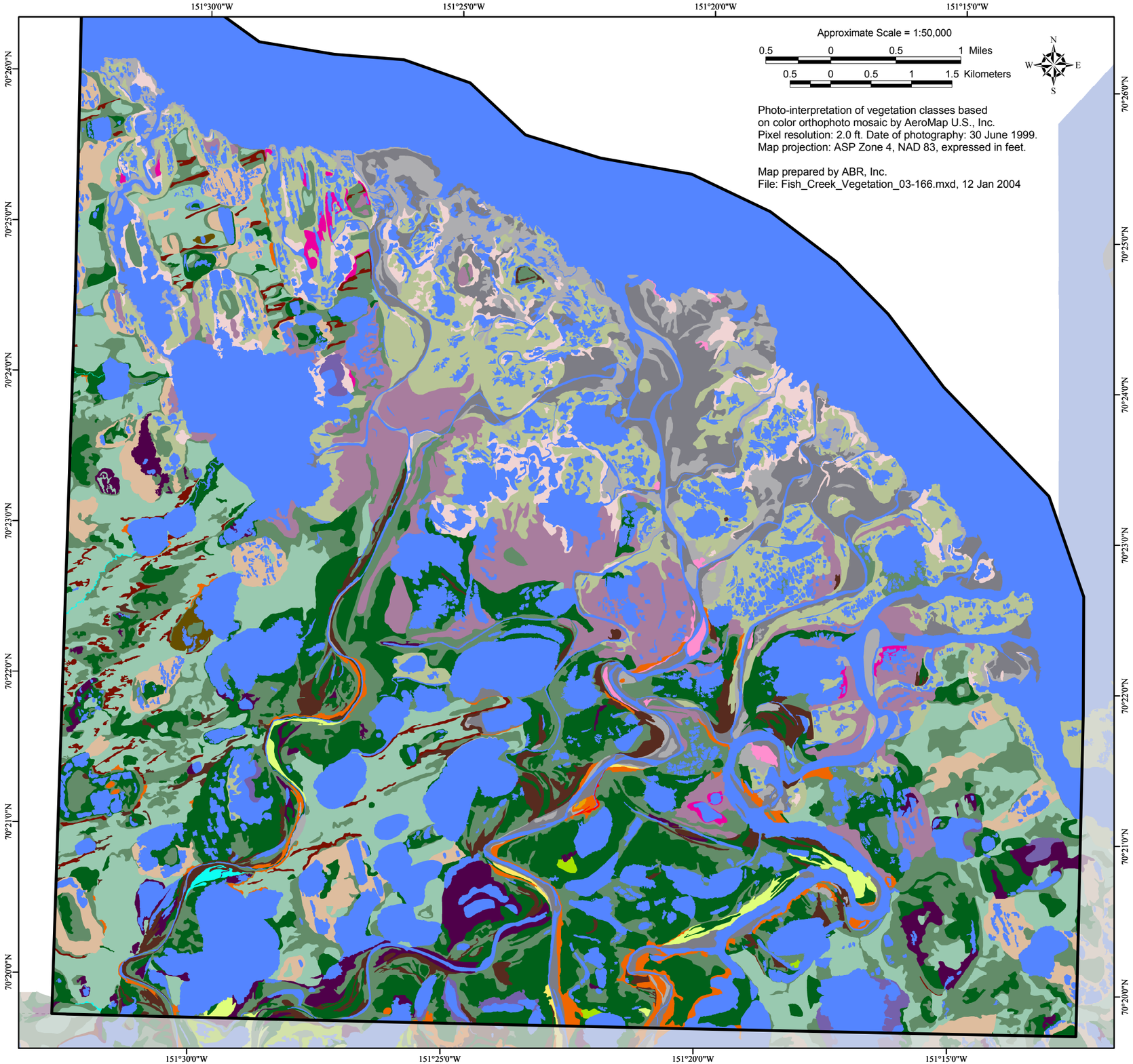
Note: Areas mapped outside the study area boundary are shown in muted colors.

Surface Form

Ecological Land Survey

Fish Creek Delta,
Northeastern NPRA

Figure 4



Vegetation Class

- Barren
- Partially Vegetated
- Halophytic Sedge–Grass Wet Meadow, saline
- Halophytic Sedge–Grass Wet Meadow, brackish
- Salt-killed Wet Meadow
- Elymus
- Open Tall Willow
- Closed Tall Willow
- Open Low Willow
- Closed Low Willow
- Dryas Dwarf Shrub Tundra
- Cassiope Dwarf Shrub Tundra
- Tussock Tundra
- Moist Sedge–Shrub Tundra
- Wet Sedge Meadow Tundra
- Fresh Sedge Marsh
- Fresh Grass Marsh
- Young Basin Wetland Complex
- Old Basin Wetland Complex
- Deep Polygon Complex
- Riverine Complex
- Dune Complex
- Coastal Complex
- Water

Note: Areas mapped outside the study area boundary are shown in muted colors.

Vegetation

Ecological Land Survey

Fish Creek Delta,
Northeastern NPRA

Figure 5

Table 5. Classification and description of coastal vegetation classes on the Fish Creek delta, northeastern NPRA, 2003.

Class	Description
Barrens	Nonvegetated flats on delta river bars, coastal dunes, and tidal flats that are recently exposed or too unstable to support more than a few pioneering plants (<5% cover). Typical species include *Deschampsia caespitosa, Elymus arenarius mollis, Chrysanthemum bipinnatum,* and *Puccinellia phryganodes*. Toward the coast, sediments are increasingly saline and tidally affected barrens are colonized by salt-tolerant species.
Partially Vegetated	Sparsely vegetated delta river bars, coastal dunes, and tidal flats that have 5–30% vegetative cover. Colonizers include *Deschampsia caespitosa*, *Salix ovalifolia*, *Chrysanthemum bipinnatum*, *Stellaria humifusa*, *Elymus arenarius mollis, Cochlearia officinalis,* and *Puccinellia phryganodes*.
Four-leaf Marestail	Permanently flooded shallow depressions on tidal flats and coastal ponds with vegetation dominated by *Hippuris tetraphylla.* Few other species are common though *Dupontia fisheri, Carex subspathacea*, and *C. ursina* may be present. This class was not mapped.
Elymus Meadow	Well drained, sandy Active Tidal Flats and Delta Active Overbank Deposits dominated by *Elymus arenarius mollis.* Soils are brackish to saline and active layer depths are relatively deep. Associated species include *Salix ovalifolia, Sedum rosea, Stellaria humifusa*, *Puccinellia andersonii* cf, and *Armeria maritima*.
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. Most salt-killed areas have < 30% live cover but are distinguished from Partially Vegetated because they are in transition from riverine to coastal environments. Common colonizing plants include *Stellaria humifusa, Puccinellia phryganodes, Cochlearia officinalis, Carex ursina, Dupontia fisheri,* and *Salix ovalifolia*. This class typically occurs either on low-lying delta deposits that originally supported Wet Sedge Meadow Tundra and Basin Wetland Complexes. Salt-killed Wet Meadow differs from other halophytic wet meadows and barrens in having extensive areas of exposed soil, substantial buried organic material, and remnant polygon rims.
Halophytic Sedge–Grass Wet Meadow, brackish	Coastal areas with wet, brackish (~800–15000 µS/cm) soils dominated by graminoids. Primarily found on Inactive Tidal Flat Deposits on nonpatterned ground this class is co-dominated by *Dupontia fisheri* and *Carex subspathacea*. Soils are loamy with buried organic layers and moderate thaw depths. Associated species often include *Puccinellia phryganodes*, *C. ursina*, *Salix ovalifolia, Calamagrostis deschampsioides, Cochlearia officinalis,* and *Stellaria humifusa.*
Halophytic Sedge–Grass Wet Meadow, saline	Saline (~>15000 µS/cm) Active and Inactive Tidal Flats co-dominated by *Puccinellia phryganodes* and *Carex subspathacea.* Soils are loamy, often with buried organic layers, and moderately deep thaw depths. *Salix ovalifolia, C. ursina*, *Cochlearia officinalis* and *Stellaria humifusa* are common associates.
Halophytic Grass Wet Meadow, saline	Active Tidal Flats dominated by *Puccinellia phryganodes.* These communities are found predominantly on the outer delta, soils are saline and loamy with moderately deep thaw depths (~60 cm). *Puccinellia* often is the only species present, though scattered individuals of *Carex subspathacea* and *Stellaria humifusa* may occur.
Halophytic Willow–Graminoid Dwarf Shrub Tundra	Coastal areas with moist, brackish soils typically co-dominated by *Salix ovalifolia* and halophytic graminoids. Primarily found on tidal flats and Delta Active Overbank Deposits with moderate thaw depths. Associated species on tidal flats often include *Carex subspathacea, Calamagrostis deschampsioides, Dupontia fisheri*, and *Stellaria humifusa.* On less saline soils of delta overbank deposits *Carex aquatilis, Eriophorum angustifolium,* and *Dupontia fisheri* are common.
Coastal Complex	Class used for mapping and characterized by a mosaic of vegetation dominated by wet graminoid meadows. The complex describes areas of Inactive Tidal Flats where homogenous patches of vegetation are too small (<0.5 ha) to map separately, more than three vegetation types are present, and no single class is dominant. Vegetation classes typically found with the complex include Halophytic Sedge–Grass Wet Meadow, brackish; Halophytic Sedge–Grass Wet Meadow, saline; Halophytic Willow–Graminoid Dwarf Shrub Tundra; Four-leaf Marestail; and lakes.
Water	Permanently flooded, non-vegetated waterbodies. Included in this class are non-vegetated brackish lakes, tidal lakes, tidal rivers and guts, and nearshore water. Areas mapped as water may include some partially vegetated waterbodies where vegetation was submerged and therefore not discernable on the aerial photography.

chemistry, vegetation structure, and plant association (Table 6). This hierarchical organization reveals that the associations among ecological components frequently are broad. For example, many geomorphic units have similar soil textures and a given plant association often occurs on several geomorphic units, depending on surface form and hydrology. Accordingly, geomorphic units with similar texture (e.g., sandy-loamy and loamy-peat-rich) or genesis were grouped to reduce the number of classes. Ecotypes then were derived from these aggregations to differentiate a limited set of closely associated ecological components.

CLASSIFICATION AND MAPPING

During mapping, we identified 288 ITU combinations on Fish Creek delta and the adjacent coastal plain. We aggregated the ITUs into 40 ecotypes of which 10 were specifically coastal: four aquatic, five terrestrial, and one a complex (Table 7, Figure 6, Appendix 3). The most common coastal ecotypes included Coastal Wet Meadow Complex, Coastal Barrens, Coastal Salt-killed Wet Meadow, Coastal Saline Wet Meadow, Nearshore Water, and Coastal Lake (Table 8, Figure 7). Coastal Barrens and Coastal Saline Wet Meadow were most common on Active Tidal Flats. Coastal Wet Meadow Complex was the most common ecotype on Inactive Tidal Flats. Minor, but frequent, variation in surface elevation on this geomorphic unit resulted in a mosaic of salt-affected vegetation including brackish and saline meadows classes, Four-leaf Marestail, Halophytic Willow–Graminoid Dwarf Shrub, and small ponds. Coastal Salt-killed Wet Meadow includes those portions of non-coastal terrain units (most typically Delta Inactive Overbank Deposits) where non-coastal vegetation has been affected by storm surges and wind-driven high tides. Salt-killed areas frequently are sparsely vegetated with colonizing salt-tolerant species. Two additional coastal ecotypes (Coastal Herb Marsh, Coastal Moist Willow Dwarf Shrub) were identified during field sampling but not mapped because they occurred in patches too small to map individually. Both classes typically were mapped as components of Coastal Wet Meadow Complex.

We mapped 30 ecotypes on the upper delta and adjacent coastal plain. Of these the most abundant were Upland Moist Tussock Meadow, Riverine Wet Sedge Meadow, and Lowland Moist Sedge–Shrub Meadow.

ECOTYPE CHARACTERISTICS

Vegetation Composition

For analysis of floristic composition, we pooled data from coastal plots in NPRA (2001–03) and the Colville River delta (1992–96) (Jorgenson et al. 1997; 2003). Salt-killed vegetation was excluded because of the great variability in re-vegetation associated with these plots, leaving 117 plots for analysis (Table 9). Species were ordered to emphasize the gradient in species distribution across ecotypes. Fifteen species were closely identified with coastal ecotypes; these comprised 1 shrub, 8 graminoids, and 6 herbs, and are listed at the top of Table 9. Analysis revealed strong associations among species growing under similar conditions. Wet, saline ecotypes were characterized by the dominance of *Puccinellia phryganodes,* whereas *Dupontia fisheri* was dominant on more brackish soils. *Carex subspathacea* was found as an associate with both species and indicative of intermediate conditions. On moist soils, *Salix ovalifolia* was predominant, and *D. fisheri* was a common associate. Although the coastal environment was relatively poor in species diversity, dominant species and plant associations were tightly coupled to environmental gradients.

Relationships among species associations were distinguished further by a Detrended Correspondence Analysis of five terrestrial, coastal ecotypes (Figure 8). A salinity gradient is apparent along the horizontal axis with Coastal Saline Wet Meadow positioned at the far left of the gradient and most Coastal Barrens plots to the right. The greatest spread in plot distribution is shown for Coastal Barrens, which can be found on Active Tidal Flats on the lower delta and Delta Active Channel Deposits on the upper delta. Consequently, these plots have relatively few species in common and support a range of salt-tolerant colonizing plants, from *Puccinellia phryganodes* on the lower delta to *Deschampsia caespitosa* farther upstream. The overlap between Coastal Dry Elymus Meadow and some Coastal Barrens plots verifies the similarity in species

Table 6. Relationships among selected components of ecosystems on the Fish Creek delta, northeastern NPRA, 2003.

