



An IKONOS Satellite Image Library of Ecosystems in the Arctic Network of National Parks

Natural Resource Technical Report NPS/ARCN/NRTR—2010/397



ON THE COVER

Example of map ecotype, Lowland Ericaceous Shrub Bog, in Kobuk Valley National Park, Alaska, at three spatial scales, from lower left to upper right: ground view, oblique aerial view, and IKONOS satellite image with training polygon in red. Photographs courtesy ABR, Inc.

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Introduction

The National Park Service's Arctic Network (ARCN) seeks to understand the natural resources and to detect changes and trends in those resources in five NPS units, including Gates of the Arctic National Park and Preserve, Kobuk Valley National Park, Noatak National Preserve, Cape Krusenstern National Monument, and Bering Land Bridge National Preserve (Figure 1). This network is one of 32 networks of the NPS Inventory & Monitoring Program and it encompasses nearly one-fourth of the NPS-administered lands in the United States. The network parks are almost completely roadless and, for the most part, distant from any airports. As a result much of the monitoring work will be accomplished by remote sensing. The purpose of this project is to capture and systematize the calibration data that was acquired to produce the ecological land survey and unified ecological unit map of the Arctic Network (Jorgenson et al. 2009). As a part of this work, numerous ground plots were sampled (primarily by helicopter access). These ground-based data were analyzed visually over IKONOS satellite imagery for their potential use as reference areas (i.e. training polygons) in a supervised classification of Landsat imagery. These reference areas provide typical examples of a wide range of vegetation and land cover types in the network. In this report, the reference areas, and associated IKONOS imagery, have been organized into a comprehensive image library for use in future image interpretation. The image library provides a guide to the visual characteristics and descriptions of diagnostic spectral features of the common ecological types of ARCN based on pan-sharpened (1-m resolution) color

infrared imagery. The image library is designed to work seamlessly with the maps and GIS data, written report, and raw field data provided by Jorgenson et al. (2009). The reference images and descriptions should greatly enhance the ability of the end user to interpret IKONOS and other similar imagery and capture valuable information that would otherwise be very difficult to obtain.

Methods

High-resolution, pan-sharpened, ortho-rectified IKONOS images for northwestern Alaska were provided by the National Park Service. ABR assembled and organized the imagery by visual assessment into three categories of image quality: A) high-quality (minimal clouds and shadow), B) medium-quality (clouds concentrated in certain areas, with the majority of the image cloud-free), and C) low-quality (majority of image obscured by cloud and shadow). The high- and medium-quality IKONOS image files were added to an ArcMap 9.3.1 map file for use in the image library. The IKONOS imagery was displayed using the color infrared band combination (bands 4/3/2) with a two-standard deviation contrast stretch, which generally provides high contrast without requiring manual contrast adjustment for each image. It is important to ensure that the background values are excluded from the image statistics calculation. With any statistically based contrast stretch, the resulting colors in the image are dependent on the distribution of pixel digital number values in each band across the entire image. In particular, substantial areas of very bright materials (such as clouds, snow

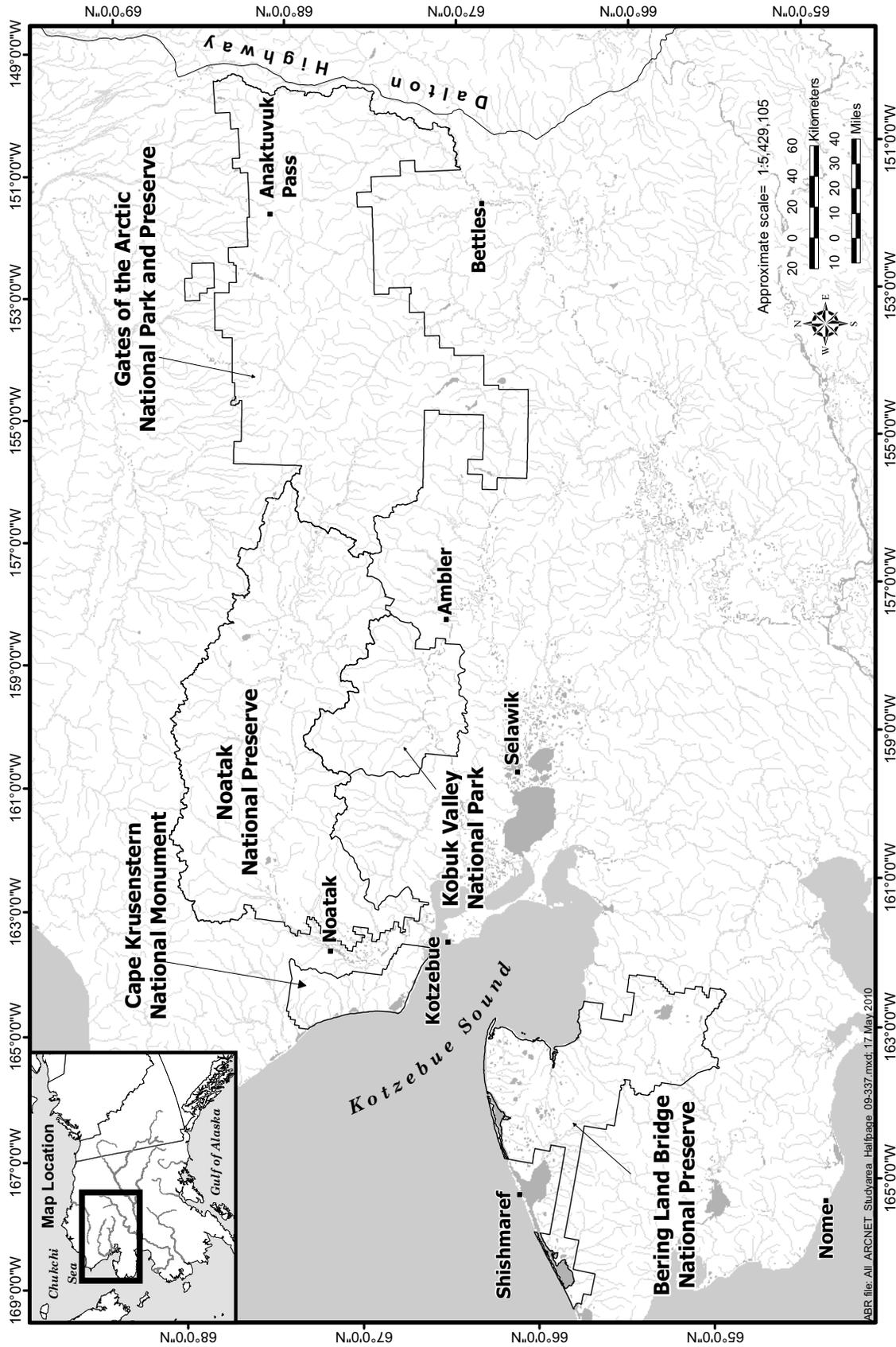


Figure 1. Overview map of the National Park Service's Arctic Network (ARCEN), Alaska.

and sand) or dark materials (such as deep water or shadows) within an image extent can have a large effect on the colors observed. Calibrating the IKONOS imagery to top-of-atmosphere reflectance and applying a fixed contrast stretch might reduce the variability between images; however, such an effort was beyond the scope of this effort.

The IKONOS color infrared band combination (bands 4/3/2) was used exclusively in this report for IKONOS image display and interpretation. This band combination generally provides the most information and the best contrast; however, the natural color band combination (3/2/1 for IKONOS imagery) is also an option. This could provide for more intuitive interpretation since the colors closely resemble those seen by the human eye. In particular, this band combination may be useful for interpreting fall colors.

Feature class files containing the training polygons and field plots used to develop the ARCN spectral classification were added to the same map file, and overlaid on the imagery. In choosing which training polygons to include in the image library, only training polygons with a field plot contained within their boundaries were included. In order to identify those training polygons containing a field plot, a spatial join was performed between the training polygon and field plot feature classes. Training polygons containing field plots were then organized by map ecotype in the feature class attribute table, and each training polygon was reviewed visually to determine whether or not it would be included in the image library. Three to five training polygons were selected for each map ecotype. The training polygons were selected to be

representative of, and include the range of variability within, each map ecotype. For each training polygon selected for use in the image library, a corresponding IKONOS image file was also selected based on the following criteria: 1) the section of image corresponding with the training polygon was cloud and shadow free, and 2) the image provided good contrast between the signature of the training polygon and directly adjacent signatures. For each map ecotype, high-quality image reproductions (.png, 300 dpi) of the training polygons overlaid on the IKONOS imagery were created, including a detailed narrative description of the diagnostic spectral features. For each map ecotype, training polygons for the ecotype of interest were symbolized in the image with a solid red outline, unless otherwise noted. Multiple training polygons were included within a single reference image for some map ecotypes. In such cases, the multiple training polygons were used to facilitate discussion regarding the types and degree of variability in IKONOS signature within a given map ecotype. Training polygons representing other map ecotypes that were located directly adjacent to the training polygon(s) of the map ecotype of interest were uniquely symbolized (dashed, color-coded outline) in the image reproductions and used to facilitate comparisons between the spectral signatures of directly adjacent types. When no adjacent training polygons were available for comparison, data from adjacent field plots was used to identify adjacent signatures. These were then symbolized using alpha codes on the image reproductions. Periglacial features were visible in many of the images produced for the image library. When describing periglacial

features, the presence of these in the area of interest were always confirmed using field plot data, including microtopographic features, plot photos, and/or field notes.

