Pacific Tidal Marsh Biophysical Setting

Southern Alaska

Conservation Status Rank: S4 (apparently secure)

Introduction

Tidal marshes develop where relatively flat land receives periodic input of tidal waters (Frohne 1953). As an interface between the ocean and land, tidal marshes combine aquatic and terrestrial habitats, anoxic and oxic conditions, as well as saline and fresh waters (Stone 1984). This dynamic environment supports life highly-adapted to saturation and saline conditions. Along the Gulf of Alaska coastline, tidal marshes are uncommon, developing as marshes in protected topographic pockets, or larger complexes on the major river deltas (Figure 1; Viereck et al. 1992). In this region they are one of Alaska's most critical habitats. As staging areas for millions of migrating shorebirds, geese, and swans, this biophysical setting supports nine animal taxa of conservation concern and provides important rearing habitat for salmon. Tidal marshes are also one of Southeast Alaska's most impacted biophysical settings due to the location of villages, towns and cities adjacent to and sometimes on these flat, yet fragile habitats. Pacific tidal marshes are considered unique from those found in Cook Inlet and western Alaska due to their wet, mild maritime climate, a lack of permafrost and the general dominance of *Carex lyngbyei*. The dominant sedge in Beringian tidal marshes is generally *Carex ramenskii* (Batten et al. 1978).

Figure 1. Tidal marsh in Kenai Fjords, Alaska.

Distribution

Tidal marshes are widely distributed along the coastline of Southern Alaska and the Aleutian Islands (Figure 2). Here, numerous small tidal marshes are maintained in protected pockets along the fjordlands' rocky shores, typically at the heads of bays or lagoons (circa one acre; Crow 1977). More extensive systems are less common; long (up to 50 km), narrow tidal marshes are found at the Copper River Delta, Yakutat Forelands (from the Dangerous River) and the Stikine River Delta. The Pacific Tidal Marsh distribution was developed from various National Wetland Inventory (NWI) tidal classes.