Soil Texture	Geomorphic Unit	Surface Form	Drainage	Soil Chemistry	Vegetation Structure	Plant Association	Ecosystem Type (Ecotype level)
Sand, Loam	Active Tidal Flat, Delta Active Channel Deposit, Eolian Active Coastal Sand Deposit	Non-patterned, Undifferentiated Mounds, Dunes	Excessive, Well	Brackish	Grass	*Elymus arenarius mollis–Salix ovalifolia*	Coastal Dry Elymus Meadow
			Well	Saline (S), Brackish (B), Fresh Alkaline (FA) -	Barren, Partially Vegetated	*Deschampsia caespitosa–Chrysanthemum bipinnatum*	Coastal Barrens
						Elymus arenarius mollis–Deschampsia caespitosa	
						Elymus arenarius mollis–Salix ovalifolia	
			Poor	S, B		*Puccinellia phryganodes*	
Loam	Active Tidal Flat (Mta), Inactive Tidal Flat (Mti), Delta Active Overbank Deposit (Fdoa)	Non-patterned	Poor, Well	Brackish	Shrub-sedge	*Salix ovalifolia–Carex subspathacaea*	Coastal Moist Willow Dwarf Shrub
						Salix ovalifolia–Carex aquatilis	
	Inactive Tidal Flat,	Non-patterned	Poor	Saline	Grass	*Puccinellia phryganodes*	Coastal Saline Wet Meadow
				Saline, Brackish	Graminoid	*Puccinellia phryganodes–Carex subspathacaea*	
Peat-rich, Loam	Mta, Mti, Fdoa	Non-patterned	Poor	Brackish	Graminoid	*Carex subspathacaea–Dupontia fisheri*	Coastal Brackish Wet Meadow
	Delta Inactive Overbank Deposit	Disjunct Polygon Rims, Low-centered, Low relief, Low-density Polygons, High-centered, Low-relief Polygons	Poor	Saline, Brackish	Barren, Partially Vegetated	None	Coastal Salt-killed Meadow
Water	Brackish Shallow Isolated Lake, Tidal Ponds	Water	Flooded	Saline, Brackish	Forb	*Hippurus tetraphylla*	Coastal Marsh
					Water	Water	Coastal Lake
	Nearshore Water	Water	Flooded	Saline, Brackish	Water	Water	Nearshore Water
	Tidal River	Water	Flooded	S, B, FA	Water	Water	Tidal River

Table 7. Classification and description of ecotypes (local-scale ecosystems) on the Fish Creek delta, northeastern NPRA, 2003. Species in bold type indicate floristic associations.

Class	Description
Coastal Barrens	Barren or partially vegetated (< 30% cover) Active Tidal Flats, Delta Active Channel Deposits, and Active Coastal Sand Deposits where frequent sedimentation restricts vegetation establishment. Soils are variably saline, alkaline, have deep thaw depths and little organic accumulation. Several communities are identifiable based on degree of tidal effect. Slightly brackish sites on the upper delta are well drained, moist to dry and colonized by ***Deschampsia caespitosa****, Astragalus alpinus, Salix alaxensis,* and ***Chrysanthemum bipinnatum.*** Farther downstream soils are more saline, moist to dry, and dominated by ***Elymus arenarius mollis,*** *Stellaria humifusa****,*** *Rumex arcticus, Sedum rosea*, and ***Salix ovalifolia***. Exposed, outer delta tide flats are saline, wet, and colonized by ***Puccinellia phryganodes*** and *Stellaria humifusa*.
Coastal Dry Elymus Meadow	Somewhat poorly vegetated, well-drained meadows on Active Tidal Flats and Delta Active Channel Deposits characterized by the presence of ***Elymus arenarius mollis***. Soils are brackish sands with little organic material and deep active layers. Commonly associated species include ***Salix ovalifolia***, *Sedum rosea, Stellaria humifusa*, (on tide flats) and *Deschampsia caespitosa* (on delta deposits).
Coastal Moist Willow Dwarf Shrub	Active and Inactive Tidal Flats, and Delta Active Overbank Deposits with vegetation dominated by dwarf willow and graminoids. Outer delta communities have brackish, loamy (with variable organic horizons), saturated soils, with ground water depths ~ 25 cm and active layer depths ~50 cm. Vegetation is dominated by ***Salix ovalifolia***, ***Carex subspathacea,*** and *Calamagrostis deschampsioides*. On sandy sites ***Elymus arenarius mollis*** is a co-dominant. On Delta Active Overbank Deposits, soils are loamy, less brackish, and associated species include ***Carex aquatilis***, and *Dupontia fisheri****.***
Coastal Brackish Wet Meadow	Communities dominated by graminoids and found predominantly on Inactive Tidal Flats. Soils are loamy to sandy, usually with buried organic material. The water table is close to the surface and thaw depths are ~50 cm. Common species include ***Carex subspathacea, Dupontia fisheri***, and ***Salix ovalifolia***, with *Puccinellia phryganodes, C. ursina,* and *Calamagrostis deschampsioides* as occasional associates.
Coastal Saline Wet Meadow	Active and Inactive Tidal Flats with vegetation dominated by ***Puccinellia phryganodes***. Soils are saturated, saline, loams with shallow to moderate (< 20cm) organic horizons. Active layer depths are moderately deep (~45–70 cm). Vegetation maybe co-dominated by ***Carex subspathacea;*** *C. ursina,* and *Stellaria humifusa* are common associates.
Coastal Salt-Killed Meadow	Barren or partially vegetated (< 30% cover) delta deposits, where saltwater intrusions from storm surges have killed much of the original vegetation and salt-tolerant plants are actively colonizing. Newly deposited sediments typically are found on top of a thick organic horizon. Salinity and pH vary with the frequency and degree of saltwater inundation; active layer depths are moderate and ground water depths shallow. Common colonizing plants include *Stellaria humifusa, Puccinellia phryganodes, Cochlearia officinalis*, *Carex ursina, Dupontia fisheri,* and *Salix ovalifolia*. Remnant patches of Riverine or Lowland Wet Sedge Meadow may be present.
Coastal Herb Marsh (not mapped)	Vegetated, permanently flooded, shallow (< 50 cm) ponds and depressions in Inactive Tidal Flats or on the margins of Coastal Lakes. Water is brackish to saline and affected by extreme tides and storm surges. The dominant plant species is ***Hippuris tetraphylla***.
Coastal Lake	Coastal waterbodies that are flooded periodically with saltwater during high tides or storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate is loamy and occasionally contains peat. Shorelines usually have halophytic vegetation. Some Coastal Lakes have distinct outlets or have been partially drained (tapped) through erosion of riverbanks. Shallow lakes (< 1.5m) freeze to the bottom during winter.
Coastal Wet Meadow Complex	Class used for ecotype mapping and characterized by a mosaic of wet graminoid meadows. The complex describes areas of Inactive Tidal Flats where homogenous patches of vegetation are too small (<0.5 ha) to map separately, more than three ecotypes are present, and no single class is dominant. Ecotype classes typically found with the complex include Coastal Saline Wet Meadow, Coastal Brackish Wet Meadow, Coastal Moist Willow Dwarf Shrub, Coastal Herb Marsh, and Coastal Lake.
Tidal River	Sections of Fish Creek and its distributaries 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. Water levels and salinity maybe substantially elevated by on-shore wind. During summer and winter currents are negligible.
Tidal Gut	Inlet or channel with a permanent connection to Harrison Bay. Tidal guts are maintained by the action of tides and marine currents and receive minimal influence from freshwater sources. Shorelines support saline vegetation.
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.

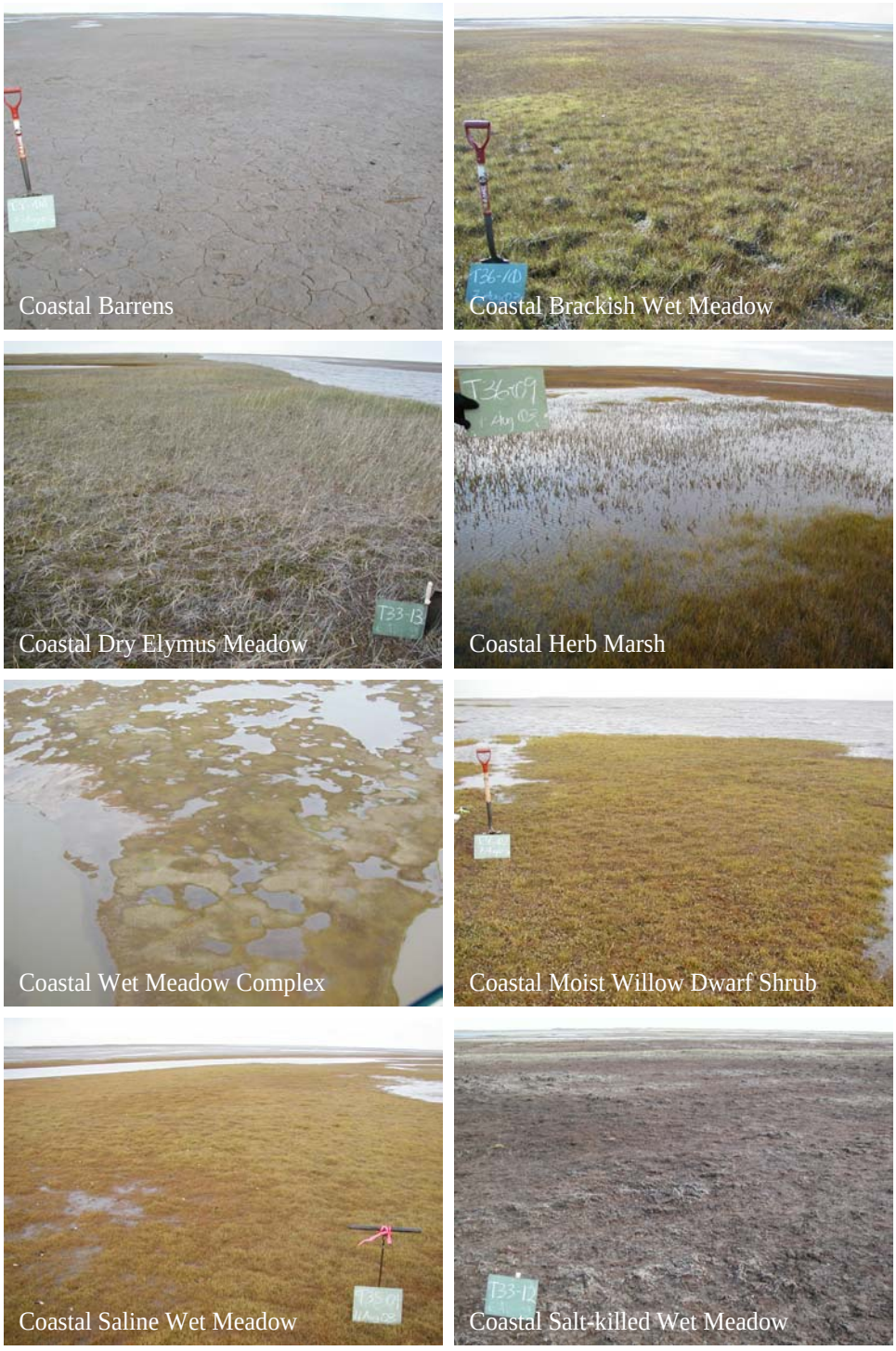
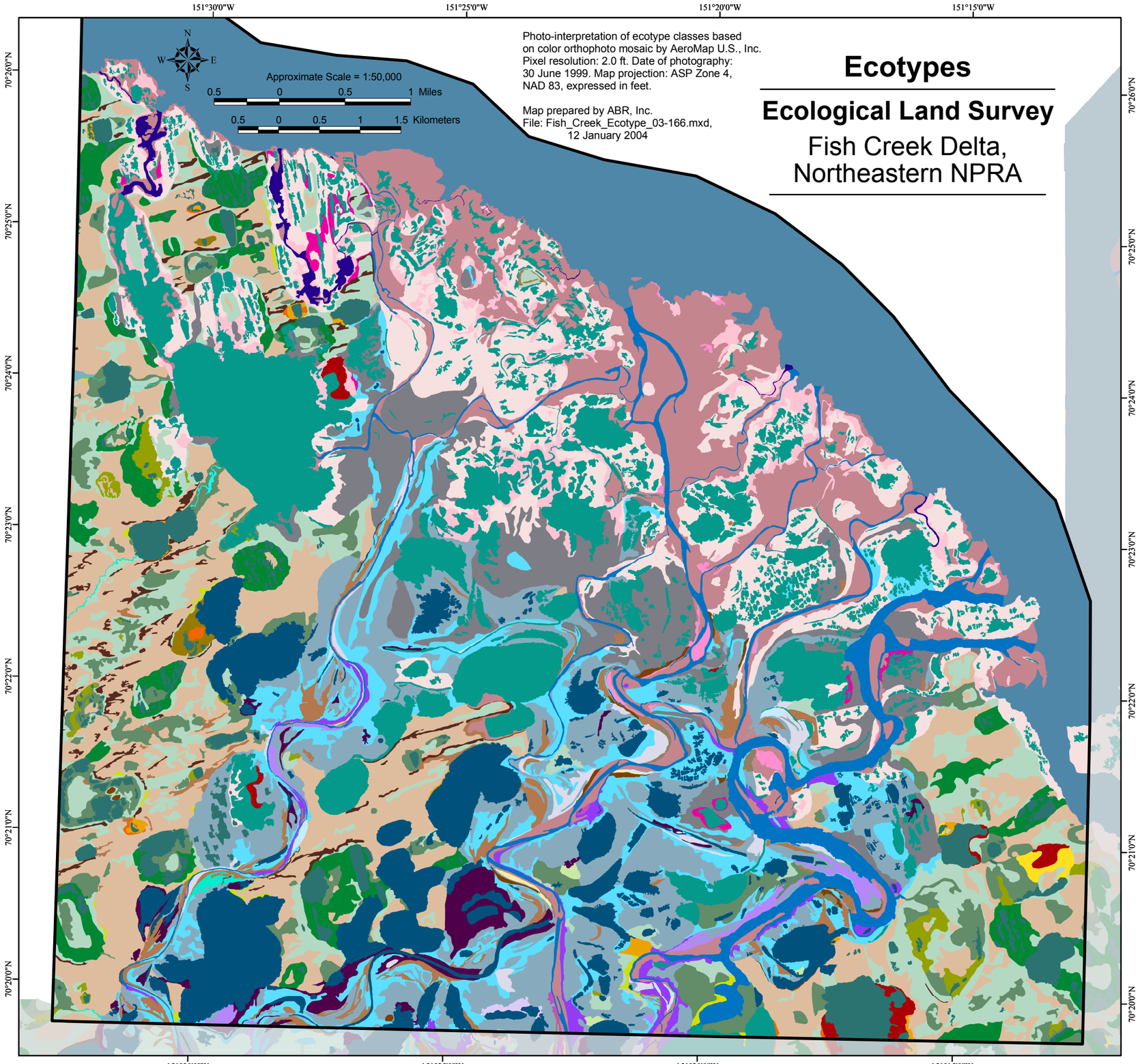