Locations for each reference image were calculated using the ArcToolbox “Feature to Point” tool, which determined the centroid (Lat./Long, decimal degrees, NAD83 Alaska Albers) of the training polygon(s) depicted in each image. For those images with multiple training polygons, the centroid of the primary training polygon (see Appendix 1) in the image was used to denote the image location. A scale-bar (meters) and spatial scale at which the image was created (e.g., 1:24,000) were printed on each image reproduction. The spatial scale will be approximately accurate as printed in the paper copy of this report. However, when this report

is viewed digitally the spatial scale may not reflect the actual scale on screen. Spatially-explicit training polygon data was organized in an ArcGIS file geodatabase. A ThumbsPlus database was created and used to organize the image reproductions.

Results

Fifty-five high-quality and 10 medium-quality IKONOS images were selected for use in the image library. Twenty-eight map ecotypes had training polygons that met the selection criteria outlined above (Appendix 1). A total of 71 training polygons (Figure 2) and 27 IKONOS images (Table 1) were combined to create 105 high quality image reproductions for use in the image library. Appendix 2 provides location information for each of the 105 reference images.

Table 1. Image date for IKONOS images used in ARCN image library.

IKONOS Image	IKONOS Image Date
Or20060808_979	August 8, 2006
Or20060818_556	August 18, 2006
Or20060819_051	August 19, 2006
Or20060819_053	August 19, 2006
Or20060830_559	August 30, 2006
Or20060830_560	August 30, 2006
Or20070706_802	July 6, 2007
Or20070711_833	July 11, 2007
Or20070808_133	August 8, 2007
Or20070808_134	August 8, 2007
Or20080629_667	June 29, 2008
Or20080705_005	July 5, 2008
Or20080707_683	July 7, 2008
Or20080707_686	July 7, 2008
Or20080707_689	July 7, 2008
Or20080807_157	August 7, 2008
Or20080809_178	August 9, 2008
Or20080819_562	August 19, 2008
Or20080820_728	August 20, 2008
Or20080825_687	August 25, 2008
Or20080825_690	August 25, 2008
Or20080902_963	September 2, 2008
Or20080906_923	September 6, 2008
Or20080908_368	September 8, 2008
Or20080913_737	September 13, 2008
Or20080914_010	September 14, 2008
20060920_174_0080001	September 20, 2006

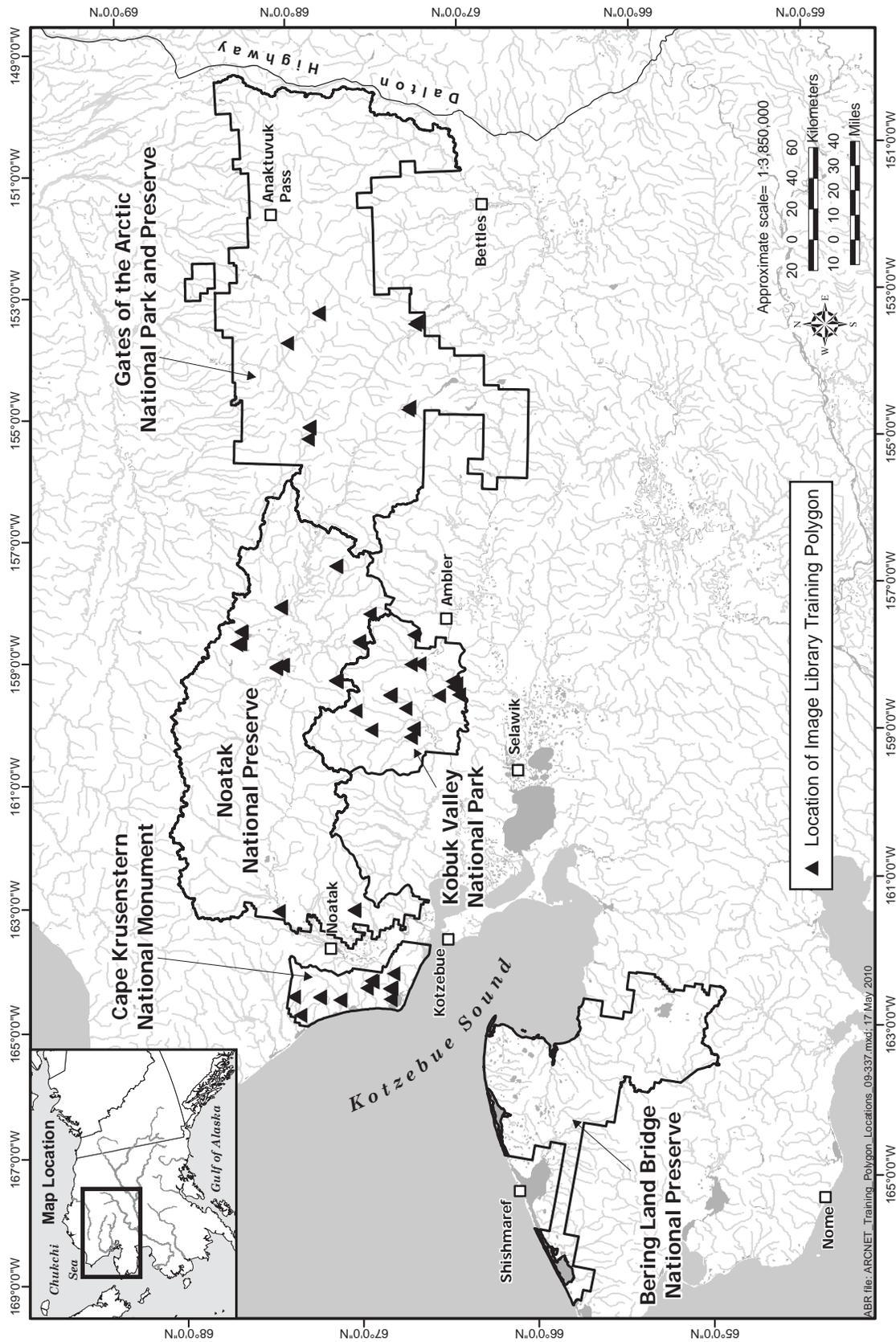


Figure 2. Locations of Jorgenson et al. (2009) training polygons used in the IKONOS image library, Arctic Network of National Parks, Alaska.

**Guide to the Visual
Characteristics of Map Ecotypes**

Alpine Acidic Barrens

This map ecotype occurs throughout ARCN on noncarbonate bedrock at higher elevations on upper slope positions, shoulders, and summits. This map ecotype is distinguished by high cover of exposed soil, rock, and crustose lichen (Figure 3). Figure 4 provides an example of this map ecotype in Noatak National Preserve. At a smaller scale, the diagnostic signature of this map ecotype, and rocky barren areas in general, is the bright cyan blue color of the exposed rock and soil (Figure 4). Microtopography plays a large role in the diagnostic signatures in this map ecotype at a larger scale (Figure 5). The bluish-black signature (A) is indicative of areas with slightly higher cover of *Dryas octopetala* and dwarf willows, while the bright pink (B) reveals small moist to wet depressions or water tracks with sedges and mesic forbs. Black signatures (C) indicate

shadow, and the bright cyan signature (D) represents areas dominated by exposed rock and soil. Map ecotypes that commonly occur adjacent to Alpine Acidic Barrens include Alpine Dryas Dwarf Shrub and Alpine Wet Sedge Meadow (Figure 4). Figure 6 provides an example of this map ecotype in Gates of the Arctic National Park and Preserve, in which the surfaces of the exposed stones and boulders are dominated by the dark-colored crustose lichens *Umbilicaria proboscidea* and *Pseudephebe pubescens*. The signature of this map ecotype is very similar to that for Alpine Alkaline Barrens. Consistent spectral diagnostic characteristics separating these two barrens types are lacking. The best strategy for distinguishing between these types may be to use a geology map in conjunction with satellite imagery.