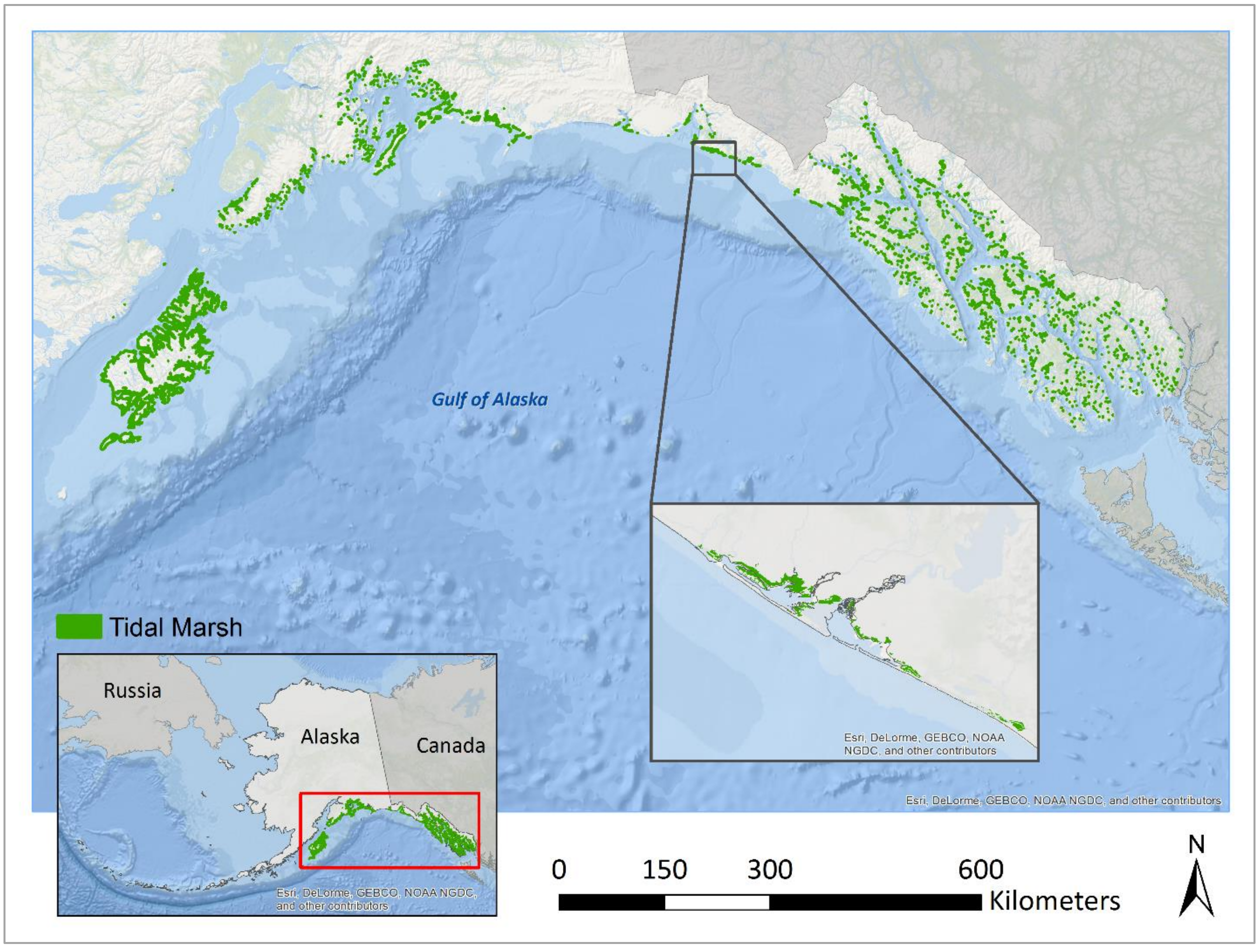

Figure 2. Distribution of the Pacific Tidal Marsh Biophysical Setting. Tidal marshes have not been mapped in the Aleutian Islands. Note that the areas of occupancy in this map are buffered for greater visibility.

Climate

Southeast Alaska and the Aleutian Islands have a cool, wet maritime climate and are generally free of permafrost (Gallant et al. 1995, Nowacki et al. 2001). The mean annual precipitation in coastal rainforests ranges from 135 to 390 cm with 80 to 600 cm falling as snow. Average summer temperatures range from 7 to 18ºC; average winter temperatures are between -3 and 3ºC. The Aleutian Islands have a mean annual precipitation ranging from 60 to 330 cm with snowfall from 55 to 150 cm. Average summer temperatures range from 6 to 15ºC; average winter temperatures are between -11 and -6ºC.

Environmental Characteristics

Tidal marshes occur wherever there is flat land at sea level (Frohne 1953). Three elements are typically required for their formation: 1) Input of tidal waters that range from twice daily inundation of mudflats to occasional exposure of upper marsh habitats to storm surges. 2) Sediment deposition from rivers depositing their sediment load on deltas, or sediment imported from adjacent coastlines via long-shore drift; there is commonly a concurrent buildup of organic matter. 3) Protection from ocean waves and ocean current erosion provided by topography (e.g. barrier islands, spits, peninsulas, shallow bays) and, at a smaller scale, by established vegetation which effectively slows the water current and/or wave energy (Chapman 1960, Boggs et al. 2008).

Tidal marshes may receive fresh water from streams and rivers, as well as overland and subsurface flow. Water salinity is inversely related to freshwater inputs and is subsequently lower in the spring when freshwater contributions from melting snow and river ice are higher (Jefferies 1977).

Figure 3. Tidal marsh in Kenai Fjords, Alaska.

The coastline along Southeast Alaska and the Aleutian Islands is extremely dynamic in relation to sea-level. Some land is currently rising due to isostatic rebound and tectonic uplift, while other coastlines are falling due to tectonic down-warping and rising sea level, as a result of climate change. Changes in relative sea level have a dramatic effect on tidal marshes and other coastal ecosystems. Along a rising coastline the upper marsh will pass out of tidal influence and transition to vegetation characteristic of the surrounding nontidal habitats. At the same time, tidal associations along the outer marsh may invade newly exposed mudflats. Along a falling coastline, tidal marshes migrate inland with tidewater inundating previously nontidal sites, such as forests or peatlands while tidal associations along the outer marsh may erode or drown. As a result of this dynamic rising and falling coastline, most tidal marshes of southern Alaska and the Aleutian Islands are relatively young (Figure 3). For example, newly uplifted inter-tidal surfaces support pioneer species (principally *Puccinellia* species and *Carex lyngbyei*), mudflats, tide channels, and distributary channels (Batten et al. 1978, Boggs and Shephard 1999, Thilenius 1990). If given enough time these tidal marshes will develop deep tide channels, levees, and basins dominated by *Carex lyngbyei* with thick root mats.