Figure 6. Photographs of common coastal ecotypes on the Fish Creek delta, northeastern NPRA, 2003.

Table 8. Areal extent of ecotypes on the Fish Creek delta, northeastern NPRA, 2003.

	Area		
Ecotype Class	Acres	Ha	%
Coastal Barrens	2484	1005	7.6
Coastal Dry Elymus Meadow	53	21	0.2
Coastal Saline Wet Meadow	637	258	1.9
Coastal Brackish Wet Meadow	67	27	0.2
Coastal Wet Meadow Complex	2591	1049	7.9
Coastal Salt-killed Wet Meadow	1573	637	4.8
Coastal Lake	3675	1487	11.2
Tidal Gut	126	51	0.4
Tidal River	1000	405	3.1
Nearshore Water	4609	1865	14.1
Lacustrine Moist Sedge–Shrub Meadow	16	7	0.1
Lacustrine Wet Sedge Meadow	40	16	0.1
Lacustrine Sedge Marsh	35	14	0.1
Lacustrine Grass Marsh	95	38	0.3
Lacustrine Basin Complex	36	15	0.1
Lowland Moist Low Willow Shrub	40	16	0.1
Lowland Moist Sedge–Shrub Meadow	1935	783	5.9
Lowland Wet Sedge Meadow	1070	433	3.3
Lowland Sedge Marsh	171	69	0.5
Lowland Basin Complex	873	353	2.7
Lowland Lake	931	377	2.8
Riverine Moist Barrens	24	10	0.1
Riverine Moist Tall Willow Shrub	7	3	<0.1
Riverine Moist Low Willow Shrub	180	73	0.5
Riverine Dry Dryas Dwarf Shrub	163	66	0.5
Riverine Moist Sedge–Shrub Meadow	1474	596	4.5
Riverine Wet Sedge Meadow	2418	979	7.4
Riverine Sedge Marsh	292	118	0.9
Riverine Grass Marsh	15	6	<0.1
Riverine Complex	24	10	0.1
Riverine Deep-polygon Complex	14	6	<0.1
Riverine Dune Complex	103	42	0.3
Riverine Lake	1984	803	6.1
Headwater Stream	5	2	<0.1
Upland Dry Barrens	32	13	0.1
Upland Dry Dryas Dwarf Shrub	408	165	1.2
Upland Dry Tall Shrub	10	4	<0.1
Upland Moist Cassiope Dwarf Shrub	200	81	0.6
Upland Moist Low Willow Shrub	48	19	0.1
Upland Moist Tussock Meadow	3312	1340	10.1
Total	32,771	13,263	100

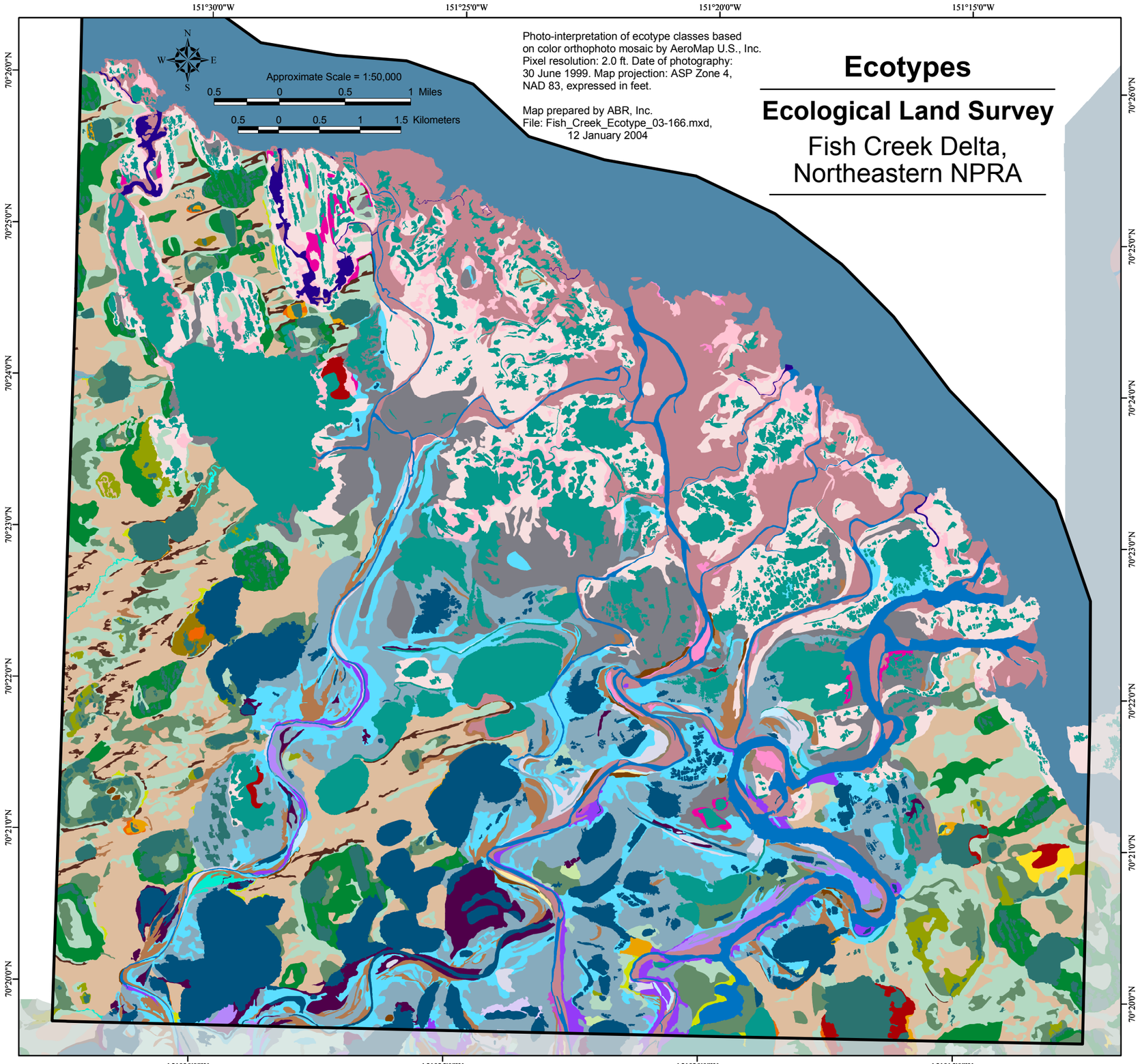


Ecotype Class

- Coastal Barrens
- Coastal Saline Wet Meadow
- Coastal Brackish Wet Meadow
- Coastal Wet Meadow Complex
- Coastal Dry Elymus Meadow
- Coastal Salt-killed Wet Meadow
- Coastal Lake
- Riverine Moist Barrens
- Riverine Moist Tall Willow Shrub
- Riverine Moist Low Willow Shrub
- Riverine Dry Dryas Dwarf Shrub
- Riverine Moist Sedge–Shrub Meadow
- Riverine Wet Sedge Meadow
- Riverine Sedge Marsh
- Riverine Grass Marsh
- Riverine Dune Complex
- Riverine Deep-polygon Complex
- Riverine Complex
- Riverine Lake
- Lacustrine Moist Sedge–Shrub Meadow
- Lacustrine Wet Sedge Meadow
- Lacustrine Sedge Marsh
- Lacustrine Grass Marsh
- Lacustrine Basin Complex
- Lowland Moist Low Willow Shrub
- Lowland Moist Sedge–Shrub Meadow
- Lowland Wet Sedge Meadow
- Lowland Sedge Marsh
- Lowland Basin Complex
- Lowland Lake
- Upland Dry Barrens
- Upland Dry Tall Shrub
- Upland Moist Low Willow Shrub
- Upland Dry Dryas Dwarf Shrub
- Upland Moist Cassiope Dwarf Shrub
- Upland Moist Tussock Meadow
- Headwater Stream
- Tidal Gut
- Tidal River
- Nearshore Water

Note: Areas mapped outside the study area boundary are shown in muted colors.

Figure 7



Ecotype Class

- Coastal Barrens
- Coastal Saline Wet Meadow
- Coastal Brackish Wet Meadow
- Coastal Wet Meadow Complex
- Coastal Dry Elymus Meadow
- Coastal Salt-killed Wet Meadow
- Coastal Lake
- Riverine Moist Barrens
- Riverine Moist Tall Willow Shrub
- Riverine Moist Low Willow Shrub
- Riverine Dry Dryas Dwarf Shrub
- Riverine Moist Sedge–Shrub Meadow
- Riverine Wet Sedge Meadow
- Riverine Sedge Marsh
- Riverine Grass Marsh
- Riverine Dune Complex
- Riverine Deep-polygon Complex
- Riverine Complex
- Riverine Lake
- Lacustrine Moist Sedge–Shrub Meadow
- Lacustrine Wet Sedge Meadow
- Lacustrine Sedge Marsh
- Lacustrine Grass Marsh
- Lacustrine Basin Complex
- Lowland Moist Low Willow Shrub
- Lowland Moist Sedge–Shrub Meadow
- Lowland Wet Sedge Meadow
- Lowland Sedge Marsh
- Lowland Basin Complex
- Lowland Lake
- Upland Dry Barrens
- Upland Dry Tall Shrub
- Upland Moist Low Willow Shrub
- Upland Dry Dryas Dwarf Shrub
- Upland Moist Cassiope Dwarf Shrub
- Upland Moist Tussock Meadow
- Headwater Stream
- Tidal Gut
- Tidal River
- Nearshore Water

Note: Areas mapped outside the study area boundary are shown in muted colors.

Figure 7

Table 9. Mean cover (%) of the most abundant species in coastal ecotypes on the Fish Creek delta, northeastern NPRA, 2003. Bolded numbers represent frequencies >60% within ecotype; blanks indicate species is absent; and 0 indicates cover <0.5%. Italicized numbers denote dominant and differential species used to name plant association.

