Supplementary Materials: Regional Patterns and Asynchronous Onset of Ice-Wedge Degradation since the Mid-20th Century in Arctic Alaska. *Remote Sensing* 2018, *8*, remotesensing-318283

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3. Results

3.1. Field Observations and Terrain Mapping

Field data collected in residual uplands corroborated the broad-scale geomorphic unit mapping [26]. The dominant texture of near-surface soils observed at plots usually conformed to the generalized texture of the geomorphic units: sandy soils on alluvial-marine and eolian sand sheet deposits, and silt-rich soils on yedoma (Supplementary Table S1); however, we found disjunct occurrences of some geomorphic units beyond the ranges evident in the regional-scale mapping. More than one upland geomorphic unit was present in two study areas; the westernmost study area (Kugachiak) included both alluvial-marine deposits and yedoma, and the easternmost study area (Kogosukruk) included both sand sheet and yedoma. The overall extent of residual uplands varied among the study areas (range 507–2825 ha; 18–84% of study area) (Table 3).

Surface forms observed in residual uplands overwhelmingly reflected high-centered, low-density polygons and mixed pits and polygons (Supplementary Table S2). Vegetation in residual uplands was primarily characterized by mesic, late-successional tundra dominated by the tussock-forming sedge *Eriophorum vaginatum* (Supplementary Table S3). This vegetation type was extensive and homogeneous in areas that were unaffected by ice-wedge degradation. Collectively, the biological and physical properties sampled on residual uplands were consistent with old, undisturbed settings where there has been a long, uninterrupted period of ice-wedge development. None of our field plots in residual uplands exhibited signs of recent ecological disturbance, with the exception of vegetation mortality and local ponding (e.g., "drowned" shrubs and tussocks) that are consistent with the initial and advanced phases of ice-wedge degradation [14,18].

Table S1. Description of geomorphic units in the North Slope study areas. Modified from Kreig and Reger (1982) [28].

Geomorphic Unit	Description
Active Marine Beach (mba)	Nonvegetated shorelines of the Chukchi Sea and large estuaries such as Wainwright Inlet. Active beaches are dynamic areas of erosion and deposition due to winds, tides, storm surges, and wave action. Beaches can also experience disturbance due to scour by sea-ice. Sediments consist of gravels and coarse sands.
Alluvial Fan (ff)	Gently sloping, cone-shaped deposit of alluvium formed where a stream issues onto a relatively flat plain. Alluvial fans are comprised predominantly of coarse-grained materials, but can also contain silt.

Geomorphic Unit	Description
Drained Lake Basin, Ice-Poor Centers (ldnc)	Lacustrine deposits that formed in depressions in undulating, sandy alluvio-marine and coarse eolian deposits with low to moderate ice content. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently. Soils of the basin center are typically more fine-textured and ice-rich compared to basin margins. Ponds in these basins typically have irregular shorelines and are highly interconnected. On the coastal plain, drained basins are typically elliptical and are orientated parallel to other lakes and basins.
Drained Lake Basin, Ice-Poor Margin (ldnm)	Lacustrine deposits that formed in depressions in undulating, sandy alluvio-marine and coarse eolian deposits with low to moderate ice content. Margin sediments are typically sandy and less ice-rich than in basin centers. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently.
Drained Lake Basin, Ice-Poor Undifferentiated (ldnu)	Lacustrine deposits that formed in depressions in undulating, sandy alluvio-marine and coarse eolian deposits with low to moderate ice contents. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently. This type is used when the lake centers and margins are poorly differentiated.
Drained Lake Basin, Ice-Rich Center (ldic)	Lacustrine deposits that formed in depressions in undulating, sandy alluvial marine and coarse eolian deposits with low to moderate ice contents. The sediments in the centers of ice-rich, drained basins are dominated by massive fines with organics, cryoturbated fines with organics, and limnic fines (algae-rich). These deposits have high potential for ice segregation and often are raised by ice aggradation. Surface morphology ranges from low-center polygons at early stages of development, to high-centered polygons on distinctly raised domes. On the coastal plain, drained basins are typically elliptical and are orientated parallel to other lakes and basins.
Drained Lake Basin, Ice-Rich Margin (ldim)	Lacustrine deposits that formed in depressions in undulating, sandy alluvial marine and coarse eolian deposits with low to moderate ice contents. Sediments near the margins of ice-rich, drained basins are dominated by massive and layered sands (fine and medium sands). Surface morphology ranges from low-center polygons at early stages of development to high-centered polygons.
Drained Lake Basin, Ice-Rich Undifferentiated (ldiu)	Lacustrine deposits that formed in depressions in undulating, sandy alluvial marine and coarse eolian deposits with low to moderate ice contents. Sediments have less ground ice with poorly developed low-centered or high-centered polygons. This type is used when the thaw lake centers and margins are poorly differentiated.
Drained Lake Basin, Pingo (ldip)	Pingos are conspicuous, dome-shaped hills typically found in ice-rich drained lake basins. Pingos are formed after lake drainage, typically by freezing of taliks (thaw bulbs) that underlie the former lake bed. Aggradation of large amounts of ground-ice pushes the ground surface upward. High-center polgyons are typically present and soils are well-drained.