Figure 3. Aerial photograph of Alpine Acidic Barrens taken July 23, 2006, Noatak National Preserve, Alaska. (Image ID Aacb_air)



Alpine Acidic Barrens

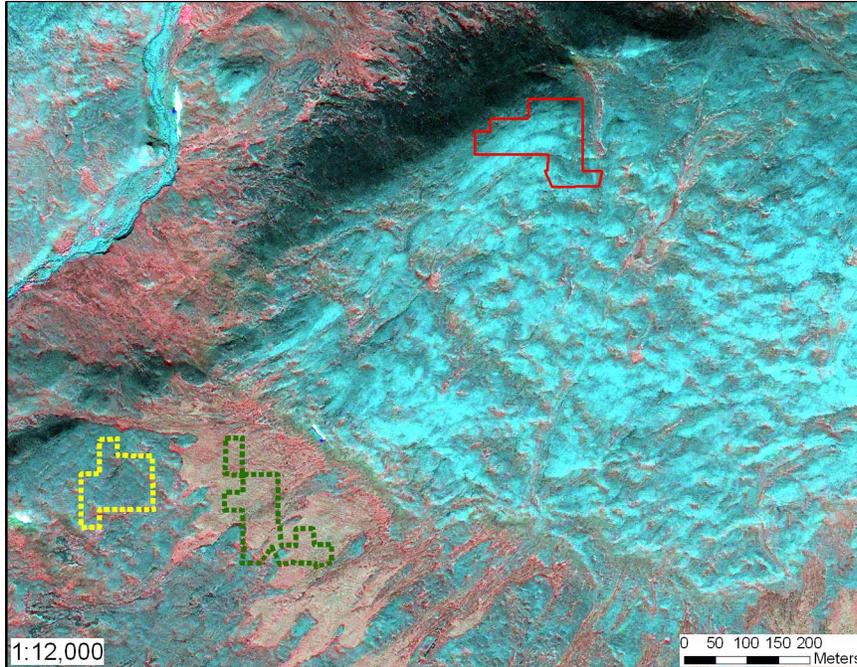


Figure 4. Alpine Acidic Barrens (solid red) and adjacent Alpine Dryas Dwarf Shrub (dashed yellow), and Alpine Wet Sedge Meadow (dashed green), Noatak National Preserve, Alaska. (Image ID Aacb1)

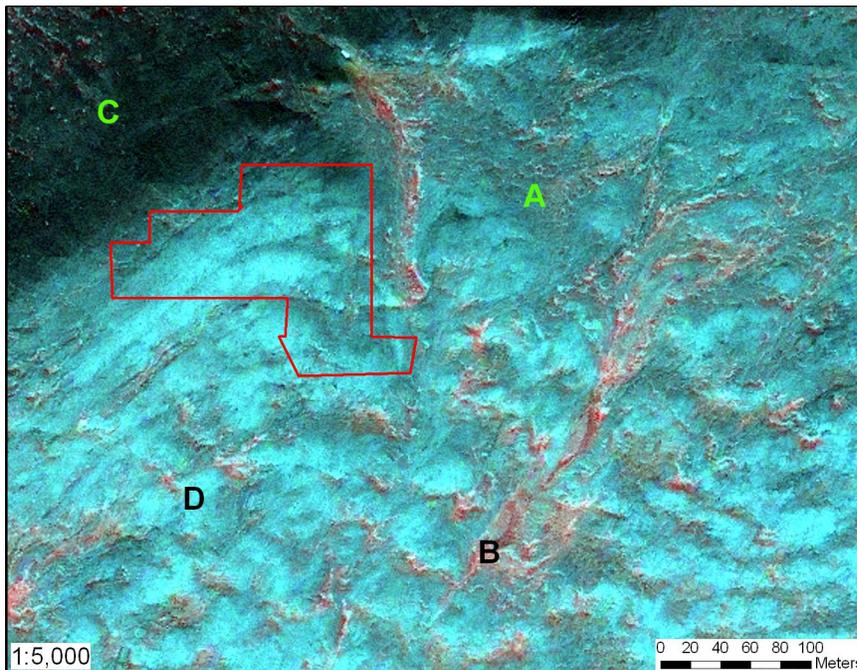
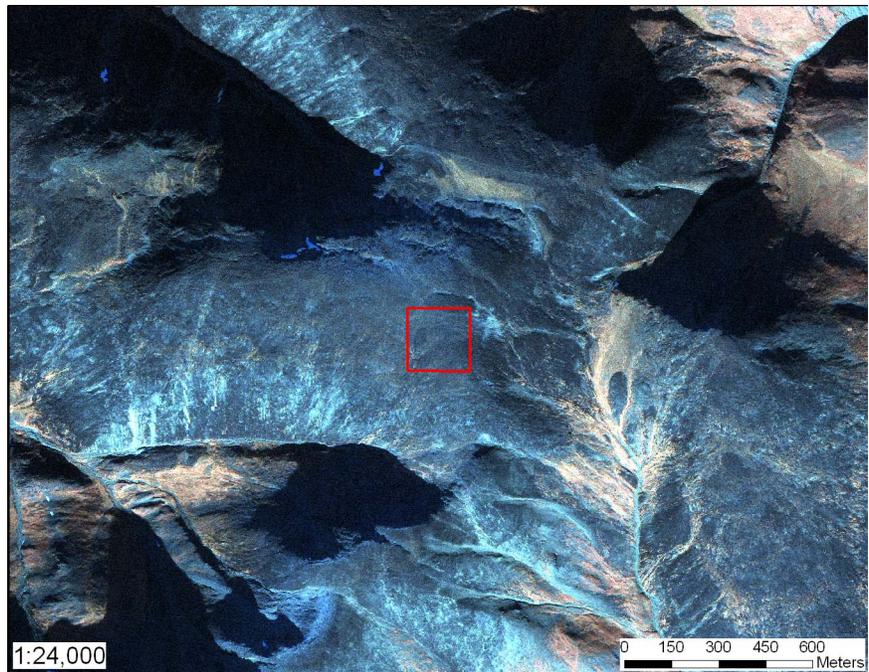


Figure 5. Close-up of Alpine Acidic Barrens (solid red), showing details of microtopography and vegetation signatures, including A) areas with higher cover of *Dryas octopetala* and dwarf willows, B) wet sedge meadow, C) shadow, and D) exposed rock, Noatak National Preserve, Alaska. (Image ID Aacb3)

Figure 6. Alpine Acidic Barrens (solid red), Gates of the Arctic National Park and Preserve, Alaska. (Image ID Aacb2)



Alpine Alkaline Barrens

This map ecotype occurs throughout ARCN on carbonate sedimentary bedrock, metamorphic carbonate bedrock, hillside colluvium and talus at higher elevations on upper slope positions, shoulders, and summits. This map ecotype is distinguished by high cover of exposed soil, rock, and crustose lichen (Figure 7). Figure 8 provides an example of this map ecotype in Cape Krusenstern National Monument. At a smaller scale, the diagnostic signature of this map ecotype, and rocky barren areas in general, is the bright cyan blue color of the exposed rock and soil (Figure 8). Microtopography plays a large role in the diagnostic signatures in this map ecotype at a larger scale (Figure 9). The dark blue signature (A) is indicative of areas of bedrock outcrop, while the bright cyan signature (B) is the typical signature of this map ecotype when it is dominated by talus and exposed soil. The grainy pink areas (C) indicate areas

of Alpine Dryas Dwarf Tundra. Figure 10 provides an example of this map ecotype in Noatak National Preserve. In this early fall imagery, the diagnostic signature for Alpine Alkaline Barrens is light gray. A close perspective reveals details of the microtopography and vegetation, including the typical signature for this map ecotype (A), adjacent Alpine Dryas Dwarf Shrub (B), and shallow drainages and small, slightly moister depressions (C) (Figure 11). Upland Sedge-Dryas Meadow is an ecotype that commonly occurs adjacent to Alpine Alkaline Barrens (Figure 10). The signature of this map ecotype is very similar to that for Alpine Acidic Barrens. Consistent spectral diagnostic characteristics separating these two barrens types are lacking. The best strategy for distinguishing between these types may be to use a geology map in conjunction with satellite imagery.