Wind also plays a strong role in retarding marsh development in the Aleutian Islands and Alaska Peninsula. Frequent strong winds leads to erosive waves even in protected lagoons. Consequently, tidal marshes are more infrequent than one would expect based on topography.

Vegetation and Succession

The zonation of vegetation within tidal marshes can be conspicuous both globally and in Alaska but is not always expressed (Hanson 1951, Vince and Snow 1984, Streveler et al. 2003). The following describes vegetation zones from mudflats, to low marsh, towards uplands along an idealized gradient of decreasing inundation and salinity (Figure 4). Relationships between tidal levels and vegetation are outlined but may vary depending on environmental conditions such as exposure, orientation, and adjoining topography and vegetation type.

At the lowest elevation exposed at low tide, barren mudflats may be interspersed with the green algae *Fucus distichus*. These mudflats support benthic invertebrates (bivalves, polychaetes, amphipods, and chironomids; Powers et al. 2002) that contribute heavily to the diet of the migrating shorebirds (Senner 1979).

Above these sparsely vegetated mudflats, the low marsh generally occurs below or at mean high tide level (Taylor 1981). The low marsh supports halophytic graminoids of the *Puccinellia* genus. Other forbs include *Cochlearia groenlandica*, *Fucus distichus*, *Eleocharis palustris*, *Glaux maritima, Plantago maritima, Potentilla anserina* ssp. *egedii, Ranunculus cymbalaria* and *Triglochin maritima*, (Batten et al. 1978, Hanson 1951, Crow 1968, Fleming and Spencer 2007, del Moral and Watson 1978, Turner 2010, Vince and Snow 1984, DeVelice et al. 1999, Boggs 2000, Shephard 1995).

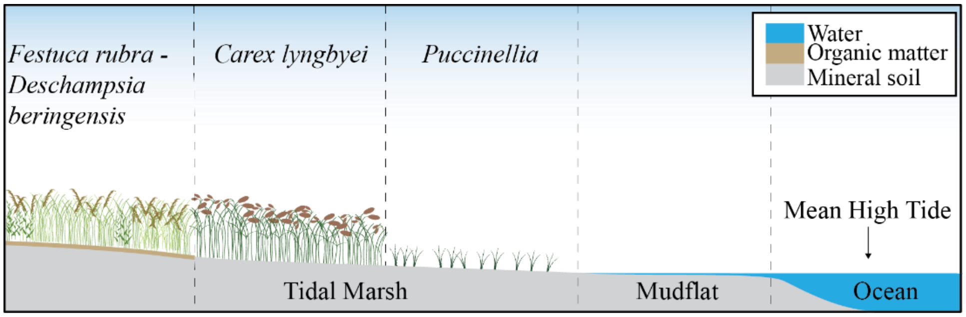

Figure 4. Schematic physiography and vegetation profile of a tidal marsh on a young tidal surface, Copper River Delta, Alaska.

The mid marsh occupies the reach of land that is inundated only at the highest tides during the growing season (Crow 1977, Batten et al. 1978). It typically supports dense swards of *Carex lyngbyei* (del Moral and Watson 1978, Stephens and Billings 1967, Turner 2010, DeVelice et al. 1999, Boggs 2000, Shephard 1995). Less common mid marsh sedges include *Carex pluriflora, C. cryptocarpa* and *C. glaerosa* (Crow 1968, Hanson 1951). With increased elevation, dominance transitions from *Carex lyngbyei* to associations dominated or codominated by *Deschampsia cespitosa* and *Vahlodea atropurpurea* (Stephens and Billings 1967, Crow 1968, Turner 2010).

The high marsh ranges from the highest tide line to the maximum level reached by storm surges during the growing season (Batten et al. 1978). It supports a diversity of salt-tolerant graminoid and forb associations including the sedges *Carex mackenziei*, and *C. pluriflora*, and the grasses *Calamagrostis canadensis, C. nutkaensis*, *Deschampsia beringensis*, *Festuca rubra, Leymus mollis* and *Poa eminens* (McCormick and Pichon 1978, Neiland 1971, Quimby 1972, Turner and Barker 1999, Batten et al. 1978, del Moral and Watson 1978, Turner 2010, Vince and Snow 1984). The forbs *Potentilla anserina* ssp. *egedii, Ligusticum scoticum* and *Lathyrus palustris* typically increase in dominance with elevation across the high marsh (Stephens and Billings 1967, Vince and Snow 1984). The low shrub *Myrica gale/Carex lyngbyei* and *Salix hookeriana* associations also occur (Hanson 1951, Boggs 2000).