Geomorphic Unit	Description
Eolian Abandoned Sand Dune (esdb)	Unconsolidated, wind-deposited accumulations of primarily very fine and fine sand. Surficial patterns associated with ice-aggradation become apparent in the interdune area in the form of ice wedge orthogonal cracks. Abandoned dunes occur in both upland areas on the arctic coastal sand sheet, and along river corridors in areas that are no longer affected by the present flooding regime. Abandoned dunes are well-vegetated and are not subject to active scouring or movement.
Eolian Active Sand Dune (esda)	Unconsolidated, wind-deposited accumulations of primarily very fine and fine sand. Surficial patterns associated with ice aggradation are absent. The sand dunes are built by deposition of sand from adjacent sandbars and are prone to wind erosion, giving them distinctive, highly dissected patterns. Active dunes primarily occur along river corridors or within recently drained lake basins. Active dunes are barren or partially vegetated and are undergoing active accretion and deflation.
Eolian Inactive Sand Dune (esdi)	Unconsolidated, wind-deposited accumulations of primarily very fine and fine sand. Surficial patterns associated with ice-aggradation are generally absent. Inactive dunes primarily occur along river corridors where the inter-dune areas are still subject to infrequent flooding from the river. Inactive dunes are well vegetated and are not subject to active scouring or movement.
Eolian Sand Sheet Upland (essu)	Flat to gently sloping upland areas that are comprised of ancient eolian sand deposits. Sand sheets exist where the grain size is too large, or wind velocities are too low, for dunes to form.
Frozen Upland Silt (elx)	Windblown silt and very fine sand in homogenous, nonstratified deposits that have shallow permafrost (within the upper 40 cm of the soil profile). On the coastal plain in the study area, deposits typically occur as a layer too thin to be mapped. Deposits are extensive, however, in the Brooks Range foothills.
Hillside colluvium (ch)	Unconsolidated fine-grained, sandy, or gravelly material resulting from mass movement of materials downslope due to gravity.
Lowland Headwater Floodplain (fhl)	Small streams and tributaries in lowland areas that are too small to be delineated apart from their associated floodplains. These low gradient streams carry little sediment and the floodplain generally is restricted to the immediate vicinity of the stream.
Lowland Retransported Deposit (fsl)	Fine-grained, organic-rich materials moved downslope by slopewash, solifluction, and in some cases, piping and therefore influenced by both fluvial and gravity processes. Loess may also be incorporated in these deposits. The surface has a dendritic, feathery pattern indicative of fluvial processes. The subsurface material is generally frozen and ice-rich. These deposits are characteristic of drainage tracks.
Marine Terrace, Undifferentiated (mtu)	Alluviomarine deposits emplaced during ancient marine transgressions and modified by alluvial and eolian processes during interceding regressions. This unit is widespread on the coastal plain inland of the Chukchi Sea and was emplaced during the Tertiary period (>1.8 million YBP). Sediments include interbedded gravels, sands, and silts.