Figure 7. Aerial photograph of Alpine Alkaline Barrens (see also Image ID Aalb2) taken July 20, 2006, Noatak National Preserve, Alaska. (Image ID Aalb_air)

Figure 8. Overview image of Alpine Alkaline Barrens (solid red) in Cape Krusenstern National Monument, Alaska. (Image ID Aalb3)

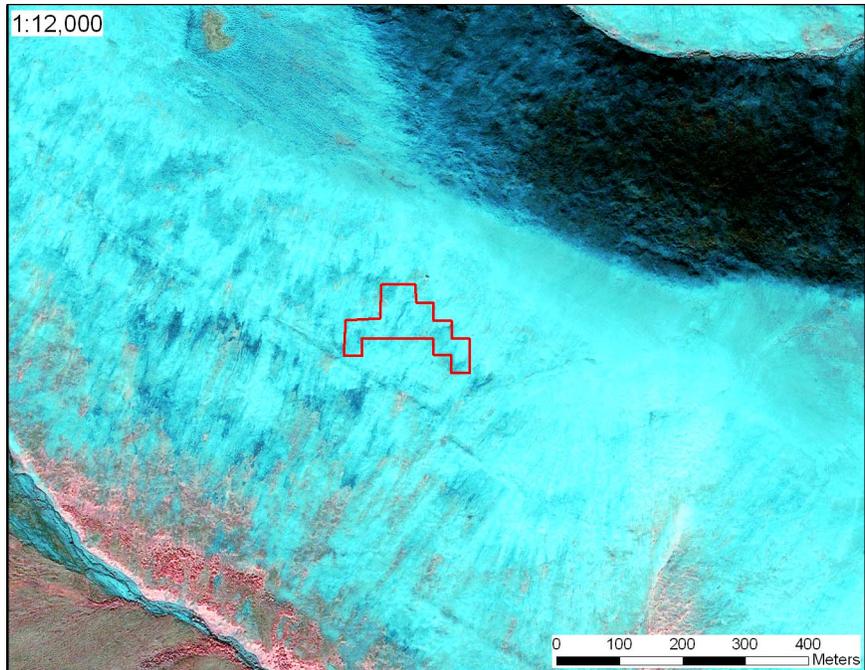
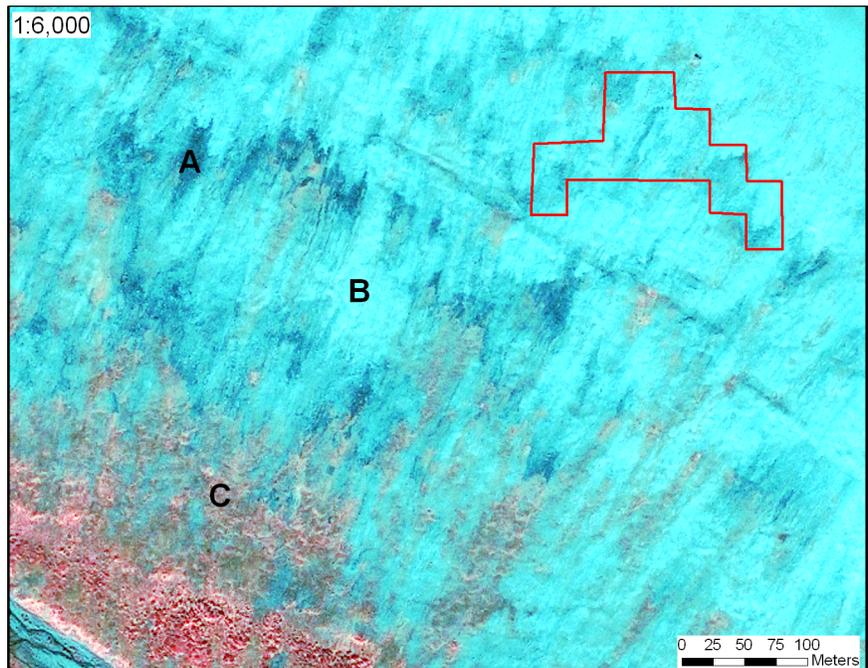


Figure 9. Close-up of Alpine Alkaline Barrens (solid red) showing details of vegetation signatures, including A) areas of bedrock outcrop, B) typical talus-covered Alpine Alkaline Barrens, and C) adjacent Alpine Dryas Dwarf Tundra. Cape Krusenstern National Monument, Alaska. (Image ID Aalb4)



Alpine Alkaline Barrens

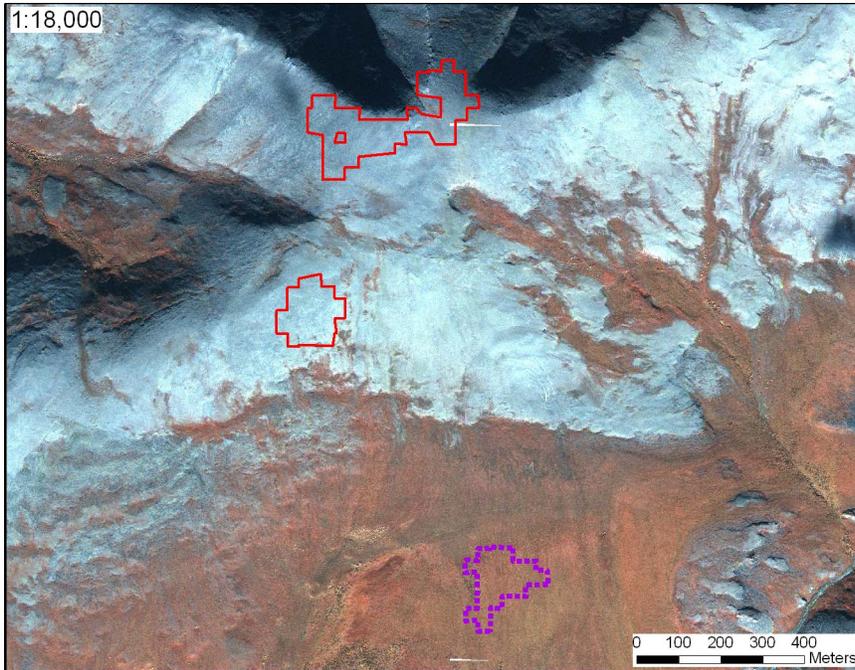


Figure 10. View showing training polygons Plot_GID 30044 (solid red, upper) and Plot_GID 30040 (solid red, lower) for Alpine Alkaline Barrens and adjacent Upland Sedge-Dryas Meadow (dashed purple), Noatak National Preserve, Alaska. (Image ID Aalb2)

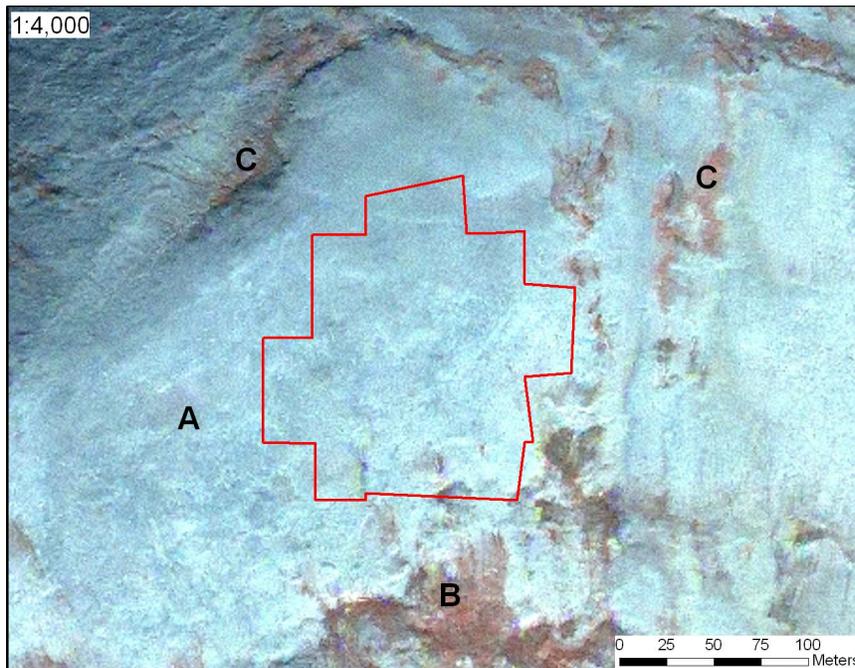


Figure 11. Close-up of Alpine Alkaline Barrens (solid red) showing details of microtopography and vegetation signatures, including A) typical Alpine Alkaline Barrens, B) adjacent Alpine Dryas Dwarf Shrub, and C) shallow drainageways and depressions. Noatak National Preserve, Alaska. (Image ID Aalb1)

Alpine Dryas Dwarf Shrub

This map ecotype includes both Alpine Alkaline Dryas Dwarf Shrub and Alpine Acidic Dryas Dwarf Shrub. This map ecotype occurs throughout ARCN on a variety of landforms and substrates, at higher elevations. Periglacial microfeatures are common in this type, including sorted stone circles and polygons, and stone stripes (Figures 12 and 13). Figure 14 provides an example of this map ecotype in Cape Krusenstern National Monument on sedimentary carbonate bedrock. Map ecotypes that commonly occur adjacent to Alpine Dryas Dwarf Shrub include Alpine Alkaline Barrens and Upland Sedge-Dryas Meadow. In the IKONOS image depicted in Figure 14, Alpine Alkaline Barrens and Alpine Dryas Dwarf Shrub have a similar signature.