Taxon	Coastal Herb Marsh	Coastal Salt-killed Wet Meadow	Coastal Saline Wet Meadow	Coastal Brackish Wet Meadow	Coastal Moist Willow Dwarf Shrub	Coastal Dry Elymus Meadow	Coastal Barrens
Hippuris tetraphylla	***22***		0	0			
Carex ursina	0	1	10	2	1	0	
Stellaria humifusa		**8**	**5**	1	2	1	1
Puccinellia phryganodes	0	5	***41***	3	0	0	*2*
Carex subspathacea	0	0	***21***	***25***	*9*		0
Dupontia fischeri	3	1	1	***22***	**6**	0	0
Salix ovalifolia		2	0	***5***	***38***	***17***	*0*
Elymus arenarius mollis		0	0	1	*0*	***17***	*2*
Sedum rosea		0	1	0	0	**1**	0
Cochlearia officinalis		0	0	1	0		0
Puccinellia andersonii cf		1	0	1	0	1	0
Calamagrostis deschampsioides			0	1	1	0	
Carex glareosa				0	1		
Rumex arcticus			0	0	0		0
Armeria maritima			0		0	0	0
Carex aquatilis		0	1		*4*		
Eriophorum angustifolium		1		1	4		
Arctophila fulva			0	0	0		
Distichium sp.				3	0		0
Campylium stellatum				0	2		0
Arctagrostis latifolia				0	0		0
Artemisia arctica SL				0	0	0	0
Poa arctica SL				0	0	0	0
Alopecurus alpinus				0	0	1	0
Deschampsia caespitosa		0		0	2	1	*4*
Chrysanthemum bipinnatum				0	1		*1*
Astragalus alpinus					1	0	0
Cerastium beeringianum beeringianum					0	0	0
Petasites frigidus					0	0	0
Salix alaxensis							0
Sample size	3	12	16	23	21	8	34

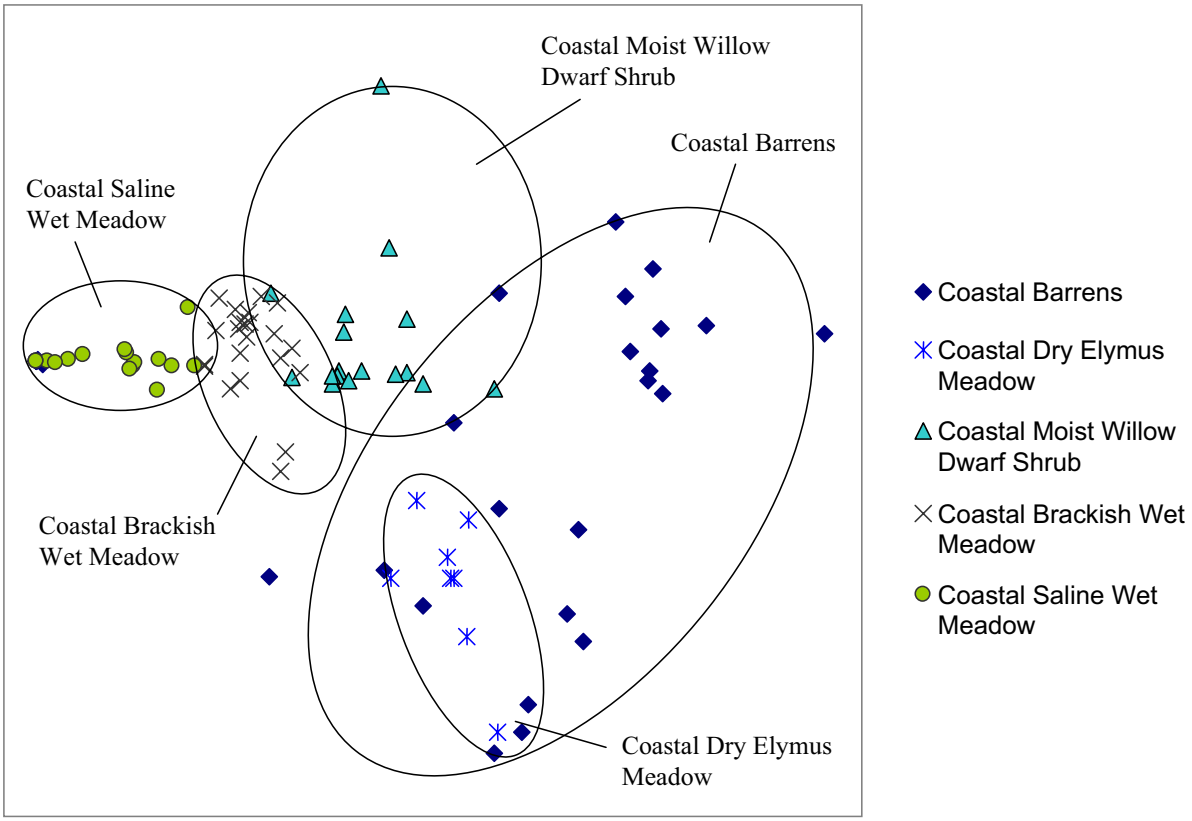


Figure 8. Detrended Correspondence Analysis of species composition of plots sampled within coastal ecotypes on the Fish Creek and Colville River deltas, 1992–2003. Ellipses depict central groupings of ecotypes.

composition that may occur between these ecotypes.

Environmental Relationships

When comparing differences in six environmental characteristics among the coastal ecotypes, gradients were much larger for some properties than others (Figure 9). Mean surface organic-horizon thickness, for example, showed only small differences (0–3 cm) among ecotypes because of the frequent occurrence of flooding and sedimentation in coastal environments. Mean cumulative organic depth, however, ranged from 3 cm in Coastal Barrens to 15 cm in Coastal Salt-killed Meadows. Mean thaw depths ranged from 51 cm in Coastal Moist Willow Dwarf Shrub to 82 cm in Coastal Dry Elymus Meadows. Mean depth to groundwater (-) or of surface water (+) was the most variable property, ranging from –60 cm in Coastal Dry Elymus Meadows to 117 cm in Tidal Rivers. Site electrical conductivity (water or soil) also showed a large gradient ranging from 2947 µS/cm for Coastal Dry Elymus Meadows to18,905 µS/cm in Coastal Lakes. Mean site pH ranged from 6.6 in Coastal Salt-killed Meadows to 8.0 in Coastal Lakes. Of these properties, electrical conductivity (salinity), water depth, and cumulative organic thickness (indicator of flooding frequency) appear to be the factors most strongly affecting ecotype distribution across coastal areas.

We also compared differences in the environments characteristics associated with 21 common coastal plant species and found that gradients were much larger for some properties than others (Figure 10). Mean surface organic-horizon thickness showed only small differences, ranging from 0 cm for *Armeria maritima* to 5 cm for *Carex aquatilis*. Mean cumulative organic depth ranged from 0 cm for *Armeria maritima* to 17 cm for *Carex ursina*. Mean thaw depths ranged from 44 cm for *Armeria maritima* to 81 cm for *Sedum rosea*. Mean depth to groundwater (-) or of surface water (+) showed a large gradient ranging from –69 cm for *Salix*

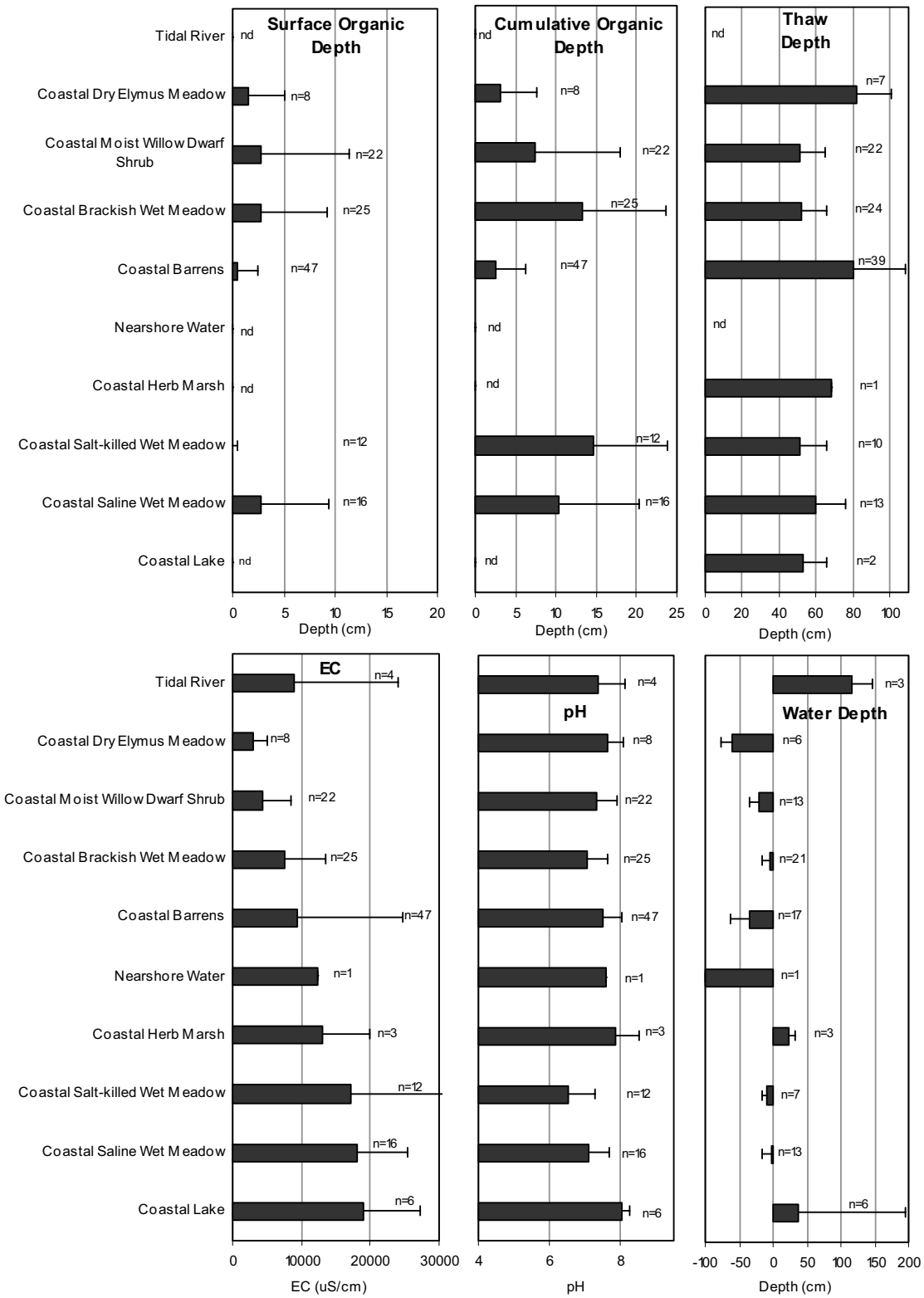


Figure 9. Mean (± SD) surface organic layer thickness, cumulative organic thickness in the top 40 cm, water depth, pH, electrical conductivity (EC), and thaw depth of ecotypes on the Fish Creek and Colville River deltas, 1992–2003.

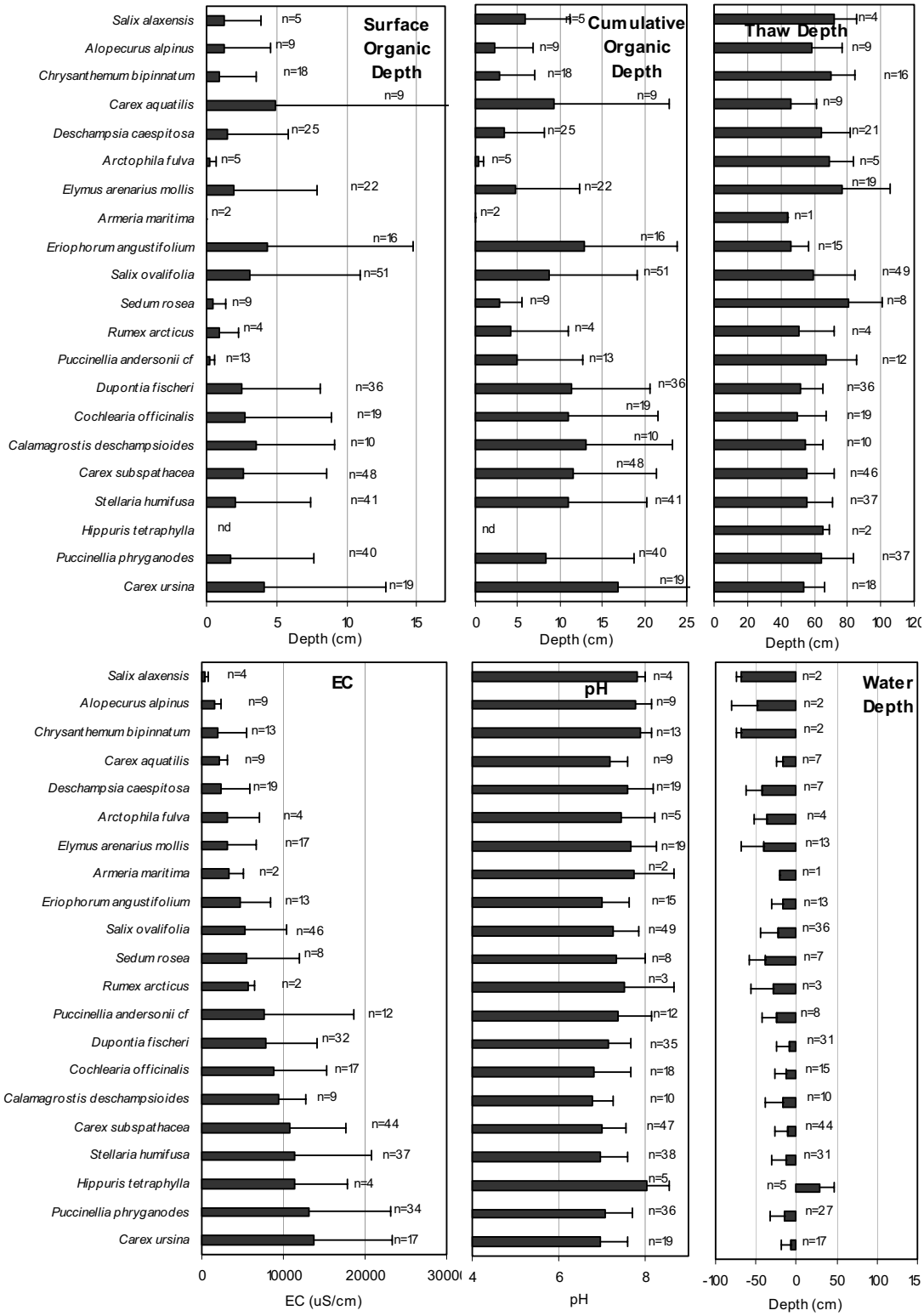


Figure 10. Mean (± SD) surface organic layer thickness, cumulative organic thickness in the top 40 cm, water depth, pH, electrical conductivity (EC), and thaw depth for abundant species on the Fish Creek and Colville River deltas, 1992–2003.

alaxensis to 29 cm for *Hippuris tetraphylla*. Site electrical conductivity also showed a large gradient ranging from 447 µS/cm for *Salix alaxensis* (found only in the upper delta) to 13,783 µS/cm for *Hippuris tetraphylla* (found only in the lower delta). Mean site pH ranged from 6.8 for *Calamagrostis deschampsioides* to 7.9 for *Chrysanthemum bipinnatum*. Of these properties, electrical conductivity (salinity), water depth, and cumulative organic thickness (indicator of flooding frequency) again appear to be the factors most strongly affecting the distribution of species across the coastal areas.