Geomorphic Unit	Description
Meander Abandoned Channel Deposit (fmrb)	Lateral accretion deposits of a meander floodplain that are no longer associated with the present fluvial regime or where flooding is sufficiently infrequent that fluvial sediments form a negligible component of surface material. Abandoned, very old channels express well-developed, low-center polygons.
Meander Abandoned Overbank Deposits (fmob)	Sediments are a mixture of peat, silt, or fine sand. Surface organic horizon is free of fluvial deposits indicating the terrain is no longer affected by riverine processes. Typically, these areas occupy the highest position on the floodplain, and represent the oldest local terrain. Abandoned floodplain deposits typically have at least 20 cm of surface organics over silt-loam or fine sand alluvium. Low-centered polygons and small ponds are common.
Meander Active Channel Deposits (fmra)	Sand and mud deposited as lateral accretion deposits in active river channels by fluvial processes. Occasional subrounded to rounded pebbles may be present. Frequent deposition and scouring from flooding usually restricts vegetation to sparse pioneering colonizers. The channel has a meandering configuration characterized by point bars.
Meander Active Overbank Deposit (fmoa)	Thin (15–30 cm), fine-grained cover deposits (primarily silt) that are laid down over sandy or gravelly riverbed deposits during flood stages. Deposition occurs sufficiently frequently (probably every 3–4 yrs) to prevent the development of a surface organic horizon. This unit usually occurs on the upper portions of point and lateral bars and supports riverine willow vegetation.
Meander Inactive Channel Deposits (fmri)	Sand and mud deposited as lateral accretion deposits in inactive meander channels during a period of high flow. Because of river meanderings 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.
Meander Inactive Overbank Deposits (fmoi)	Interbedded layers of peat and silty very fine sand material (15–60 cm thick), indicating a low frequency of flood deposition. Cover deposits below this layer generally consist of silt but may include pebbly silt and sand and usually are in sharp contact with underlying channel deposits. This unit has substantial segregated and massive ice, as indicated by the occurrence ice-wedge polygons.
Organic Fen (of)	Minerotrophic wetlands with thick (>40 cm) organic matter accumulations developed in basins fed by mineral-rich surface water or groundwater. Water chemistry is typically circumneutral (pH 5.5-7.3) or alkaline (pH > 7.3), and dissolved minerals are present at moderate to high concentrations (electrical conductivity >100 μS). The surface is flat and the water table is at or near the surface.

Geomorphic Unit	Description
Recent Alluvial Terrace (ftr)	Recent alluvial terraces are old (millennia) and flooding is very rare. Return intervals for flooding are upwards of 500 to >1000 years. These surfaces represent the highest surface that may be flooded under the current flood regime (albeit extremely rarely), and often feature a distinct rise of one to several meters in elevation that separates it from abandoned overbank deposits. Soils will have been stable long enough for weak to moderately developed subsurface diagnostics to form. Depending on climate and ecoregion, this development may range from thick organic mats (>40 cm), ice-rich permafrost, or the development of spodic materials.
Solifluction Deposit (cs)	Unconsolidated fine-grained, sandy, or gravelly material, resulting from mass movement of saturated materials above the permafrost table. Usually associated with gelifluction processes on moderately steep slopes (approx. 7 to 35°), and in snowbeds.
Thaw Basin, Ice-Poor Center (ltnc)	Lacustrine deposits formed by the draining of thermokarst lakes or other lakes. Soils of the basin center are typically fine-grained and organic-rich, with stratigraphy re-formed by subsidence. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently. Ponds in these basins typically have irregular shorelines and are highly interconnected.
Thaw Basin, Ice-Poor Undifferentiated (ltnu)	Lacustrine deposits formed by the draining of thermokarst lakes or other lakes formed in ice-rich loess or finer-grained alluvium. The presence of nonpatterned ground or disjunct polygonal rims indicates that ground ice content is low and that lake drainage has occurred recently. Ponds in these basins typically have irregular shorelines and are highly interconnected. This type is used when the thaw lake centers and margins are poorly differentiated.
Thaw Basin, Ice-Rich Undifferentiated (ltiu)	Lacustrine deposits formed by the draining of thermokarst lakes or other lakes formed in ice-rich loess or finer-grained alluvium. Sediments have less ground ice with poorly developed low-centered or high-centered polygons. This type is used when the thaw lake centers and margins are poorly differentiated.
Thaw Basin, Pingo (ltip)	Sediments similar to ice-rich, thaw basin centers but with much more ground ice indicated by an approximately circular, raised area of well-drained high-centered polygons.
Tidal Flat, Active (mta)	Flat intertidal areas that are regularly inundated by tides and are undergoing sedimentation. Tidal flats occur on seaward margins of estuaries, leeward portions of bays and inlets, and river mouths. Sediments typically consist of fine-textured sand and silt.
Tidal Flat, Inactive (mta)	Flat coastal areas that lie above the typical intertidal zone but are occasionally inundated by storm surges. These areas are generally not subject to sedimentation, so some surface organic matter is usually present. Vegetation is usually present.

Table S2. Description of surface forms in the North Slope study areas. Modified from Washburn (1980) [1].