However, Alpine Dryas Dwarf Shrub tends to have a slightly duller cyan blue color with tones of brown, green, and pink. Figure 15 provides an example of this map ecotype in Cape Krusenstern National Monument on metamorphic, noncarbonate bedrock. Adjacent vegetation type signatures contrast sharply with the dark to light blue of Alpine Dryas Dwarf Shrub, including the dull pink-orange of areas dominated by dwarf ericaceous shrubs (A), the bright pink of areas dominated by low willows (B), and shadow (C). The difference in signature between the two training polygons of this map ecotype is related to periglacial features, including sorted stone stripes lending to a darker blue color in the upper polygon (dashed yellow) in Figure 16.

Figure 12. Aerial photograph of Alpine Dryas Dwarf Shrub (see also Image ID Adds4) on sedimentary carbonate bedrock in an area with sorted stone polygons, July 16, 2003, Cape Krusenstern National Monument, Alaska. (Image ID Adds_air)



Alpine Dryas Dwarf Shrub

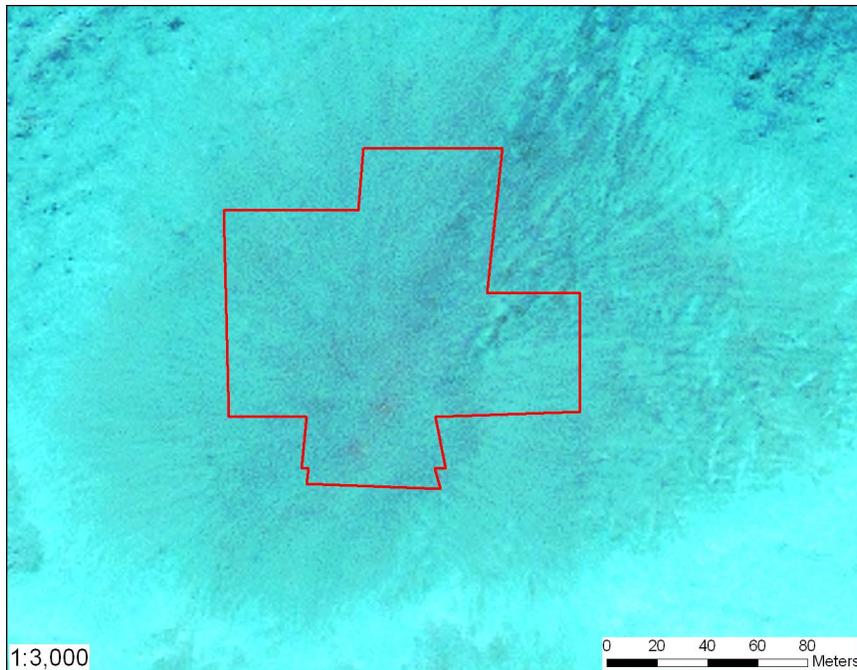


Figure 13. Close-up of Alpine Dryas Dwarf Shrub showing detailed signature of this map ecotype featuring sorted stone polygons, Cape Krusenstern National Monument, Alaska. (Image ID Add54)

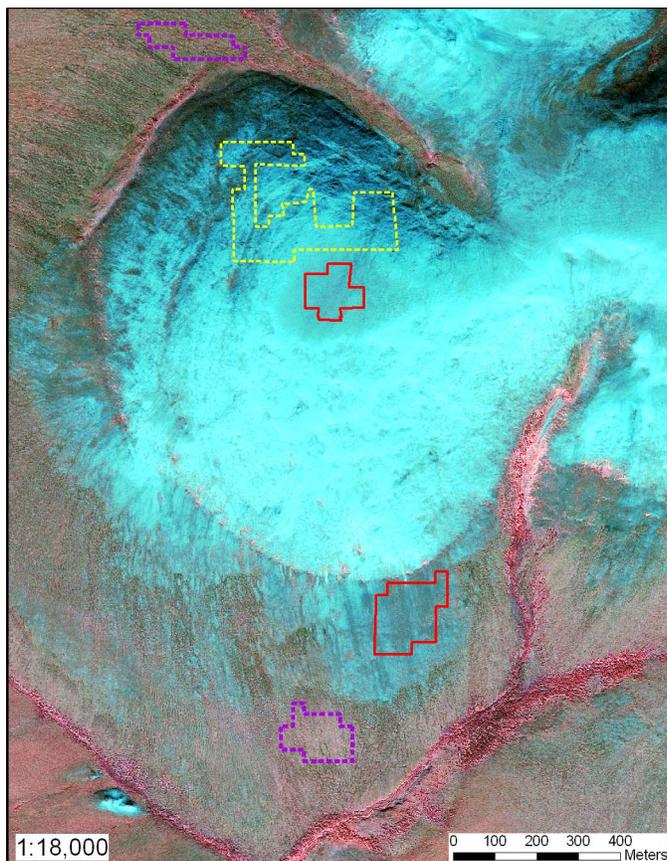


Figure 14. View showing training polygons Plot_GID 31904 (solid red, upper) and Plot_GID 31902 (solid red, lower) for Alpine Dryas Dwarf Shrub and adjacent Alpine Alkaline Barrens (dashed yellow) and Upland Sedge-Dryas Meadow (dashed purple), Cape Krusenstern National Monument, Alaska. (Image ID Add53)

Figure 15. View showing training polygons Plot_GID 31785 (solid red, upper) and Plot_GID 31787 (solid red, lower) for Alpine Dryas Dwarf Shrub showing adjacent vegetation signatures, including A) areas dominated by dwarf ericaceous shrubs, B) areas dominated by low willows, and C) shadow, Cape Krusenstern National Monument, Alaska. (Image ID Adds2)

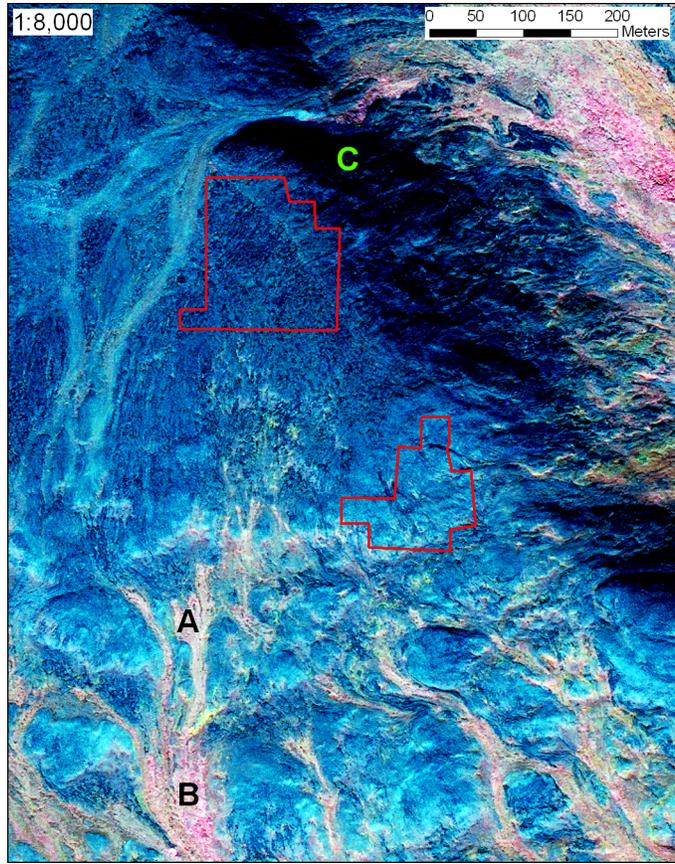
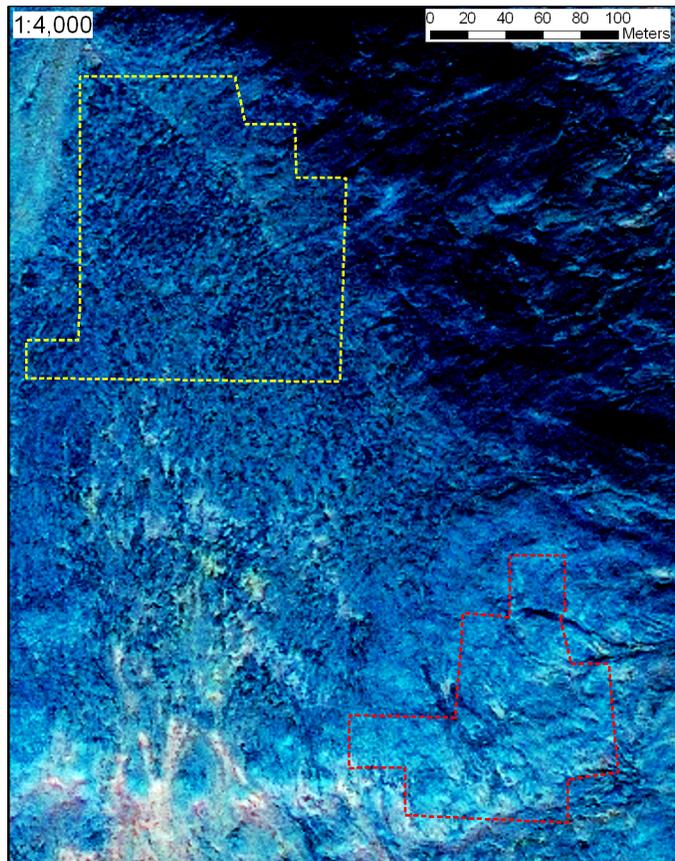