RARE PLANTS

Of the 35 locations where collections were made (Figure 11), 24 were identified in the field as *Carex holostoma* Drej, 4 as *Koeleria asiatica* Domin, and 7 as *Poa hartzii* Gandog. ssp. *alaskana* Soreng. (Table 10). Other species included in the search, but not found in the study area included *Mertensia drummondii* (Lehm.) G. Don, *Pleuropogon sabinei* R. Br., *Thlaspi arcticum* Porsild, *Potentilla stipularis* L., and any unusual crucifers, particularly *Draba* spp. Collection points referenced in Figure 11 do not represent the entire area searched. For additional information on rare plant species locations and collections refer to Jorgenson et al. 2003.

Carex holostoma was discovered at many locations and was collected at a representative variety of sites. This species appears to be common within the study area. It is listed by the Alaska Natural Heritage Program as "G4? S2" (of concern globally, but apparently secure; imperiled within Alaska [www.uaa.alaska.edu/enri/aknhp_web]). The species occurred on moist microsites within low-centered polygons or strang in ice-rich drained basins, frequently along the lower edges of polygon rims. Associated species included *Carex aquatilis, C. bigelowii, Eriophorum angustifolium, Salix planifolia pulchra*, and *Pedicularis sudetica*. *Carex holostoma* was found along the road alignment, at Spark, CD6, Clover, and many lowland tundra locations in the vicinity of the Ublutuoch River and Fish Creek.

Poa hartzii alaskana was observed and collected along active riverbars of Judy Creek and the upper Fish Creek delta. The species is listed as "G3G4T1 S1" (subspecies critically imperiled globally; critically imperiled within Alaska). *Poa hartzii alaskana* is not common along the Judy Creek drainage, but where it occurs it is well established and abundant. Associated species included *Deschampsia caespitosa, Festuca rubra, Poa glauca, Chrysanthemum bipinnatum,* and *Salix alaxensis*. Though searches were made for *Poa hartzii alaskana* along other drainages in the study area, it was found only along Judy Creek and the upper Fish Creek delta. The species may be restricted in the planning area to the Judy Creek drainage.

Koeleria asiatica was observed on sand dunes at many riverine locations. This species was collected less frequently than the others because its identification is straightforward and because it is widely distributed in the study area. Distribution maps for this species show the study area as the eastern most extent of the known range (Hultén 1968). *Koeleria asiatica* is listed as "G4 S2S3" (secure, but of concern globally; rare or imperiled within Alaska). *Koeleria asiatica* typically occurs on partially vegetated, active sand dunes adjacent to regularly flooded riverbars, though it was occasionally found on older stabilized dunes. Associated species include *Salix alaxensis, Chrysanthemum bipinnatum, Deschampsia caespitosa, Equisetum arvense, Festuca rubra*, and, occasionally, *Dryas integrifolia* and *Arctostaphylos rubra.*

SUMMARY AND CONCLUSIONS

This report presents the results of an ecological land survey (ELS) that inventoried, classified, and evaluated the ecological characteristics of the Fish Creek delta in the northeastern NPRA, which is in close proximity to areas being considered for oil development. This report, which focuses on coastal ecosystems in the delta, provides an addendum to the more comprehensive ELS prepared for the Northeast Planning Area of the NPRA (Jorgenson et al. 2003).

Field surveys at 144 plots during August 2003 collected information on the geomorphic, topographic, hydrologic, pedologic, and vegetative characteristics of ecosystems across the entire range of coastal environmental gradients in the Fish Creek delta. Individual ecological

Table 10. Locations and preliminary identification of specimens collected during a rare plant survey in the northeastern planning area of the NPRA, 2003.

Collection ID	General Location	Species	Latitude (dd83)	Longitude (dd83)
CAHO-CD6	CD6	*Carex holostoma*	70.27111667	-151.53878333
CAHO-SPARK	Spark	*Carex holostoma*	70.23886667	-151.68628333
CAHO2-CD6	CD6	*Carex holostoma*	70.26796667	-151.53301667
CAHO2SPARK	Spark	*Carex holostoma*	70.23703333	-151.69015000
CAHO6	Ublutuoch	*Carex holostoma*	70.21378333	-151.38623333
CAHO7	Ublutuoch	*Carex holostoma*	70.21211667	-151.39138333
CAHO8	Ublutuoch	*Carex holostoma*	70.21330000	-151.39840000
CARHOL1	CD6	*Carex holostoma*	70.26923333	-151.53165000
CARHOL1a	Road_Alignment	*Carex holostoma*	70.31978333	-151.17726667
CARHOL2	Spark	*Carex holostoma*	70.23858333	-151.68798333
CARHOL2a	Road_Alignment	*Carex holostoma*	70.30878333	-151.18561667
CARHOL3	Spark	*Carex holostoma*	70.23886667	-151.68813333
CARHOL3a	Road_Alignment	*Carex holostoma*	70.29973333	-151.23656667
CARHOL4	Spark	*Carex holostoma*	70.23990000	-151.69180000
CARHOL4a	Road_Alignment	*Carex holostoma*	70.29911667	-151.25631667
CARHOL5	Spark	*Carex holostoma*	70.23803333	-151.69520000
CARHOL5a	Road_Alignment	*Carex holostoma*	70.29088333	-151.25220000
CARHOL6	Spark	*Carex holostoma*	70.23785000	-151.69606667
CLOV-CAHO1	Clover	*Carex holostoma*	70.23793333	-151.26685000
CLOV-CAHO2	Clover	*Carex holostoma*	70.23890000	-151.26530000
CLOV-CAHO3	Clover	*Carex holostoma*	70.24103333	-151.26916667
T16-CARHO1	T16_2001	*Carex holostoma*	70.31918333	-151.95740000
T16-CARHO2	T16_2001	*Carex holostoma*	70.31958333	-151.96115000
T16-CARHO3	T16_2001	*Carex holostoma*	70.30713333	-151.97128333
KOAS-FC	Fish Creek	*Koeleria asiatica*	70.26111667	-152.02028333
KOAS-FC2	Fish Creek	*Koeleria asiatica*	70.26335000	-152.07801667
KOLASI1	Ublutuoch	*Koeleria asiatica*	70.23063333	-151.30466667
KOLASI3	Ublutuoch	*Koeleria asiatica*	70.22346667	-151.32713333
POAHAR1-JC	Judy Creek	*Poa hartzii alaskana*	70.16953333	-152.02421667
POAHAR2-JC	Judy Creek	*Poa hartzii alaskana*	70.17836667	-152.01921667
POAHAR3-JC	Judy Creek	*Poa hartzii alaskana*	70.17931667	-151.98418333
RPS-01	Fish Creek	*Poa hartzii alaskana*	70.31818333	-151.35496667
RPS-02	Fish Creek	*Poa hartzii alaskana*	70.31675000	-151.43930000
V38-POAHAR	V38_2003	*Poa hartzii alaskana*	70.32106667	-151.40240000

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

Mapping (1:10,000 scale) of the Fish Creek delta and adjacent coastal plain uses an integrated terrain unit (ITU) approach that incorporates geomorphic units (surficial geology and waterbodies), surface forms (related to permafrost processes), and vegetation (Alaska Vegetation Classification Level IV). Mapping and consolidation of ITUs resulted in 40 ecotypes of which 10 were coastal. Coastal ecosystems included 6 terrestrial geomorphic units, 8 aquatic geomorphic units (waterbodies), 8 surface forms,

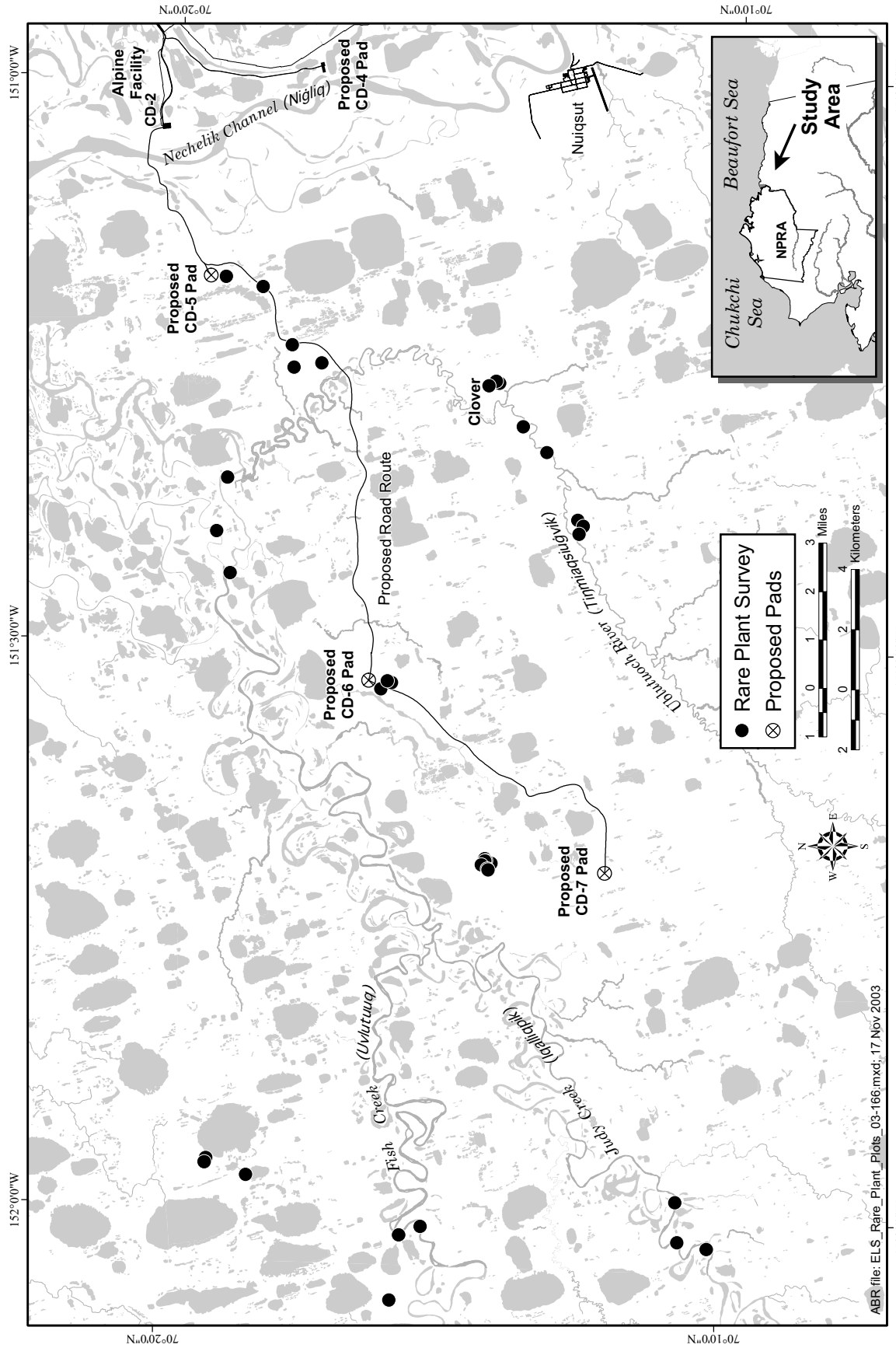


Figure 11. Sampling locations for rare plants within the 2002 study area, northeastern NPRA, 2003.

and 11 vegetation classes. The most abundant coastal ecotypes were Coastal Wet Meadow Complex, Coastal Barrens, Coastal Salt-killed Wet Meadow, Coastal Saline Wet Meadow, Nearshore Water, and Coastal Lake.

Multiple environmental factors contributed to the distribution of coastal ecotypes and their associated plant species. Environmental gradients were relatively strong for cumulative organic thickness, salinity (electrical conductivity–EC), water depths, and weaker for surface organic thickness, thaw depths, and pH. Mean cumulative organic depth, an indicator of flooding frequency, ranged from 3 cm in Coastal Barrens to 15 cm in Coastal Salt-killed Meadows. EC, important for osmotic regulation of plants and animals, ranged from 2947 µS/cm for Coastal Dry Elymus Meadows to 18,905 µS/cm in Coastal Lakes. Mean depth to water, important for water and oxygen availability, ranged from –60 cm in Coastal Dry Elymus Meadows to 117 cm in Tidal Rivers. Mean surface organic-horizon thickness, an indicator of time elapsed since the last sedimentation event, ranged from 0 cm in waterbodies to 3 cm in Coastal Brackish Wet Meadow. Mean thaw depths ranged from 51 cm in Coastal Moist Willow Dwarf Shrub to 82 cm in Coastal Dry Elymus Meadows. Mean site pH ranged from 6.6 in Coastal Salt-killed Meadows to 8.0 in Coastal Lakes.