Surface Form	Description
Basin Complex (xb)	Complex microrelief within large basins formed by the thawing and draining of lakes in permafrost-dominated landscapes. In young, ice-poor thaw basins, the complex generally includes ponds, nonpatterned ground, and disjunct polygons. In older, ice-rich thaw basins, the complex usually consists of ponds, low-centered polygons, and high-centered polygons.
Beaded Stream (tb)	This surface form is used in association with lowland headwater streams that are formed through the connection of adjacent thermokarst pits. The stream channel consists of small linked ponds, resembling beads on a string.
Bluffs and Streambanks (sb)	Moderate to steep slopes of unconsolidated material. Banks form from undercutting by streams or thermal erosion due to the transfer of heat by water and wind at lake margins.
Channel, Swale, or Gut (fc)	Low-lying concave portions of the floodplain developed from river scouring. Tend to be water gathering. Often used with the active, inactive, and abandoned channel geomorphic classes.
Disjunct Polygon Rims (pd)	Disjunct polygon rims are found where ice-wedge development is not sufficiently advanced to create closed polygons. This surface form is common in recently-drained thaw basins and isolated depressions in older basins where ice wedges are actively developing.
Drainage, Undifferentiated (d)	A general term for a concave, often incised area that includes ephemeral, intermittent, or perennial stream channels. This surface form differs from water tracks in that it is limited to above ground water movement in a restricted channel.
Dune, Undifferentiated (en)	A low mound, banks, or ridge of loose, windblown, granular material (generally sand) that is either active or stabilized. Common dune types in the study area include linear, streaked, and parabolic dunes. Linear dunes are long and straight deposits that form in areas with limited sand supply and converging wind directions. Streaked dunes are characterized by thin, elongated stripes where wind scouring has caused undulations in the surface of the dune. The striped patterns in a streaked dune are roughly parallel and form an acute angle to the long axis of the dune. Parabolic dunes have a convex surface that is shaped like a parabola with the open end facing upwind.
Dune Complex (xd)	Complex microrelief that includes three or more unique vegetation communities or dune geomorphic classes. This class most often applies to dunes that have formed along a river corridor where the active, inactive, and abandoned dunes are either too small to delineate at the scale of mapping, or where moist and wet inter-dune areas must be mapped in the same delineation.

Surface Form	Description
Footslope (sf)	The hillslope profile position that forms the linear or concave surface at the base of a hill. It is a transition zone between upslope sites of erosion and transport (crest, shoulder, and backslope) and downslope sites of deposition (toeslope). Footslopes exhibiting any form of ground ice-expression (e.g., ice-wedge polygons) were mapped according to the dominant ice-related feature instead of the hillslope position.
Frost Scars and Boils (ff)	Surface features that are roughly circular and slightly domed. They are composed of fine-grained mineral material that undergoes strong frost-heave. This process of cryoturbation recurs annually, preventing the development of an organic mat. Frost scars and boils are isolated, while nonsorted circles may be extensive and cover a large area. For this study area, the patterned ground and isolated frost features were mapped together.
High-Centered, High-Relief Polygons (phh)	High-centered polygons are composed of a raised "center" surrounded by a low "trough" separating the center from adjacent polygons. Troughs are underlain by ice wedges. Most high-centered polygons range between 5 and 10 m in diameter. High-centered polygons generally result from the progressive thawing of ice wedges, which initiates subsidence and the development of deep (> 50 cm) troughs. This thermokarst process is frequently related to changes in drainage and is often found near lake outlets and streambanks, or following a surface disturbance.
High-Centered, Low-Relief Polygons (phl)	Similar to above, but polygon centers are only slightly raised (< 50 cm) with respect to the troughs. This class also includes “flat-centered” polygons where the relief between centers and troughs is barely noticeable. This surface form is common on old surfaces such as abandoned floodplains deposits, alluvial–marine terraces, or older ice-rich drained basins. It is also common on gently-sloping hills in the Brooks Range foothills.
Low-Centered, High-Relief, High-Density Polygon (plhh)	Low-centered polygons are composed of a low-lying, often wet or flooded “center” surrounded by a “rim” that separates the center from adjacent polygons. Rims are underlain by ice wedges. Low-centered polygons in this class have rims that exceed 50 cm in height with respect to centers. High-relief polygons are more likely to have well-developed troughs between polygon rims. Relief can be accentuated by thaw settlement of the polygon center. High-density polygons are relatively small (≈8 to 15 m across), resulting in high microtopographic variability.
Low-Centered, High-Relief, Low Density (plhl)	Similar to the above, with rims greater than 50 cm tall, but the individual polygons are larger (≈15 to 30 m across).
Low-Centered, Low-Relief, Low-Density Polygons (plll)	Similar to the preceding low-centered polygon classes, but rims are less than 50 cm tall. Low-density polygons are relatively large (≈15 to 30 m across). Larger polygons often are partially bisected by indistinct rims, which overlie newly-developing ice wedges.
Low-Centered, Low-Relief, High-Density Polygons (pllh)	Similar to the preceding class, with rims less than 50 cm tall, but individual polygons are relatively small (≈8 to 15 m across).