Figure 16. Close-up of training polygons Plot_GID 31785 (upper) and Plot_GID 31787 (lower) for Alpine Dryas Dwarf Shrub showing an example of this map ecotype with sorted stone stripes (dashed yellow) and without (dashed red), Cape Krusenstern National Monument, Alaska. (Image ID Adds1)



Alpine Ericaceous Dwarf Shrub

This map ecotype includes both Alpine Ericaceous-Dryas Dwarf Shrub and Alpine Cassiope Dwarf Shrub. In general, this map ecotype is common throughout ARCN above 450 meters. It occurs on hillside colluvium, older moraines, talus, weathered bedrock, and abandoned alluvial fan deposits. However, the specific ecotypes that were combined into this map ecotype for mapping purposes are distributed differently throughout the study area. Specifically, the ecotype Alpine Cassiope Dwarf Shrub is distributed in small patches located primarily on north aspects and in late-lying snow beds. Examples of both ecotypes are provided below. Periglacial micro-features are common in this type, including sorted stone circles and polygons, and stone stripes (Figures 17–19). Figure 19 provides an example of the Alpine Ericaceous-Dryas Dwarf Shrub component of this map ecotype on mafic bedrock in an area featuring sorted stone stripes (dark-colored stripes) in Noatak National Preserve. The narrow, dull pink stripes, alternating with the stone stripes, indicate areas of finer soils dominated by dwarf

ericaceous shrubs. The black-dark blue-cyan signature (A) represents adjacent Alpine Mafic Barrens, while the bright pink signature (B) represents adjacent upland areas dominated by low willows. Figure 20 provides an example of the Alpine Cassiope Dwarf Shrub component of this map ecotype in Gates of the Arctic National Park and Preserve on felsic granitic bedrock. The dull pink signature represents this map ecotype, while areas featuring a light to dark gray signature indicate areas with higher coverage of exposed bedrock and talus, including the adjacent map ecotype Alpine Acidic Barrens. Figure 21 depicts the contrast within this map ecotype between the ecotype components Alpine Ericaceous-Dryas Dwarf Shrub lacking microtopographic features (smooth, dull pink-brown signature) and Alpine Cassiope Dwarf Shrub in an area featuring frost boils and sorted stone stripes and polygons (grainy, alternating pink and light blue signatures). The stippled, reddish signature (A) in Figure 21 represents adjacent upland areas dominated by low willows.



Figure 17. Aerial photograph of the map ecotype Alpine Ericaceous Dwarf Shrub (see also Image ID Aeds3) in an area featuring frost boils and sorted stone stripes and polygons, taken on August 3, 2007, Noatak National Preserve, Alaska. (Image ID Aeds_air)

Figure 18. View for map ecotype Alpine Ericaceous Dwarf Shrub (solid red) showing the detailed signature in an area featuring frost boils and sorted stone stripes and polygons, Noatak National Preserve, Alaska. (Image ID Aeds3)

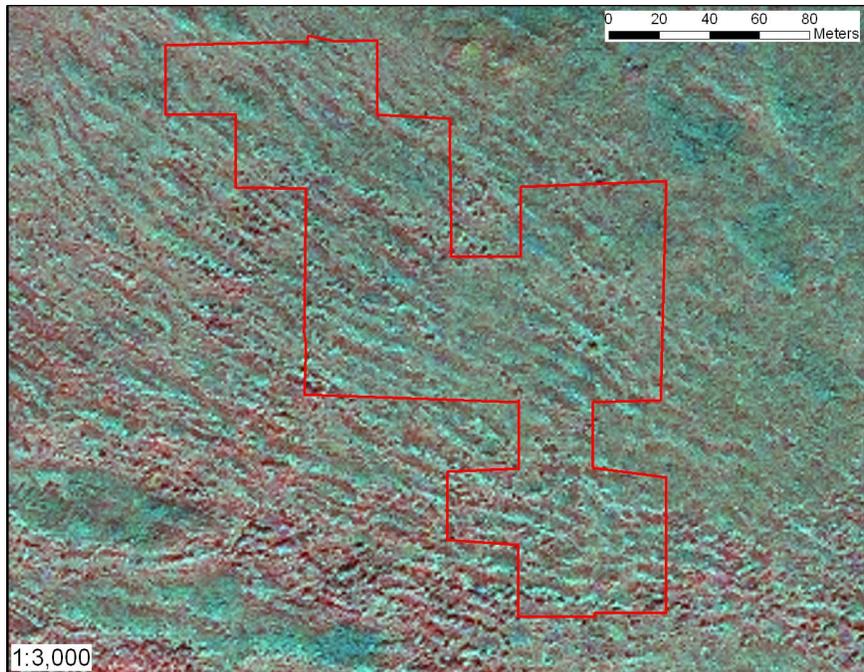
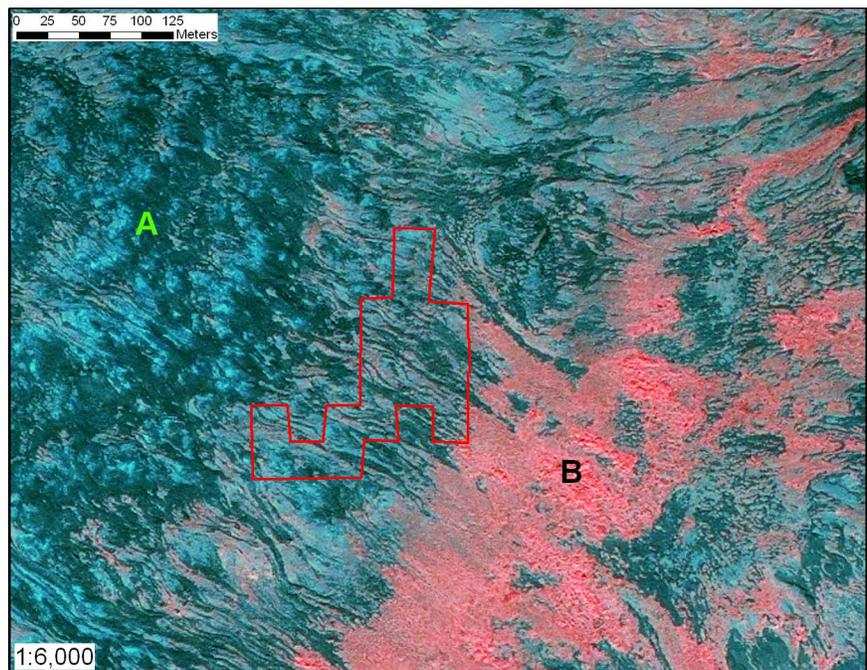


Figure 19. View showing Alpine Ericaceous Dwarf Shrub on mafic bedrock with sorted stone stripes. The black-dark blue-cyan signature (A) represents adjacent Alpine Mafic Barrens, while the bright pink signature (B) represents adjacent upland areas dominated by low willows, Noatak National Preserve, Alaska. (Image ID Aeds1)