Conservation Status

Rarity: Tidal marshes are widely distributed along the coastlines of Southeast Alaska and the Aleutian Islands, but their small total area (450 km^2), and the fidelity of its component species makes this biophysical setting of one conservation concern.

Threats: Due to their landscape position, tidal marshes are highly susceptible to damage from development, oil spills, sea level rise, and earthquake-induced slides and tsunamis. Because tidal marshes in Southeast Alaska provide flat land along an otherwise rocky coastline, cities, towns and villages are often located adjacent to these habitats (e.g. Seward, Juneau, Cordova).

Trend: Short-term decline due to development and human activity is expected; long-term trend is more difficult to predict. Degree of damage from an oil spill to nearshore waters is expected to vary with factors such as degree of tidal influx, tide level, location, season and extent and duration of the spill. Sites with high freshwater outflow will be less susceptible (Crow 1977). The long-term loss of coastal habitat due to climate-induced, global sea level rise is difficult to predict as projections must account for local trends of tectonic uplift and subsidence, the potential for seismic repositioning of the shoreline and glacial rebound in relation to global sea level rise. The average global sea level rose about 18 cm over the 20th century, 10 times faster than the average rate of sea-level rise during the previous 3,000 years (Haufler 2010). Since 1990, sea level has been rising 0.4 cm/year, twice as fast as the average over the 20th century and projections show the rate will continue to accelerate (Haufler 2010, Garrett 2014). Sea level, however, has rarely been constant in southern Alaska and the Aleutian Islands. Some land is currently rising due to isostatic rebound and tectonic uplift, while other coastlines are falling due to tectonic down-warping. The occurrence of deep subduction zone earthquakes and their attendant disturbances are notoriously difficult to predict. For southern Alaska the reoccurrence time for these large-magnitude earthquakes is estimated to be on the order of 500 to 1,350 years (Plafker and Rubin 1978). Considering the relative recentness of the 1964 Good Friday Earthquake, impacts from this threat are only expected in the extreme long-term.

Species of Conservation Concern

Tidal marshes provide a staging area for millions of migrating shorebirds and waterfowl (Figure 5), is an important rearing habitat for salmon, and supports numerous taxa of concern.

Figure 5. Tidal marshes and mudflats at Hartney Bay near Cordova, Alaska.

The animal and plant species listed below are designated critically imperiled or vulnerable either globally (G1-G3) or within Alaska (S1-S3) and are known or suspected to occur in this biophysical setting (Table 1, Table 2). Please visit the Alaska Center for Conservation Science website for species descriptions (ACCS 2016).

Table 1. Bird and amphibian species of conservation concern within the Pacific Tidal Marsh Biophysical Setting.

Common Name	**Scientific Name**	**Global Rank**	**State Rank**	**Habitat Description**
Amphibians				
Western toad	*Anaxyrus boreas*	G4	S3S4	Known to occur in southeast Alaska's island and mainland coastal rainforest habitat; could occur on upper tidal marsh.
Birds				

Common Name	Scientific Name	Global Rank	State Rank	Habitat Description
Aleutian Tern	*Sterna aleutica*	G4	S3B	Nests usually on sand spits, sandbar islands, sand dunes, and flat vegetated summits of more rugged islands; on low wet coastal marsh and tundra in some areas.
Bar-tailed Godwit	*Limosa lapponica*	G5	S3B	Nests in sedge meadows and coastal tundra. Staging in nearshore estuarine areas and beaches.
Beringian Marbled Godwit	*Limosa fedoa beringiae*	G5T2T3	S2B	The entire breeding population is thought to move to intertidal and estuarine habitats of the Alaska Peninsula after breeding.
Black Guillemot	*Cepphus grylle*	G5	S2	Nest along beaches and in coastal cliff crevices in Northern Alaska.
Black Oystercatcher	*Haematopus bachmani*	G5	S2S3B	Breeding habitat is exclusively associated with the high tide margin of the inter-tidal zone. In Alaska, the highest breeding densities occur on nonforested islands dominated by sloping beaches of shell or gravel (Andres 1998).
Black Scoter	*Melanitta americana*	G5	S3S4B, S3N	May use inshore marine habitat during nonbreeding seasons. Nests near lakes and pools on grassy or bushy tundra (AOU 1983).
Black Turnstone	*Arenaria melanocephala*	G5	S3N, S4B	Nonbreeding found on rocky seacoasts and offshore islets (AOU 1983). Nests mainly in salt-grass tundra; breeds along the coast or on offshore islands.
Bristle-thighed Curlew	*Numenius tahitiensis*	G2	S2B	Known to nest in the low mountainous regions of the Yukon-Kuskokwim delta and the Seward Peninsula. Tidal flats and beaches near Prince William Sound provide migration habitat on a rare occasion.
Double-crested Cormorant	*Phalacrocorax auritus*	G5	S3	Habitat includes: lakes, ponds, rivers, lagoons, swamps, coastal bays, marine islands, and seacoasts; usually within sight of land. Nests on the ground or in trees in freshwater, and on coastal cliffs.
Dusky Canada Goose	*Branta canadensis occidentalis*	G5T3	S3B	Breeding range restricted to the Cooper River Delta. Common on tidal marshes, uplifted tidal marshes and barrier islands.
Eurasian Wigeon	*Anas penelope*	G5	S3N	Winters primarily in freshwater (marshes, lakes) and brackish situations in coastal areas but migrates through inland regions. Rare in Southcoastal Alaska.
Great Blue Heron	*Ardea herodias*	G5	S2S3	Nest in tall trees of wetlands near tidal and freshwater. Tidal marshes of southern Alaska provide hunting habitat.