Surface Form	Description
Mixed High- and Low-Centered Polygons (pm)	This surface form refers to a polygonal network in which individual features are transitioning from low to high centers. This is caused when the ice wedges between low center polygons begin to melt, and drainage is altered. Also, the accumulation of organic matter and ground ice in the low centers can raise the surface to high-centers.
Mixed Thaw Pits and Polygons (tm)	This class contains elements of both high- and low-centered polygons and is characterized by flooded, often deep (2 m) thermokarst pits at the intersections of polygon troughs. The pits form due to thaw of the uppermost parts of ice wedges, resulting in surface subsidence.
Mounds, Undifferentiated (mu)	Isolated but repeating mounds that are not attributable to a specific geomorphic or periglacial process.
Nonpatterned (n)	Flat areas that lack 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 (if present) are generally <30 cm high and compose less than 5% of the surface area. Nonpatterned ground includes some of the youngest portions of the tundra landscape, such as recently drained thaw lakes or young floodplains, where ground ice is not abundant.
Palsa (fpa)	An elliptical, dome-like permafrost mound containing alternating layers of ice lenses and peat or mineral soil, commonly 3–5 m high and 2–25m long, occurring in bogs and often surrounded by water.[1]
Riverine Complex (xr)	This class is used when surface components of a floodplain are too small to be mapped separately. Surface forms in this type include water, beads, and disjunct and high-centered low-relief polygons.
Slope, Undifferentiated (s)	This class was used to characterize gentle hillslopes that did not fit the definition for crest, shoulder, upper slope, footslope, or toeslope. This class was also used in areas that, due to the scale of mapping, necessitated the consolidation of two or more slope classes in one polygon.
Strang (ms)	Small, hummocky ridges (<50 cm high), or "strings", formed by ground ice development and oriented perpendicular to the direction of slope. Areas between strings often have standing water.
Toeslope (st)	The hillslope position that forms the gently-inclined surface at the base of a hillslope. In profile, toeslopes are usually gentle and linear, and are constructional surfaces forming the lower part of a hill-slope continuum that grades to valley or closed-depression floors. Toeslopes with any form of ice-expression (e.g., ice-wedge polygons) were mapped according to the dominant ice-related feature instead of the hillslope position.[1]
Upper Slope (su)	Generally convex upper and middle portions of a hillslope. The surface typically is erosional, water shedding, and exposed to more solar radiation.
Water (w)	Permanent waterbodies.

Surface Form	Description
Water Tracks (fsl)	Small drainages on permafrost-affected hillslopes that have a unique hydrology that primarily involves subsurface water flow rather than aboveground flow. The main difference between water tracks and undifferentiated drainages is that water tracks lack an incised drainage channel.

Table S3. Description of vegetation types in the North Slope study areas. Modified from Viereck et al. (1992) [29].

Vegetation Class	Description
Barrens and Partially Vegetated (bpv)	Nonvegetated areas on river bars, active sand dunes, and upland ridgecrests that are too unstable or exposed to support continuous cover of vegetation (<30% cover). This class is also used for areas covered by gravel and other fill material. Typical species include *Salix alaxensis*, *Festuca rubra*, *Deschampsia caespitosa*, *Juncus arcticus*, *Arctophila fulva*, and *Equisetum arvense*.
Closed Tall Willow (stcw)	This class is strongly dominated by willows *Salix alaxensis*, *S. glauca*, *S. arbusculoides*, and/or *S. lanata* ssp. *Richardsonii*. The shrub canopy is tall (>1.5 m) and dense (>75% cover). This class is most common on active and inactive overbanks of larger rivers, particularly the Colville River, where dense stands of *S. alaxensis* can exceed 4 m in height. Closed tall willow is also found on moderately steep upland slopes and can develop after human disturbance. Soils in floodplains tend to be interbedded fines and organics, while upland deposits have thin surface organic horizons. Common associates include *Alnus crispa*, *Artemisia tilesii*, and *Equisetum arvense*
Open Tall Alder (stoa)	Found only in the Brooks Range foothills region, this class is similar to aclosed tall alder except that the tall shrub canopy is less dense (<75% cover) and there is greater cover of associate species such as *Salix glauca*, *S. arbusculoides*, *Betula nana*, and *Arctagrostis latifolia*; there also tends to be a more well-developed moss layer. This class is common on moderately-steep upland slopes near the major rivers.
Open Tall Willow (stow)	This class is similar to closed tall willow, except that the tall shrub canopy is not as dense (<75% cover) and there is greater cover of associate species in the gaps between the tall willows. This class is fairly common in early succession on active and inactive overbanks of larger rivers, and on moderately-steep uplands and bluffs near the rivers. It can also occur in other successional habitats, such as recently-drained lake basins. The understory may be poorly-developed on early successional sites, but commonly includes *Artemisia tilesii*, *Hedysarum alpinum*, and *Equisetum arvense*.
Open Tall Alder-Willow (stoaw)	This class is similar to the preceding open tall shrub classes, except that *Alnus crispa* and willows are co-dominant. This class is locally common on moderately-steep slopes and bluffs near the larger rivers, especially the Colville River.
Closed Low Willow (slcw)	Closed low willow tends to occur in narrow along beaded streams, water tracks, and headwater floodplains in the Brooks Range foothills. The shrub canopy is dense (>75% cover) but is <1.5 m in height. Common species include *Salix richardsonii*, *S. pulchra*, and *S. glauca*. Soils tend to be loamy and there is often substantial movement of water in the subsurface.
Open Low Birch-Ericaceous Shrub (slobe)	This class is very common in the study area, especially in the Brooks Range foothills along small upland drainages and in old thaw basins. This type is frequently encountered on high center polygons. *Empetrum nigrum*, *Ledum decumbens*, and *Vaccinium vitis-idaea* each have cover values of about 10%. Other frequent species include *Arctostaphylos alpina*, *Hierochloe alpina*, *Polygonum bistorta*, *Vaccinium uliginosum*, and *Hylocomium splendens*. For mapping, this class was combined with open low birch-willow. Soils are typically acidic and are organic-rich.