Alpine Ericaceous Dwarf Shrub

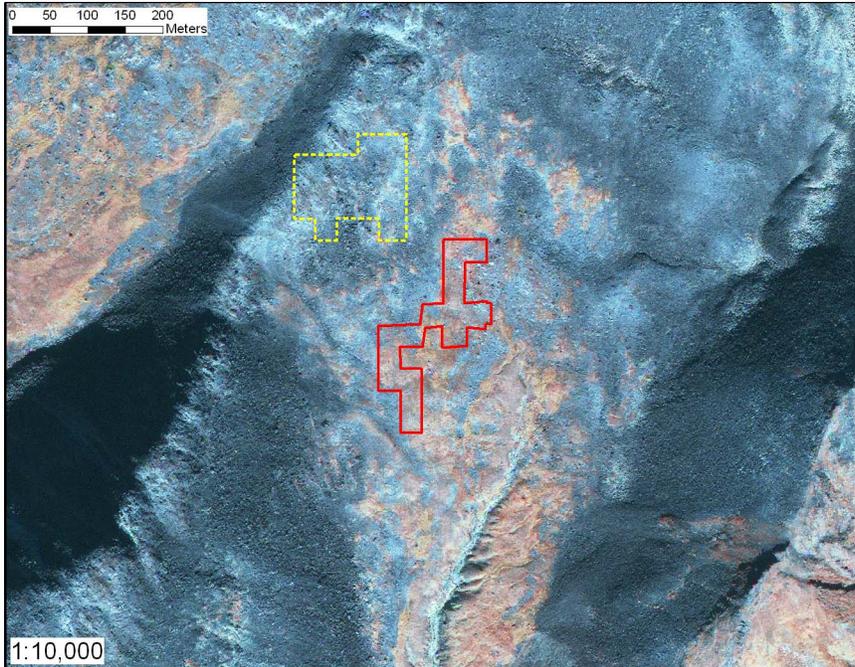


Figure 20. Image for Alpine Ericaceous Dwarf Shrub (solid red) and adjacent Alpine Acidic Barrens (dashed yellow), Gates of the Arctic National Park and Preserve, Alaska. (Image ID Aeds4)

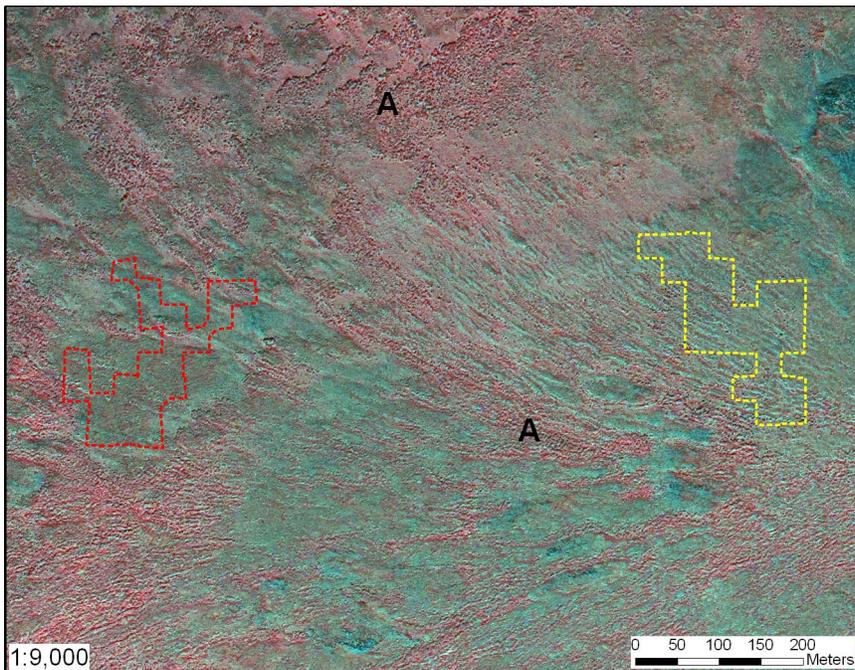


Figure 21. View showing training polygons Plot_GID 32514 (right) and Plot_GID 32517 (left) for the map ecotype Alpine Ericaceous Dwarf Shrub showing the difference between the ecotypes Alpine Ericaceous-Dryas Dwarf Shrub lacking micro-topographic features (dashed red) and Alpine Cassiope Dwarf Shrub in an area featuring frost boils and sorted stone stripes and polygons (dashed yellow). The stippled, reddish signature (A) represents adjacent upland areas dominated by low willows, Noatak National Preserve, Alaska. (Image ID Aeds2)

Alpine Mafic Barrens

This map ecotype occurs in alpine areas of ARCN with intermediate, mafic, and ultramafic plutonic rocks (Figure 22). An abundance of iron- and manganese-rich minerals lends a darker color to these rocks, which typically results in a black to dark blue signature in the IKONOS imagery (Figures 23 and 24). Figure 23 shows a large-scale view of the diagnostic signature of this map ecotype on mafic plutonic bedrock. The dull pink stripes interspersed with darker bands (A) are adjacent Alpine Ericaceous Dwarf Shrub in an area featuring sorted stone stripes. Figure 24 provides a smaller scale view with an example of the signature for Alpine Ericaceous Dwarf Shrub, a map ecotype that

commonly occurs adjacent to Alpine Mafic Barrens. When this map ecotype occurs on lighter colored intermediate plutonic rocks (Figure 25) the signature tends to be a brighter cyan blue color (Figures 26 and 27). Figure 27 provides a side-by-side comparison between black and dark blue signatures of areas where this map ecotype occurs on ultramafic plutonic rocks (solid red training polygon), and the bright cyan of areas where this map ecotype occurs on intermediate plutonic rocks (A, B). Another map ecotype that commonly occurs adjacent to this map ecotype is Alpine Wet Sedge Meadow, which tends to have a grainy, dull reddish signature (Figures 26 and 27).

Figure 22. Aerial photograph of the map ecotype Alpine Mafic Barrens (see also Image ID Amb1) on mafic plutonic bedrock taken July 25, 2005. Noatak National Preserve, Alaska. (Image ID Amb_air1)



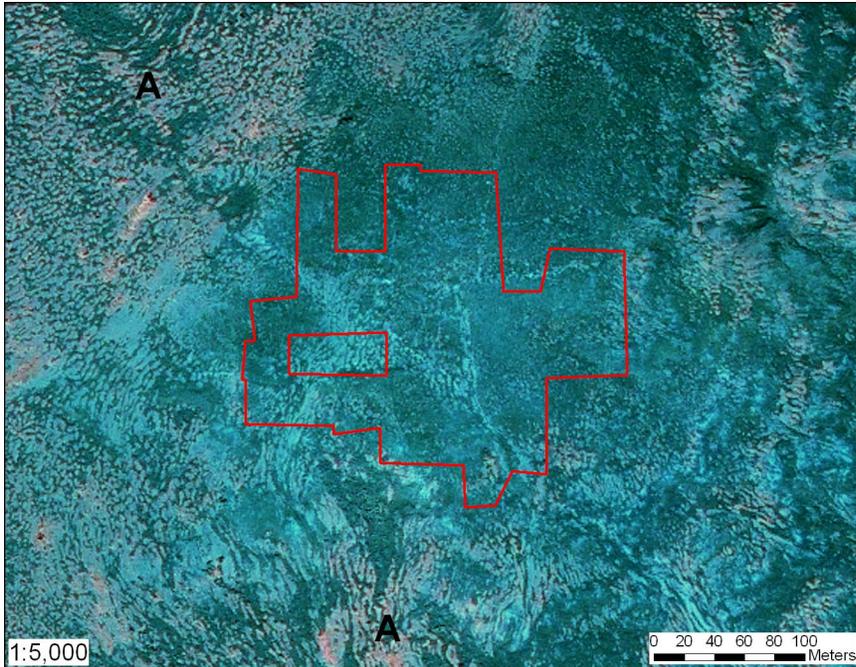


Figure 23. Close-up of Alpine Mafic Barrens (solid red) showing details of microtopography and vegetation. The dull pink stripes interspersed with darker banks (A) are adjacent Alpine Ericaceous Dwarf Shrub in an area featuring sorted stone stripes, Noatak National Preserve, Alaska. (Image ID Amb4)