Common Name	Scientific Name	Global Rank	State Rank	Habitat Description
Hooded Merganser	*Lophodytes cucullatus*	G5	S3B	Streams, lakes, swamps, marshes, and estuaries; winters mostly in freshwater but also regularly in estuaries and sheltered bays (AOU 1983).
Hudsonian Godwit	*Limosa haemastica*	G4	S2S3B	Nests on grassy tundra, near bogs and marshes or near coast/rivers. Nonbreeding habitat includes marshes, beaches, flooded fields, and tidal mudflats (AOU 1983); lake and pond shores, inlets.
Lesser Scaup	*Aythya affinis*	G5	S3N, S5B	Breeds in marshes, ponds, and small lakes (AOU 1998). Usually nests near small ponds and lakes, sedge meadows, creeks with some cover.
Marbled Murrelet	*Brachyramphus marmoratus*	G3G4	S2S3	Nest in old-growth hemlock and Sitka spruce on moss-covered trunks, or on ground near sea-facing talus slopes or cliffs. Forages in nearshore waters and less frequently in tidal marshes (Figure 6).
McKay's Bunting	*Plectrophenax hyperboreus*	GU	S3	May use coastal habitat in the Bering Sea including Nunivak Island during migration. This species is only known to breed on St. Matthews and Hall islands in rocky areas and beaches. The McKay's bunting would be a rare spring migrant through Southcoastal Alaska.
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	G5	S3B	Rare visitor to southern southeast Alaska. Likely uses tidal marshes for feeding habitat.
Peale's Peregrine Falcon	*Falco peregrinus pealei*	G4T3	S2S3	Utilizes coastal beaches, tidal flats, islands, marshes, estuaries, and lagoons. Nests primarily on ledges of vertical rocky cliffs in the vicinity of seabird colonies.
Pribilof Rock Sandpiper	*Calidris ptilocnemis ptilocnemis*	G5T3	S2N, S3B	Winter range includes intertidal habitats along the Gulf of Alaska and Cook Inlet.
Queen Charlotte Goshawk	*Accipiter gentilis laingi*	G5T2	S2	Primarily a forest dwelling species, this goshawk likely uses tidal marshes on occasion for hunting.
Redhead	*Aythya americana*	G5	S3S4B	Nest in Interior Alaska (ponds, lakes) but could rarely use tidal marshes in southeast Alaska during migration.
Red Knot	*Calidris canutus*	G5	S2S3B	Nests on ground of barren tundra and well vegetated moist tundra in Northwest Alaska including the Seward Peninsula and less commonly near Point Barrow. Likely uses barrier island and spits for migration and staging.