Vegetation Class	Description
Open Low Birch-Willow (slobw)	Similar to open low birch-ericaceous shrub, but willows are co-dominant with *Betula nana*. This class is especially common in the Brooks Range foothills in watertracks and headwater floodplains. For mapping, this class was combined with Open Low Birch Ericaceous.
Open Low Willow (slow)	Open low willow is common in the study area in a variety of habitats including on floodplain deposits, thaw basins, and on non-acidic soils in the Brooks Range foothills. They can be dominated by *Salix pulchra*, *S. glauca*, or *S. richardsonii*. Associated species include Carex *aquatilis*, *Eriophorum angustifolium*, and mosses. Soils typically are well-drained and frost depths may exceed 0.5 m. Floodplain soils are interbedded fines and organics, other deposits have thin surface organic horizons.
Open Low Alder-Sedge Tussock Tundra (sloatt)	Very similar to open mixed low shrub-tussock tundra, except that there is a conspicuous overstory of alders (generally >20% total cover). Alders often exceed 1.5 m height, but tall individuals do not exceed 25% total cover. This class is found in the Brooks Range foothills in the southeastern portion of the study area; it is very common in the vicinity of Umiat on solufluction deposits and upper hillslopes.
Open Mixed Low Shrub-Tussock Tundra (slott)	Widespread across the study area and abundant in the Brooks Range foothills, this class is co-dominated by the tussock-forming sedge *Eriophorum vaginatum* and a mixture of low and dwarf shrubs with >25% total cover, including *Betula nana*, *Salix pulchra*, *Ledum decumbens*, and *Vaccinium vitis-idaea*. Mosses also may be abundant including *Dicranum* sp., *Polytrichum strichum*, *Hylocomium splendens*, *Aulacomnium palustre*, and *Sphagnum* spp. Soils tend to be acidic and organic-rich, with shallow thaw depth (<50 cm). This class is most common on low-relief high center polygons and nonpatterned ground on gently-sloping uplands
Dryas Dwarf Shrub Tundra (sddt)	Well-drained tops of high-centered polygons, pingos, ridge crests, and river terraces dominated by *Dryas integrifolia.* These communities may be co-dominated by sedges or lichens, although vegetation cover is often discontinuous in exposed sites. Associated species include *Carex bigelowii*, *Salix rotundifolia*, *S. reticulata*, *Arctagrostis latifolia*, *Poa arctica*, *Thamnolia vermicularis*, and *Flavocetraria cuculata*. Soils have a neutral pH, are sandy to loamy, usually well-drained, and thaw depths can exceed 1.0 m.
Dryas-Lichen Dwarf Shrub Tundra (sddl)	Similar to dryas dwarf shrub tundra. This type is associated with well drained frost features and dominated by *Dryas integrifolia* and fruticose and crustose lichens. Other associated species include *Salix rotundifolia*, *Saxifraga oppositifolia*, and *Thamnolia vermicularis*. For mapping this class was combined with dryas dwarf shrub tundra.
Ericaceous Dwarf Shrub Tundra (sdet)	Banks and slopes on the coastal plain sand sheet and ice-rich thaw basins dominated by ericaceous shrubs including *Cassiope tetragona* and *Arctostaphylos alpina* and often *Dryas integrifolia*, *Betula nana*, *Salix reticulata*, *S. rotundifolia*, and *Carex bigelowii*. This class is floristically variable; although plant species composition is often similar to dryas dwarf shrub tundra, ericaceous dwarf shrub tundra is less well drained, has shallower thaw depths, and is often associated with late-lying snowbeds.