Rare plant surveys within the 2001-2002 study area were done for: (1) the proposed road alignment from the Nigliq Channel to the Ublutuoch River; (2) areas around the Spark and CD6 proposed well-site locations, and the proposed Clover mine site; and (3) sections of Fish Creek, Judy Creek, Ublutuoch River, and adjacent coastal plain (Figure 11). Rare plants were found at 35 locations and included: *Carex holostoma* Drej, *Koeleria asiatica* Domin, and *Poa hartzii* Gandog. ssp. *alaskana* Soreng. Other species included in the search, but not found in the study area included *Mertensia drummondii* (Lehm.) G. Don, *Pleuropogon sabinei* R. Br., *Thlaspi arcticum* Porsild, *Potentilla stipularis* L., and any unusual crucifers, particularly *Draba* spp.

Overall, three main benefits are derived from this ecological land survey approach. First, it analyzes landscapes as ecological systems with functionally related parts and recognizes the importance that geomorphic and hydrologic processes have on disturbance regimes, the flow of energy and material, and ecosystem development. The hierarchical approach, which incorporates numerous ecological components into ecotypes with co-varying properties, allows users to partition the variability of a wide range of ecological characteristics. Second, the mapping of ITUs based on these relationships provides a spatial database structure that preserves the diversity of environmental characteristics across the landscape. Finally, this linkage of ecological characteristics within a spatial database improves our ability to predict the response of ecosystems to human impacts and facilitates the production of thematic maps for specialized engineering and environmental applications and analyses. Expansion of the ELS for the Northeast Planning Area to the Fish Creek delta will be particularly useful in evaluating oil spill sensitivity and contingency planning.

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Appendix 1. Data file listing of ecological components of ground reference plots on the Fish Creek delta, northeastern NPRA, 2003.

Site No.	Date	Latitude (dd83)	Longitude (dd83)	Physiog.[1]	Slope(deg)	Aspect(deg)	Geom. Unit[2]	Surface Form[2]	Microrelief (cm)	VegClass[2]	Ecotype	Plant association	Most abundant plant species
G30-01	5-Aug-03	70.3629	-151.2803	C	0	0	Fdoi	Plll	25	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	dupfis-eriang-carurs-salova
G38-01	11-Aug-03	70.3300	-151.4341	U	0	0	Ltip	Phh	150	Slow	Upland Moist Low Willow Shrub	salgla-arcrub	dryint-Moss-salgla-Lichen-salret-astumb
G38-02	11-Aug-03	70.3298	-151.4209	R	0	0	Fdoi	N	20	Slow	Riverine Moist Low Willow Shrub	salric-equvar	Moss-salric-caraqu-eriang-dupfis
T30-01	5-Aug-03	70.3621	-151.2771	C	0	0	Fdra	N	10	Hgwhsgs	Coastal Saline Wet Meadow	pucphr-carsub	carsub-pucphr-Elymol-stehum
T30-02	5-Aug-03	70.3621	-151.2771	C	0	290	Fdoa	Mu	25	Hgdl	Coastal Dry Elymus Meadow	elymol-salova	salova-elymol-Moss-artarc
T30-03	5-Aug-03	70.3627	-151.2769	C	0	0	Mti	N	5	Sdwgh	Coastal Moist Willow Dwarf Shrub	salova-carsub	carram-salova-caldes-carsub-Moss
T30-04	5-Aug-03	70.3618	-151.2784	C	0	0	Fdri	N	10	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	carsub-carram-dupfis-Moss-caldes-salova
T30-05	5-Aug-03	70.3626	-151.2790	C	0	0	Mti	Plll	20	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	carrar-salova-eriang-dupfis
T30-06	5-Aug-03	70.3627	-151.2793	C	0	0	Welsi	Lp	0	W	Coastal Lake	water	water-hiptet
T30-07	5-Aug-03	70.3627	-151.2908	R	0	0	Fdoi	Plhl	55	Hgwst	Riverine Moist Sedge–Shrub Meadow	salova-caraqu	eriang-caratr-dryint-salova-salric
T30-08	5-Aug-03	70.3627	-151.2830	R	0	0	Fdoi	Plhl	50	Hgwst	Riverine Moist Sedge–Shrub Meadow	salova-caraqu	eriang-carsax-Moss-carbig-salarc-caraqu
T31-01	8-Aug-03	70.3514	-151.3822	C	0	0	Wert	W	0	W	Tidal River	water	water
T31-02	8-Aug-03	70.3517	-151.3835	C	0	0	Fdoa	Mu	50	Bpv	Coastal Barrens	descae-chrbip	salala-equarv-salric
T31-03	8-Aug-03	70.3525	-151.3845	R	0	0	Fdri	N	2	Hgwst	Riverine Wet Sedge Meadow	caraqu-salric-equvar	Moss-salric-eriang-carsax-caraqu-carbig
T31-04	8-Aug-03	70.3525	-151.3859	U	0	0	Esi	Es	100	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-Lichen-astalp-salric-arcrub
T31-05	8-Aug-03	70.3518	-151.3887	U	0	0	Esi	Phl	10	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-salret-Moss-Lichen-salgla-salric
T31-06	8-Aug-03	70.3513	-151.3915	R	0	0	Fdoi	Plll	10	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-salric	Moss-carsax-eriang-salgla-dryint-caraqu
T31-07	8-Aug-03	70.3499	-151.4009	U	0	0	Esi	Phl	20	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-castet-astumb-Lichen-salric-silaca
T31-08	8-Aug-03	70.3483	-151.4094	R	0	0	Fdoi	Plll	5	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-salric	Moss-eriang-dryint-salric-salret-carbig
T31-09	8-Aug-03	70.3481	-151.4108	R	0	0	Fdoi	Pd	4	Hgwst	Riverine Wet Sedge Meadow	caraqu-salric-equvar	Moss-caraqu-carsax-eriang-salarc-dryint
T31-10	8-Aug-03	70.3482	-151.4135	L	0	0	Ltim	Phl	20	Hgmss	Lowland Moist Sedge–Shrub Meadow	dryint-carbig-salric	Moss-eriang-salric-carbig-dryint-salarc
T32-01	8-Aug-03	70.3651	-151.4461	R	0	0	Fdoa	N	0	Sddt	Riverine Dry Dryas Dwarf Shrub	dryint-equvar	dryint-salova-Moss-arcrub-oxydef-elymol
T32-02	8-Aug-03	70.3651	-151.4457	C	0	0	Wert	W	0	W	Tidal River	water	water
T32-03	8-Aug-03	70.3652	-151.4462	R	0	0	Fdoa	N	15	Slow	Riverine Moist Low Willow Shrub	salric-equvar	salgla-Moss-arcrub-dryint-salric-oxydef
T32-04	8-Aug-03	70.3654	-151.4489	R	0	0	Fdoi	Phl	15	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-salric	dryint-Moss-caraqu-equvar-eriang-salric
T32-05	8-Aug-03	70.3672	-151.4557	U	3	110	Esi	Es	15	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-Lichen-oxydef-pedcap
T32-06	8-Aug-03	nd	nd	U	0	0	Esi	Es	50	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-Lichen-Moss-salret-caraqu-oxydef
T32-07	8-Aug-03	70.3652	-151.4604	R	0	0	Fdoi	Plll	25	Hgwst	Riverine Wet Sedge Meadow	caraqu-salric-equvar	Moss-eriang-caraqu-salric
T32-08	8-Aug-03	70.3644	-151.4623	U	5	62	Esi	Es	60	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-Lichen-arcrub-oxydef-oxyvis-pedcap
T32-09	8-Aug-03	70.3644	-151.4680	R	0	0	Fdoi	Phh	80	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-salric	Moss-dryint-salret-Lichen-caraqu-astumb
T32-10	8-Aug-03	70.3631	-151.4728	R	0	0	Fdoi	Phh	60	Hgmss	Riverine Moist Sedge–Shrub Meadow	dryint-carbig-salric	Moss-dryint-carbig-Lichen-caraqu-petfri
T33-01	7-Aug-03	70.3820	-151.3426	C	0	0	Wert	W	2	W	Tidal River	water	water
T33-02	7-Aug-03	70.3819	-151.3430	C	0	0	Mta	Dr	2	Bbg	Coastal Barrens	descae-chrbip	soil
T33-03	7-Aug-03	70.3820	-151.3434	C	0	0	Mta	Mu	30	Hgdl	Coastal Dry Elymus Meadow	elymol-salova	salova-elymol-Moss-puclan
T33-04	7-Aug-03	70.3809	-151.3433	C	0	0	Mta	N	5	Sdwgh	Coastal Moist Willow Dwarf Shrub	elymol-salova	salova-descae-Moss-rumarc
T33-05	7-Aug-03	70.3813	-151.3454	C	0	0	Mta	N	1	Sdwgh	Coastal Moist Willow Dwarf Shrub	salova-carsub	salova-carsub-Moss-dupfis
T33-06	7-Aug-03	70.3803	-151.3441	C	0	0	Fdoi	N	2	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	pucphr-stehum-puclan-carurs
T33-07	7-Aug-03	70.3811	-151.3500	C	0	0	Mti	N	0	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carsub-carurs
T33-08	7-Aug-03	70.3793	-151.3505	C	0	0	Welsi	Wi	0	W	Coastal Lake	water	water-hiptet
T33-09	7-Aug-03	70.3785	-151.3487	C	0	0	Fdoi	Phl	20	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	stehum-salova-carurs-dupfis-elymol-Moss
T33-10	7-Aug-03	70.3795	-151.3607	C	0	0	Mti	N	2	Hgwhsgs	Coastal Saline Wet Meadow	pucphr-carsub	pucphr-carurs-stehum
T33-11	7-Aug-03	70.3779	-151.3700	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carsub-carurs-stehum
T33-12	7-Aug-03	70.3770	-151.3692	C	0	0	Fdoi	Pd	15	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	soil

Appendix 1. Continued.