Common Name	Scientific Name	Global Rank	State Rank	Habitat Description
Ring-billed Gull	*Larus delawarensis*	G5	S3N	Prefers nearshore coastal or freshwater habitat. Nests rocky, sandy, and grassy islets or isolated shores, occasionally on marshy lands, often with other water birds; mainly at inland lakes.
Ring-necked Duck	*Aythya collaris*	G5	S2N, S3B	Nests in freshwater marshes and wooded ponds/lakes. Likely uses tidal marshes as wintering habitat.
Rock Sandpiper	*Calidris ptilocnemis*	G5	S3N, S4B	Winters on rocky seacoasts, breakwaters, and mudflats. Nests in the open on the ground, prefers grassy or mossy tundra in coastal or montane areas (AOU 1983).
	Calidris alba	G5	S2B	Breeds in small area of high arctic tundra on the Arctic Coastal Plain near Barrow. Likely uses tidal marshes near the Copper River Delta during migration.
Smith's Longspur	*Calcarius pictus*	G5	S3S4B	Smith's Longspur breed in dry tundra. Tidal marshes could be used during migration in the Yakutat area.
Stilt Sandpiper	*Calidris himantopus*	G5	S3B	Breeding range from Canadian border to Barrow, Alaska along coastal plain at least several km inland. Suspected to use nearshore marine habitat for migration.
Surfbird	*Aphriza virgata*	G5	S2N, S3B	Nests on dry alpine tundra. Winter habitat could include coastal tidal marshes but prefers rocky habitat.
Whimbrel	*Numenius phaeopus*	G5	S3S4B	Feeds on sandy beaches and spits during breeding season. Nests in nearby dwarf shrub tundra. Uses nearshore marine waters in Southcoastal Alaska during migration.
White-rumped Sandpiper	*Calidris fuscicollis*	G5	S3B	Grassy or mossy tundra, often not far from water; wet tundra, with nest sites on tops of hummocks. Tidal marshes are likely used as feeding, staging, and migration habitat.

Figure 6. Marbled Godwit (photo by T. Bowman).

Table 2. Plant species of conservation concern within the Pacific Tidal Marsh Biophysical Setting.

Scientific Name	Global Rank	State Rank	Habitat Description
Bolboschoenus maritimus	G5	S3	Brackish to saline coastal shores and marshes.
Carex glareosa ssp. *pribylovensis*	G4G5T2T3	S2	An Alaskan endemic, known only from 6 locations in salt marshes and gravelly seashores of the Pribilof and Aleutian islands.
Carex stipata	G5	S1	Seasonally saturated or inundated soils in wet meadows, marshes, edges of tidal marshes, swamps, alluvial bottomlands
Cochlearia sessilifolia	G1G2Q	S2Q	Grows in intertidal gravel and fines that typically are submersed at high tide.
Phyllospadix serrulatus	G4	S3	Known from widely scattered rocky tidal and subtidal sites along the coast.
Plagiobothrys orientalis	G3	S3	Found in open mud at margin of Carex lyngbyei zone
Sidalcea hendersonii	G3	S1	Known from the Juneau area, where it occurs in upper tidal marshes and raised beach meadows.

Plant Associations of Conservation Concern

The plant associations listed below are designated critically imperiled or vulnerable either globally (G1-G3) or within Alaska (S1-S3) and are known or suspected to occur in this biophysical setting (Table 3).

Table 3. Plant associations of conservation concern within the Pacific Tidal Marsh Biophysical Setting.

Name	Global Rank	State Rank	Concept Source
Shrubs			
Myrica gale/Carex lyngbyei	G3	S3	DeVelice et al.1999, Boggs 2000
Myrica gale-Salix hookeriana	G3	S3	DeVelice et al. 1999
Salix arctica/Carex lyngbyei	G3	S3	DeVelice et al.1999, Boggs 2000
Herbaceous			
Agropyron trachycaulum- Festuca rubra-Achillea borealis-Lathyrus palustris	G3	S3	Hanson 1951

Name	Global Rank	State Rank	Concept Source
Carex glareosa	G3	S3	Boggs 2000
Carex lyngbyei-Cicuta mackenziana	G3	S3	Crow 1968
Carex pluriflora-Carex lyngbyei	G3	S3	Hanson 1951
Cochlearia officinalis	G3	S3	Wiggins and Thomas 1962
Cochlearia officinalis-Achillea borealis	G3	S3	Byrd 1984
Cochlearia officinalis-Lathyrus maritimus	G3	S3	Bank 1951
Cochlearia sessilifolia	G1G2	S1S2	Boggs et al. 2008
Deschampsia caespitosa	G4	S3	DeVelice et al. 1999
Puccinellia glabra-Plantago maritima	G3	S3	Hanson 1951
Puccinellia phryganodes – Cochlearia officinalis	G3	S3	Thomas 1951
Puccinellia phryganodes – Salicornia europaea	G3	S3	Hanson 1951

Classification Concept Source

The classification concept for this biophysical setting is based on Crow (1968).

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