Vegetation Class	Description
Elymus (hgdl)	Mapped only at Atqasuk East, this vegetation class is rare and is restricted to active sand dunes. Vegetation is discontinuous and is strongly dominated by the grass *Leymus mollis*. Soils are sandy, circumneutral, and somewhat excessively drained. Permafrost may be present but the active-layer is relatively thick (>1 m)
Moist Tussock Tundra (hgmt)	Widespread vegetation class dominated by the tussock-forming sedge *Eriophorum vaginatum*. This class is similar to open mixed low shrub-tussock tundra, but total shrub cover is <25%. Tussock tundra occurs on upland landscapes on raised surfaces, usually high-centered polygons. Common vascular species also include *Salix pulchra*, *E. angustifolium*, *Ledum decumbens*, *Vaccinium vitis-idaea*, *Poa arctica*, *Hierochloe alpina*, *Luzula confusa*, and *Cassiope tetragona.* Soils are loamy or sandy, moist, circumneutral, and thaw depth is usually < 50 cm of the surface.
Moist Sedge-Shrub Tundra (hgmss)	Widespread across the study area in moderately well-drained flats within thaw basins and older floodplain deposits, as well as moderately well-drained upland slopes. Occurs on high-centered polygons, mixed pits and polygons, and well-drained nonpatterned surfaces. Vegetation is co-dominated by dwarf shrubs and sedges, particularly *Carex bigelowii*, *Eriophorum angustifolium*, *Dryas integrifolia*, and *Salix reticulata.* Associated species include *S. arctica*, *C. membranacea*, *C. misandra*, *C. aquatilis*, *Tomentypnum nitens*, *Flavocetraria nivalis*, *Hylocomium splendens*, and *Thamnolia vermicularis*. This class is similar to tussock tundra except shrubs cover is lower and the tussock forming sedge *Eriophorum vaginatum* is not dominant. Soils are loamy or sandy, have a shallow surface organic layer, and are saturated at intermediate depths (>20 cm). This class includes moist sedge-willow and moist sedge-dryas tundra.
Moist Sedge-Willow Tundra (hgmsw)	Similar to moist sedge-shrub tundra except vegetation is co-dominated specifically by willows. Found in riverine areas and in lowlands on headwater overbank deposits and in thaw basins. Usually occurs on high center polygons. Dominants include *Salix pulchra*, *S. ovalifolia*, *Eriophorum angustifolium*, *Carex aquatilis*, *C. maritima*, and *Tomentypnum nitens*. Included in moist sedge-shrub tundra class for mapping.
Wet Sedge Meadow Tundra (hgwst)	Low-lying, poorly drained areas with vegetation dominated by *Carex aquatilis*, *Eriophorum angustifolium*, and mosses. Wet sedge tundra occurs on nonpatterned ground and low-centered or disjunct polygons in thaw basins (both ice-rich and ice-poor) and overbank floodplain deposits. This class also is found in water tracks and swales where willows may be co-dominant. Associated species include *C. saxatilis*, *C. misandra*, *Salix pulchra*, *S. reticulata*, *Dryas integrifolia*, *Saxifraga hirculis*, *and Pedicularis sudetica.* Frequently occurring mosses include *Scorpidium scorpioides*, *Tomentypnum nitens*, *Drepanocladus* spp., and *Aulacomnium turgidum*. When polygons are present the rim vegetation is similar to moist sedge-shrub tundra. Wet sedge meadow Tundra generally is flooded during early summer (depth <0.3m) and water remains close to the surface throughout the growing season. Soils usually have a moderately thick organic layer over silt loam or sandy loam. This class includes wet sedge-willow tundra, where the community is co-dominated by *S. pulchra* or *S. reticulata*.