Site No.	Date	Latitude (dd83)	Longitude (dd83)	Physiog.[1]	Slope(deg)	Aspect(deg)	Geom. Unit[2]	Surface Form[2]	Microrelief (cm)	VegClass[2]	Ecotype	Plant association	Most abundant plant species
T33-13	7-Aug-03	70.3781	-151.3399	C	0	0	Mta	N	0	Hgdl	Coastal Dry Elymus Meadow	elymol-salova	salova-elymol-stehum
T34-01	6-Aug-03	70.3945	-151.4255	C	0	0	Wert	W	0	W	Tidal River	water	water
T34-02	6-Aug-03	70.3942	-151.4250	C	1	20	Mta	N	0	Bpv	Coastal Barrens	elymol-salova	soil-elymol-Moss-salova-carsub
T34-03	6-Aug-03	70.3944	-151.4252	C	1	20	Mta	N	0	Hgwhsgb	Coastal Brackish Wet Meadow	salova-carsub	carsub-pucphr-salova-carram-Moss-elymol
T34-04	6-Aug-03	70.3929	-151.4237	R	0	0	Fdoi	Phl	53	Hgmss	Riverine Moist Sedge–Shrub Meadow	salova-caraqu	salova-eriang-caraqu-Moss-dupfis-salarc
T34-05	6-Aug-03	70.3930	-151.4194	C	0	0	Fdoi	Pd	15	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	soil-Moss-pucphr-stehum
T34-06	6-Aug-03	70.3930	-151.4153	C	0	0	Mti	N	15	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carurs-carram-eriang
T34-07	6-Aug-03	70.3929	-151.4150	C	0	0	Welsi	Wi	0	W	Coastal Lake	water	water
T34-08	6-Aug-03	70.3973	-151.4109	C	2	0	Mta	Mu	50	Hgdl	Coastal Dry Elymus Meadow	elymol-salova	elymol-Moss-salova-astalp-braya-parkot
T35-01	11-Aug-03	70.3899	-151.2673	C	0	0	Wmn	W	0	W	Nearshore Water	water	water
T35-02	11-Aug-03	70.3899	-151.2679	C	0	0	Mta	N	0	Bbg	Coastal Barrens	elymol-salova	soil
T35-03	11-Aug-03	70.3888	-151.2721	C	2	90	Fdoa	Phl	45	Hgdl	Coastal Dry Elymus Meadow	elymol-salova	elymol-salova-aloalp-Lichen
T35-04	11-Aug-03	70.3877	-151.2752	C	0	0	Mti	N	0	Hgwhsgs	Coastal Saline Wet Meadow	pucphr-carsub	carurs-pucphr-carsub-stehum
T35-05	11-Aug-03	70.3873	-151.2777	C	0	0	Mta	N	0	Bbg	Coastal Barrens	pucphr	soil-water
T35-06	11-Aug-03	70.3922	-151.2763	C	0	0	Mti	N	5	Hgwhgs	Coastal Saline Wet Meadow	pucphr	pucphr-carsub
T35-07	11-Aug-03	70.3927	-151.2798	C	0	0	Mti	N	5	Hgwhgs	Coastal Saline Wet Meadow	pucphr-carsub	pucphr-stehum-carsub-dupfis
T35-08	11-Aug-03	70.3822	-151.2880	C	1	20	Mti	N	0	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carsub-stehum
T35-09	11-Aug-03	70.3835	-151.2929	C	0	0	Fdoi	Phl	45	Hgwhk	Coastal Salt-killed Wet Meadow	stehum	pucphr-carurs-stehum
T35-10	11-Aug-03	70.3841	-151.2951	C	0	0	Welsi	W	55	Habm	Coastal Herb Marsh	hiptet	water-hiptet
T36-01	7-Aug-03	70.3868	-151.3290	C	0	0	Weldc	Wi	0	W	Coastal Lake	water	water
T36-02	7-Aug-03	70.3867	-151.3290	C	0	0	Mti	N	15	Sdwgh	Coastal Moist Willow Dwarf Shrub	salova-carsub	salova-carram-carsub-caldes-dupfis-eriang
T36-03	7-Aug-03	70.3852	-151.3280	C	0	0	Mti	Plll	25	Hgwhsgb	Coastal Brackish Wet Meadow	salova-carsub	salova-carram-Moss-carurs-dupfis-carsub
T36-04	7-Aug-03	70.3855	-151.3264	U	0	0	Fto	Phl	35	Sddt	Upland Dry Dryas Dwarf Shrub	dryint-arcalp-salgla	dryint-Moss-salret-arclat-astumb-salgla
T36-05	7-Aug-03	70.3851	-151.3234	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	carsub-carurs-carram-cocoff-pucphr-stehum
T36-06	7-Aug-03	70.3847	-151.3221	C	0	0	Mti	Plll	20	Sdwgh	Coastal Moist Willow Dwarf Shrub	salova-carsub	salova-carram-Moss-carsub
T36-07	7-Aug-03	70.3835	-151.3243	C	0	0	Mta	N	5	Hgwhsgs	Coastal Saline Wet Meadow	pucphr-carsub	pucphr-carsub-stehum-salova-Moss
T36-08	7-Aug-03	70.3833	-151.3227	C	0	0	Mta	N	1	Bbg	Coastal Barrens	pucphr	soil
T36-09	7-Aug-03	70.3821	-151.3337	C	0	0	Welsi	Wi	15	Habm	Coastal Herb Marsh	hiptet	water-hiptet-dupfis-ranhyp-Moss
T36-10	7-Aug-03	70.3821	-151.3343	C	0	0	Mti	N	10	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carram-Moss
T36-11	7-Aug-03	70.3800	-151.3353	C	0	0	Mta	N	5	Hgdl	Coastal Dry Elymus Meadow	elymol-salova	elymol-salova-carurs-pucphr-sedros-stehum
T37-01	6-Aug-03	70.4138	-151.3957	C	0	0	Welt	W	0	W	Coastal Lake	water	water
T37-02	6-Aug-03	70.4135	-151.3957	C	0	0	Mti	N	5	Hgwhsgs	Coastal Saline Wet Meadow	pucphr-carsub	carsub-pucphr
T37-03	6-Aug-03	70.4121	-151.3987	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	carsub-dupfis-salova-stehum
T37-04	6-Aug-03	70.4111	-151.3923	C	0	0	Welt	Lp	0	W	Coastal Lake	water	water
T37-05	6-Aug-03	70.4098	-151.3966	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carsub-salova
T37-06	6-Aug-03	70.4087	-151.3925	C	0	0	Mti	N	5	Hgwhgs	Coastal Saline Wet Meadow	pucphr	pucphr
T37-07	6-Aug-03	70.4090	-151.3945	C	0	0	Mti	N	5	Hgwhsgs	Coastal Saline Wet Meadow	pucphr-carsub	carurs-carsub-pucphr-stehum
T37-08	6-Aug-03	70.4076	-151.4012	C	0	0	Mta	N	5	Bbg	Coastal Barrens	pucphr	soil-water
T37-09	6-Aug-03	70.4082	-151.4093	C	0	0	Mti	N	5	Hgwhgs	Coastal Saline Wet Meadow	pucphr	pucphr
T37-10	6-Aug-03	70.4082	-151.4150	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	carsub-dupfis-stehum-salova
T37-11	6-Aug-03	70.4135	-151.4143	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Meadow	carsub-dupfis	dupfis-carsub-cocoff-salova

[1] Physiography: C = Coastal, U = Upland, R = Riverine
[2] see Table 1 for code definitions

Appendix 2. Data file listing of environmental characteristics of ground reference plots on the Fish Creek delta, northeastern NPRA, 2003.

Site No.	NWI Regime	Water Depth	Saturated<30 cm	Drainage	Soil Moisture	Mottle Depth	Matrix Depth	Hydric Soil	Cryoturbation	Thaw Depth	SurfOrg (cm)	CumOrg40 (cm)	DomMineral40	DomText40	Site pH	Site EC	Site Chemistry
G30-01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	Brackish
G38-01	U	<-48	n	W	M	18	a	y	n	48	6	6	L	L	7.6	160	Alkaline
G38-02	Nsa	-10	y	Pv	W	a	13	y	n	26	13	13	L	L	7.2	460	Circumneutral
T30-01	Ti	20	y	F	A	5	5	y	n	>65	0	0	S	S	8.1	14100	Brackish
T30-02	U	>-50	n	E	D	a	a	n	n	83	0	0	S	S	8.1	60	Alkaline
T30-03	Nsa	-25	y	P	M	10	32	y	n	68	1	4	L	L	6.6	9130	Brackish
T30-04	Nsa	0	y	P	W	a	4	y	n	51	4	18	L	L	7.1	6500	Brackish
T30-05	Nsa	-13	y	Pv	M	0.5	11	y	n	57	0.5	20	L	L	6.9	3300	Brackish
T30-06	Np	60	y	F	A	a	nd	y	n	nd	nd	nd	L	L	8.2	6620	Brackish
T30-07	Nsa	-9	y	Pv	W	a	a	y	n	41	41	40	O	O	7.1	730	Circumneutral
T30-08	Nsa	-12	y	P	W	a	a	y	n	50	5	35	L	O	6.9	950	Brackish
T31-01	Np	100	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	6.6	150	Circumneutral
T31-02	Ti	>-40	n	W	M	a	a	n	n	91	0	3	S	S	7.6	190	Alkaline
T31-03	Ti	0	y	P	W	a	>40	y	n	48	1	30	S	O	6.6	1110	Brackish
T31-04	U	>-40	n	Es	D	a	a	n	n	114	0.5	2	S	S	8	100	Alkaline
T31-05	U	>-40	n	Es	D	23	>40	n	n	84	1	4	S	S	7.7	120	Alkaline
T31-06	Ti	0	y	Ps	W	a	>40	y	n	58	1	30	S	O	6.8	1220	Brackish
T31-07	U	>-40	n	Es	D	16	>40	n	y	91	0.5	15	S	S	7.6	160	Alkaline
T31-08	Ti	0	y	P	W	a	>40	y	n	54	2	25	S	O	6.8	930	Brackish
T31-09	Ti	-2	y	P	W	p	>40	y	n	40	2	40	S	O	7.3	350	Circumneutral
T31-10	Ti	-25	y	P	M	19	a	y	y	39	3	20	L	L	6.4	170	Circumneutral
T32-01	Nse	<-50	n	W	M	a	a	n	n	87	0.5	3	S	S	8.1	210	Alkaline
T32-02	Np	nd	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	8	350	Alkaline
T32-03	Ni	<-50	n	W	M	a	a	n	n	83	3	4	S	S	7.8	150	Alkaline
T32-04	Nsa	-21	y	P	M	6.5	7	n	n	55	2	2	S	S	7.1	360	Circumneutral
T32-05	U	-103	n	Es	D	a	a	n	n	105	0	1	S	S	8.2	80	Alkaline
T32-06	U	-86	n	Wm	M	18	18	y	n	86	2	3	S	S	7.6	210	Alkaline
T32-07	Nsp	3	y	Pv	W	a	33	y	n	56	33	34	S	O	7.4	670	Circumneutral
T32-08	U	-56	n	Es	D	a	a	n	n	56	1	2	S	S	8.2	90	Alkaline
T32-09	Nsa	-35	y	Ps	M	15	a	y	n	58	4	6	S	S	7.2	320	Circumneutral
T32-10	Nsa	-23	y	P	M	3	16	y	n	43	6	10	L	L	7.2	440	Circumneutral
T33-01	Ts	100	y	F	A	a	nd	nd	nd	nd	nd	nd	nd	nd	6.8	26400	Saline
T33-02	Ti	-39	y	W	M	28	>40	y	n	117	0	2	S	S	7.3	19600	Saline
T33-03	Tr	-43	n	W	M	10	nd	n	n	91	0	2	S	S	7.7	5900	Brackish
T33-04	Ti	-25	y	Wm	M	8	>40	y	n	76	0.5	3	S	S	7.8	6200	Brackish
T33-05	Ti	-11	y	P	W	8	23	y	n	64	1	6	L	L	7.3	7700	Brackish
T33-06	Ti	-1	y	P	W	1	>40	y	n	70	0	10	L	L	6.8	40100	Saline
T33-07	Tr	1	y	P	W	p	43	y	n	53	1	20	L	L	7.4	13200	Brackish
T33-08	Nsp	16	y	F	W	a	nd	nd	nd	62	nd	nd	nd	nd	8.4	>2000	Brackish
T33-09	Ti	-12	y	P	W	17	p	y	n	55	0	25	L	O	7.4	>2000	Brackish
T33-10	Ti	0	y	P	W	24	30	y	n	53	0.5	25	L	O	6.8	13810	Brackish
T33-11	Ti	1	y	P	W	26	30	y	n	47	1	20	L	O	7.8	13800	Brackish
T33-12	Ti	0	y	P	W	33	34	y	n	57	0	25	L	O	7.2	29700	Saline
T33-13	Tr	-52	n	W	M	34	>41	y	n	87	0.5	3	S	S	nd	2430	Brackish

Appendix 2. Continued.

Site No.	NWI Regime	Water Depth	Saturated<30 cm	Drainage	Soil Moisture	Mottle Depth	Matrix Depth	Hydric Soil	Cryoturbation	Thaw Depth	SurfOrg (cm)	CumOrg40 (cm)	DomMineral40	DomText40	Site pH	Site EC	Site Chemistry
T34-01	Ts	150	y	F	A	a	a	y	n	nd	0	0	S	S	8	>2000	Brackish
T34-02	Nse	-65	n	W	D	a	a	n	n	120	0	2	S	S	7	>2000	Brackish
T34-03	Nse	-25	y	W	M	7	20	y	n	93	0	5	S	S	7.1	1240	Brackish
T34-04	Nsa	-15	y	P	M	7	14	y	n	41	5	5	L	L	7.1	>2000	Brackish
T34-05	Ti	-11	y	P	W	a	a	y	n	42	0	13	L	L	6.9	>2000	Brackish
T34-06	Nsa	0	y	Pv	W	a	17	y	n	52	17	17	L	L	7	>2000	Brackish
T34-07	Np	~200	y	F	A	nd	nd	nd	n	nd	nd	nd	nd	nd	8	>2000	Brackish
T34-08	U	-66	n	Es	D	a	a	y	n	108	2	3	S	S	7.2	>2000	Brackish
T35-01	na	>100	y	F	A	nd	nd	nd	n	nd	nd	nd	nd	nd	7.6	12300	Brackish
T35-02	Ts	-10	y	P	M	6	31	y	n	42	8	15	L	L	7.1	17550	Saline
T35-03	U	-71	n	Es	D	a	a	n	n	75	10	14	S	S	7.5	3040	Brackish
T35-04	Ti	-2	y	Pv	W	5	18	y	n	70	1	3	L	L	6.9	14900	Brackish
T35-05	Ti	-28	y	Ps	W	20	A?	y	n	>124	0	5	L	L	6.2	47000	Saline
T35-06	Tr	-2	y	P	W	16	28	y	n	62	3	19	L	L	6.9	15800	Saline
T35-07	Tr	-10	y	P	W	12	19	y	n	62	0	1	L	L	6.9	33400	Saline
T35-08	Nsa	0	y	Pv	W	a	5	y	n	60	4	10	L	L	7.2	16400	Saline
T35-09	Ti	-3	y	P	W	a	2	y	n	71	0	29	S	O	7.1	27400	Saline
T35-10	Np	25	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	8.3	6060	Brackish
T36-01	Np	~300	y	F	A	nd	nd	y	nd	nd	nd	nd	nd	nd	7.9	24200	Saline
T36-02	Nsa	-10	y	Pv	W	7	13	y	y	51	2	17	L	L	6.9	9200	Brackish
T36-03	Nsa	-5	y	Pv	W	a	20	y	n	42	5	25	L	O	6.9	9100	Brackish
T36-04	U	~-200	n	Es	D	a	a	n	y	60	4	6	S	S	7.5	295	Alkaline
T36-05	Nsa	-4	y	Pv	W	a	30	y	n	55	0	37	L	O	6.6	14600	Brackish
T36-06	Nsa	-15	y	P	M	9	9	y	n	58	0	10	L	L	6.8	8800	Brackish
T36-07	Ti	-1	y	P	W	3	24	y	y	86	0	4	S	S	6.9	20000	Saline
T36-08	Ti	-10	y	P	W	a	a	y	n	>125	0	0	S	S	6.8	23900	Saline
T36-09	Np	30	y	F	A	nd	nd	y	nd	68	nd	nd	L	L	8.2	19700	Saline
T36-10	Nsa	0	y	P	W	18	21	y	n	52	10	11	L	L	7.1	18700	Saline
T36-11	U	-43	n	W	M	a	a	n	n	82	0	2	S	S	7	5500	Brackish
T37-01	Te	30	y	F	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	7.8	23000	Saline
T37-02	Tr	-1	y	Pv	W	1	30	y	n	58	0	15	L	L	6.9	19600	Saline
T37-03	Tr	-1	y	Pv	W	1	23	y	n	48	0	16	L	L	6.8	16400	Saline
T37-04	Tr	15	y	F	A	nd	nd	nd	nd	43	nd	nd	nd	nd	7.8	21800	Saline
T37-05	Ti	-2	y	Pv	W	1	20	y	n	51	0	9	L	L	7.1	13000	Brackish
T37-06	Ti	0	y	Pv	W	1	22	y	n	65	0	8	L	L	7.1	21900	Saline
T37-07	Ti	-2	y	Pv	W	0	13	y	n	58	0	9	L	L	7.1	20500	Saline
T37-08	Tr	0	y	Pv	W	22	>40	y	n	98	0	0	L	L	8.1	20000	Saline
T37-09	Tr	0	y	Pv	W	0	30	y	n	84	0	4	L	L	7.7	27000	Saline
T37-10	Ti	-2	y	Pv	W	0	22	y	n	47	0	11	L	L	7.1	5140	Brackish
T37-11	Ti	-3	y	Pv	W	0	22	y	n	50	0	7	L	L	7.1	12900	Brackish

Appendix 3. System for aggregating geomorphic, surface form, and vegetation classes into ecotypes mapped in the vicinity of Fish Creek delta, northeastern NPRA, 2003.