Vegetation Class	Description
Fresh Grass Marsh (hgwfg)	Lakes within ice-poor thaw basins, river ox-bows, and shallow water of slow-moving headwater streams dominated by the aquatic grass *Arctophila fulva*. Occurs in shallow isolated thaw lakes and on the margins of deep isolated thaw lakes. Water depths are generally <1.0m. *Hippuris vulgaris*, *Utricularia intermedia*, and *Carex aquatilis* may be present in water <0.5m deep.
Fresh Sedge Marsh (hgwfs)	Permanently flooded shallow water within thaw basins, shallow margins of large lakes, and shallow water of slow-moving headwater streams dominated by *Carex aquatilis*. Water depth mostly is ≤0.5m deep. *Carex aquatilis* is dominant; common associates include the mosses *Scorpidium scorpioides* and *Calliergon giganteum*, and vascular plants *Eriophorum angustifolium*, *Caltha palustris*, and *Ranunculus* spp. Aquatic species, such as *Utricularia vulgaris*, may also be present. Polygon development is minimal though disjunct polygon rims may be present. Thaw depth is usually <1.0m.
Fresh Grass Marsh (hgwfg)	Lakes within Ice-Poor Thaw Basins, river ox-bows, and shallow water of slow-moving headwater streams dominated by the aquatic grass *Arctophila fulva*. Occurs in Shallow Isolated Thaw Lakes and on the margins of Deep Isolated Thaw Lakes. Water depths generally are <1.0m. *Hippuris vulgaris, Utricularia intermedia* and *Carex aquatilis* may be present in water <0.5m deep.
Halophytic Sedge-Grass Wet Meadow, Brackish (hgwhsgb)	Mapped only at Wainwright. This coastal vegetation type occurs on wet, brackish soils and is typically dominated by halophytic and semi-halophytic sedges, such as *Carex subspathacea* and *Eriophorum angustifolium*, and grasses such as *Pucinellia phryganodes* and *Calamagrostis deschampsioides.* Common associates include *Salix ovalifolia*, *Cochlearia officinalis*, and *Stellaria humifusa.* Primarily found on inactive tidal flats.
Ice-Rich Basin Wetland Complex (xbo)	Mosaic of three vegetation types occurring in older drained thaw lake basins where no class is dominant and patches are too small (<0.5 ha) to map individually. Older thaw lake basins are characterized by obvious ice wedge development and aggregation of segregated ice; polygonized ground is well-developed and common. Complexes in ice-rich thaw basin margins include wet sedge meadow tundra with low-centered polygons, fresh water, and moist sedge-shrub and tussock tundra on high-centered polygons. Fresh grass marshes are rare and sedge marsh occurs only in flooded portions of pond margins.
Ice-Poor Basin Wetland Complex (xby)	Young basin wetland complexes occur in portions of recently drained lake basins and are characterized by a mosaic of open water, fresh sedge and grass marshes, wet sedge meadow, barren or partially vegetated, and moist sedge-shrub tundra where no class is dominant and patches are too small (<0.5 ha) to map individually. Young basins are distinguished from older basins because they have little ground ice development and are typically dominated by more productive vegetation than older basins. Surface forms are nonpatterned ground or disjunct polygons. Young, ice-poor, basins occur less frequently in the study than older, ice-rich basins.

Vegetation Class	Description
Dune Complex (xd)	Mosaic of three or more vegetation types occurring in and adjacent to active dunes on the eolian sand sheet of the northeastern part of the study area. Vegetation communities are patchily distributed on dune surfaces of varying age and activity; recent dune blow-outs are common. Vegetation classes include partially vegetated and barrens, open low willow, and moist sedge-shrub tundra.
Riverine Complex (xr)	Permanently flooded channels and narrow bands or patches of vegetation too small to be mapped separately. The variety of vegetation reflects the degree and regularity of flooding. Vegetation classes include water, barren or partially vegetated gravel bars, fresh sedge or grass marsh, wet sedge meadow, moist sedge-shrub tundra, or low willow shrub. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer.
Thermokarst Pit and Polygon Complex (xt)	This complex is associated with polygonized, formerly stable upland areas that have experienced extensive ice-wedge thermokarst and thermo-erosion in the recent past, resulting in a ground surface that is pock-marked with small, flooded pits and a mosaic of vegetation types. Vegetation classes include remnant open mixed low shrub-tussock tundra (foothills) or moist tussock tundra (coastal plain), wet sedge meadow tundra, fresh sedge marsh, and fresh water.
Fresh Water (wf)	Permanently flooded, non-vegetated waterbodies. Included in this class are non-vegetated thaw lakes, headwater streams, riverine lakes, and beaded streams. This class may include some waterbodies with submerged vegetation that was not mappable.
Brackish Water (wb)	Permanently flooded, non-vegetated coastal waterbodies that receive both saltwater and freshwater inputs. Included in this class are estuarine water and tidal lakes. This class may include some waterbodies with submerged vegetation that was not mappable.