Ecotype Class	ITU Code	Ecotype Class	ITU Code
Coastal Barrens	Fdra/Mu/Bpv	Coastal Salt-killed Wet Meadow	Fdri/N/Hgwhk
	Fdra/N/Bbg		Fdri/Plll/Hgwhk
	Fdra/N/Bpv		Fto/Phh/Hgwhk
	Ltdn/N/Bbg		Fto/Phl/Hgwhk
	Ltdn/N/Bpv		Ltdi/Plll/Hgwhk
	Mta/Mu/Bpv		Ltic/Phl/Hgwhk
	Mta/N/Bbg		Ltic/Pm/Hgwhk
	Mta/N/Bpv		Ltim/Phl/Hgwhk
	Mta/Plll/Bpv		Ltim/Pm/Hgwhk
	Mti/N/Bbg	Coastal Wet Meadow Complex	Fdoi/N/Xc
	Mti/N/Bpv		Fdoi/Phl/Xc
Coastal Brackish Wet Meadow	Fdoi/N/Hgwhsgb		Fdoi/Plhl/Xc
	Fdoi/Phl/Hgwhsgb		Fdoi/Plll/Xc
	Ltdn/N/Hgwhsgb		Fdoi/Pm/Xc
	Ltic/Pm/Hgwhsgb		Fdra/Mu/Xc
	Mti/N/Hgwhsgb		Fdra/N/Xc
	Mti/Pd/Hgwhsgb		Fdri/N/Xc
	Mti/Phl/Hgwhsgb		Ltdn/N/Xc
	Mti/Pm/Hgwhsgb		Ltim/N/Xc
Coastal Dry Elymus Meadow	Fdoa/Mu/Hgdl		Ltim/Pd/Xc
	Fdra/Mu/Hgdl		Ltim/Pm/Xc
	Fdra/N/Hgdl		Mti/Mu/Xc
	Mta/Mu/Hgdl		Mti/N/Xc
	Mta/N/Hgdl		Mti/Pd/Xc
Coastal Lake	Weldc/Lp/W		Mti/Phl/Xc
	Weldc/W/W		Mti/Plhh/Xc
	Weldc/Wi/W		Mti/Plll/Xc
	Weldi/Lp/W		Mti/Pm/Xc
	Weldi/W/W	Headwater Stream	Wrhl/Tb/W
	Weldi/Wi/W		Wrhl/W/W
	Welsc/W/W	Lacustrine Basin Complex	Ltnm/Xb/Xby
	Welsc/Wi/W		Ltnu/Xb/Xby
	Welsi/Lp/W	Lacustrine Grass Marsh	Welsc/Wi/Hgwfg
	Welsi/W/W		Welsi/Wi/Hgwfg
	Welsi/Wi/W		Wlsit/Wi/Hgwfg
	Welt/Lp/W	Lacustrine Moist Sedge–Shrub Meadow	Ltnc/Pm/Hgmss
	Welt/W/W		Ltnm/N/Hgmss
	Welt/Wi/W		Ltnm/Pd/Hgmss
Coastal Saline Wet Meadow	Fdra/N/Hgwhsgs		Ltnm/Phl/Hgmss
	Ltdn/N/Hgwhsgs	Lacustrine Sedge Marsh	Ltnm/N/Hgwfs
	Ltdn/Pd/Hgwhsgs		Wlsit/Wi/Hgwfs
	Ltim/N/Hgwhsgs	Lacustrine Wet Sedge Meadow	Ltnc/N/Hgwst
	Ltim/Pd/Hgwhsgs		Ltnm/N/Hgwst
	Ltim/Plll/Hgwhsgs		Ltnm/Pd/Hgwst
	Mta/N/Hgwhsgs		Ltnm/Plll/Hgwst
	Mta/Pd/Hgwhsgs		Ltnu/Pd/Hgwst
	Mta/Plll/Hgwhsgs	Lowland Basin Complex	Ltdi/Xb/Xbo
Coastal Salt-killed Wet Meadow	Fdoi/N/Hgwhk		Ltic/Xb/Xbo
	Fdoi/Pd/Hgwhk		Ltim/Xb/Xbo
	Fdoi/Phl/Hgwhk		Ltiu/Xb/Xbo
	Fdoi/Plhl/Hgwhk	Lowland Lake	Wldct/Wi/W
	Fdoi/Plll/Hgwhk		Wldit/W/W
	Fdoi/Pm/Hgwhk		Wldit/Wi/W
	Fdoi/Tm/Hgwhk		Wlsit/Lp/W

Appendix 3. Continued.

Ecotype Class	ITU Code	Ecotype Class	ITU Code
Lowland Lake	Wlsit/W/W	Lowland Wet Sedge Meadow	Ltim/N/Hgwst
	Wlsit/Wi/W		Ltim/Pd/Hgwst
Lowland Moist Low Willow Shrub	Esi/Phl/Slow		Ltim/Plhh/Hgwst
	Fdob/Phl/Slow		Ltim/Plll/Hgwst
	Ltic/Phh/Slow		Ltim/Tm/Hgwst
	Ltim/Pm/Slow		Ltiu/N/Hgwst
Lowland Moist Sedge–Shrub Meadow	Esi/Mg/Hgmss		Ltiu/Pd/Hgwst
	Esi/Phl/Hgmss		Ltiu/Plll/Hgwst
	Esi/Pm/Hgmss		Ltiu/Pm/Hgwst
	Esi/Tm/Hgmss		Ltiu/Tm/Hgwst
	Fdob/N/Hgmss	Nearshore Water	Wmn/W/W
	Fdob/Phl/Hgmss	Riverine Complex	Fdoi/Xr/Xr
	Fdob/Plhh/Hgmss		Fhl/Tb/Xr
	Fdob/Pm/Hgmss	Riverine Deep-polygon Complex	Fdoi/Plhh/Xp
	Fdob/Tm/Hgmss		Fdoi/Plhl/Xp
	Fto/Dt/Hgmss	Riverine Dry Dryas Dwarf Shrub	Fdoi/N/Sddt
	Fto/Phl/Hgmss		Fdoi/Phl/Sddt
	Fto/Pm/Hgmss		Fdri/N/Sddt
	Fto/Tm/Hgmss		Fdri/Phl/Sddt
	Ltic/N/Hgmss	Riverine Dune Complex	Esi/Xd/Xd
	Ltic/Pd/Hgmss	Riverine Grass Marsh	Wlsir/Wi/Hgwfg
	Ltic/Phl/Hgmss	Riverine Lake	Wldcrh/Wi/W
	Ltic/Plhh/Hgmss		Wldir/Lp/W
	Ltic/Pm/Hgmss		Wldir/W/W
	Ltic/Tm/Hgmss		Wldir/Wi/W
	Ltim/N/Hgmss		Wldirt/Wi/W
	Ltim/Pd/Hgmss		Wlscr/W/W
	Ltim/Phl/Hgmss		Wlscrh/W/Hgwfg
	Ltim/Pm/Hgmss		Wlscrh/W/W
	Ltim/Tm/Hgmss		Wlscrh/Wi/W
	Ltiu/Phl/Hgmss		Wlsir/Lp/W
	Ltiu/Pm/Hgmss		Wlsir/W/W
	Ltiu/Tm/Hgmss		Wlsir/Wi/W
Lowland Sedge Marsh	Fdob/N/Hgwfs		Wlsirt/W/W
	Fdob/Pllh/Hgwfs		Wlsirt/Wi/W
	Ltic/Pd/Hgwfs	Riverine Moist Barrens	Fdoa/Mu/Bpv
	Ltim/Ms/Hgwfs		Fdoa/N/Bpv
	Ltim/N/Hgwfs		Fdoi/N/Bpv
	Ltim/Pd/Hgwfs		Fdri/Mu/Bpv
	Ltiu/N/Hgwfs		Fdri/N/Bbg
	Ltiu/Pd/Hgwfs		Fdri/N/Bpv
Lowland Wet Sedge Meadow	Esi/Dt/Hgwst	Riverine Moist Low Willow Shrub	Fdoa/N/Slow
	Esi/Plll/Hgwst		Fdoi/N/Slcw
	Esi/Pm/Hgwst		Fdoi/N/Slow
	Esi/Tm/Hgwst		Fdoi/Phh/Slow
	Fdob/Plhh/Hgwst		Fdoi/Phl/Slow
	Fdob/Plhl/Hgwst		Fdoi/Pm/Slow
	Fdob/Pm/Hgwst		Fdoi/Tm/Slow
	Fto/Plll/Hgwst		Fdra/Mu/Slow
	Fto/Pm/Hgwst		Fdri/N/Slow
	Ltic/N/Hgwst		Fdri/Phl/Slow
	Ltic/Pd/Hgwst	Riverine Moist Sedge–Shrub Meadow	Fdoi/N/Hgmss
	Ltic/Pllh/Hgwst		Fdoi/Phl/Hgmss
	Ltic/Plll/Hgwst		Fdoi/Plhh/Hgmss
	Ltic/Pm/Hgwst		Fdoi/Plhl/Hgmss
	Ltim/Ms/Hgwst		Fdoi/Pm/Hgmss

Appendix 3. Continued.

Ecotype Class	ITU Code	Ecotype Class	ITU Code
Riverine Moist Sedge–Shrub Meadow	Fdoi/Tm/Hgmss	Upland Dry Barrens	Esi/Es/Bpv
	Fdri/N/Hgmss		Esi/Sb/Bpv
	Fdri/Pd/Hgmss	Upland Dry Dryas Dwarf Shrub	Esi/Es/Sddt
	Fdri/Phl/Hgmss		Esi/Phl/Sddt
	Fdri/Pm/Hgmss		Fto/Phl/Sddt
Riverine Moist Tall Willow Shrub	Fdoa/N/Stcw		Ltic/N/Sddt
	Fdoa/N/Stow	Upland Dry Tall Shrub	Esa/Es/Stow
Riverine Sedge Marsh	Fdoi/N/Hgwfs	Upland Moist Cassiope Dwarf Shrub	Esi/Es/Sdec
	Fdoi/Pd/Hgwfs		Esi/Phl/Sdec
	Fdoi/Plhl/Hgwfs		Esi/Sb/Sdec
	Fdoi/Plll/Hgwfs		Fto/Sb/Sdec
	Fdri/N/Hgwfs		Ltim/Sb/Sdec
	Fdri/Pd/Hgwfs	Upland Moist Low Willow Shrub	Esi/Es/Slow
	Ltdi/Plll/Hgwfs		Esi/Sb/Slow
	Wlsir/W/Hgwfs		Ltip/Phh/Slow
	Wlsir/Wi/Hgwfs	Upland Moist Tussock Meadow	Esi/Phh/Hgmt
Riverine Wet Sedge Meadow	Fdoa/N/Hgwst		Esi/Phl/Hgmt
	Fdoi/N/Hgwst		Esi/Tm/Hgmt
	Fdoi/Pd/Hgwst		Fdob/Phl/Hgmt
	Fdoi/Plhh/Hgwst		Fdob/Tm/Hgmt
	Fdoi/Plhl/Hgwst		Fto/Phh/Hgmt
	Fdoi/Plll/Hgwst		Fto/Phl/Hgmt
	Fdoi/Pm/Hgwst		Fto/Pm/Hgmt
	Fdoi/Tm/Hgwst		Fto/Tm/Hgmt
	Fdra/N/Hgwst		Ltic/Phh/Hgmt
	Fdri/N/Hgwst		Ltic/Phl/Hgmt
	Fdri/Pd/Hgwst		Ltic/Pm/Hgmt
	Fhl/Pm/Hgwst		Ltic/Tm/Hgmt
	Ltdi/Plll/Hgwst		Ltim/Phl/Hgmt
Tidal Gut	Wertg/W/W		Ltim/Tm/Hgmt
	Wertg/Wi/W		Ltip/Phh/Hgmt
Tidal River	Wert/W/W		Ltip/Phl/Hgmt
Upland Dry Barrens	Esa/Ek/Bpv		Ltiu/Phl/Hgmt
	Esa/Es/Bpv		Ltiu/Tm/Hgmt