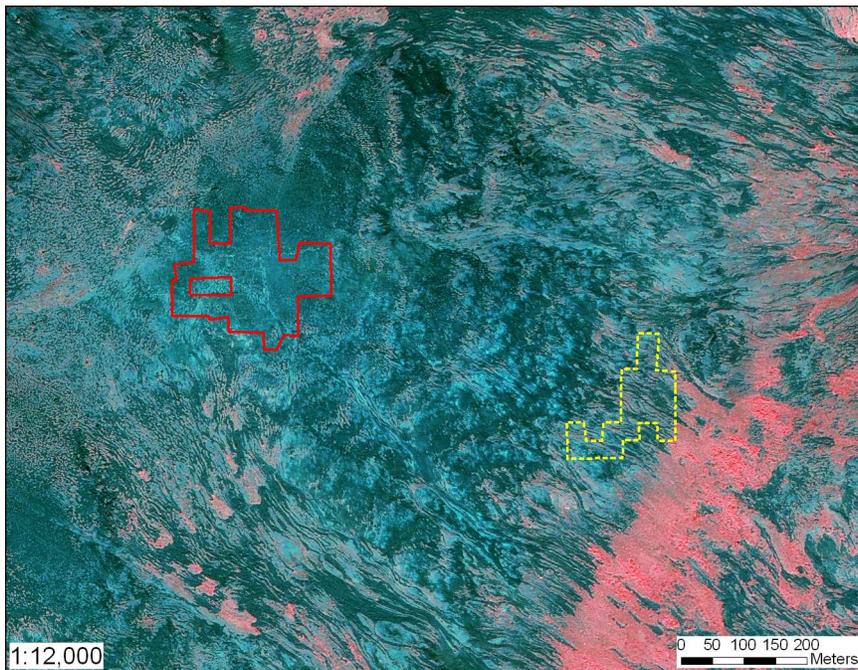


Figure 24. View showing Alpine Mafic Barrens (solid red) and adjacent Alpine Ericaceous Dwarf Shrub (dashed yellow), Noatak National Preserve, Alaska. (Image ID Amb1)

Figure 25. Aerial photograph of the map ecotype Alpine Mafic Barrens (see also Image ID Amb2) on intermediate plutonic rocks (brown rocks in foreground) and ultramafic plutonic rocks (dark rocks in background) taken July 22, 2006, Noatak National Preserve, Alaska. (Image ID Amb_air2)



Figure 26. View showing Alpine Mafic Barrens (solid red) on intermediate plutonic bedrock, and adjacent Alpine Wet Sedge Meadow (dashed purple), Noatak National Preserve, Alaska. (Image ID Amb2)



Alpine Mafic Barrens

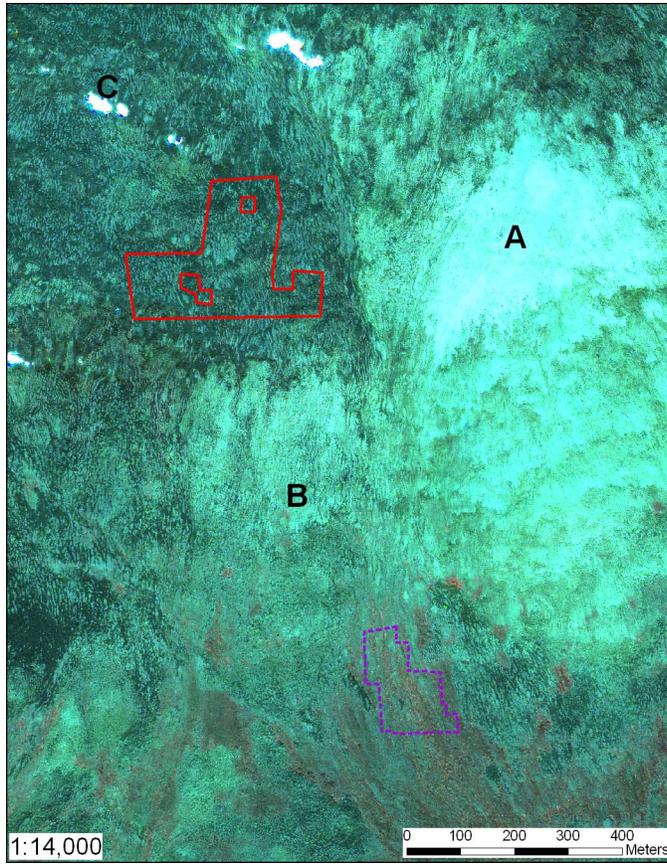


Figure 27. View showing Alpine Mafic Barrens (solid red) on ultramafic plutonic bedrock, and adjacent Alpine Wet Sedge Meadow (dashed purple). Image shows contrast between 1) the black signature of the ultramafic bedrock (solid red training polygon), 2) the bright cyan (A) of this map ecotype on intermediate plutonic bedrock, 3) the stippled black and cyan signature (B) of this map ecotype on mixed ultramafic and intermediate plutonic rocks, and 4) the bright white signature (C) of late lying snow banks, Noatak National Preserve, Alaska. (Image ID Amb3)

Alpine Wet Sedge Meadow

This map ecotype occurs in alpine areas of ARCN on gradual slopes on concave surfaces and toeslopes where water tends to collect, and is often associated with nonsorted stripes or seeps. Figure 28 provides an oblique aerial view of this map ecotype in a nonpatterned wetland directly adjacent to Alpine Dryas Dwarf Shrub. The diagnostic signature for this type in nonpatterned meadows is typically a smooth bright pink (Figure 29). Figure 30 displays a smaller scale perspective of this map ecotype with common adjacent map ecotypes, including Alpine Dryas Dwarf Shrub (pinkish- blue signature), and Alpine Acidic Barrens (cyan signature). When this map ecotype is associated

with nonsorted stripes, the signature is typically somewhat different (Figure 31). Nonsorted stripes lend a striated or grainy signature that is typically dark pink to red. Figure 32 is a large-scale depiction of this map ecotype with nonsorted stripes. The alternating bluish and red linear features running parallel to one another lend to the grainy signature when viewed at small spatial scales. Alpine Mafic Barrens is another map ecotype that commonly occurs adjacent to Alpine Wet Sedge Meadow (Figure 31). The blue-black-cyan signature of Alpine Mafic Barrens contrasts sharply with the pink-red signature of Alpine Wet Sedge Meadow.

Figure 28. Aerial photograph of the map ecotype Alpine Wet Sedge Meadow (see also Image ID Awsm1), July 23, 2006. Lobes of light gray-brown along upper boundary of photo are adjacent Alpine Dryas Dwarf Shrub, Noatak National Preserve, Alaska. (Image ID Awsm_air)



Alpine Wet Sedge Meadow

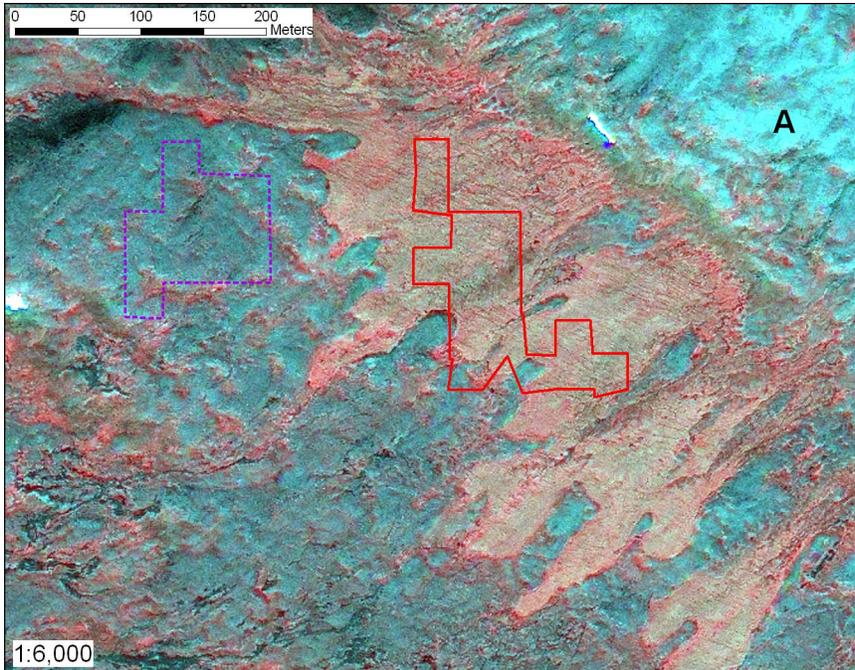


Figure 29. Close-up of Alpine Wet Sedge Meadow (solid red) and adjacent Alpine Dryas Dwarf Shrub (dashed purple). The bright cyan signature (A) represents adjacent Alpine Acidic Barrens. Noatak National Preserve, Alaska. (Image ID Awsm3)

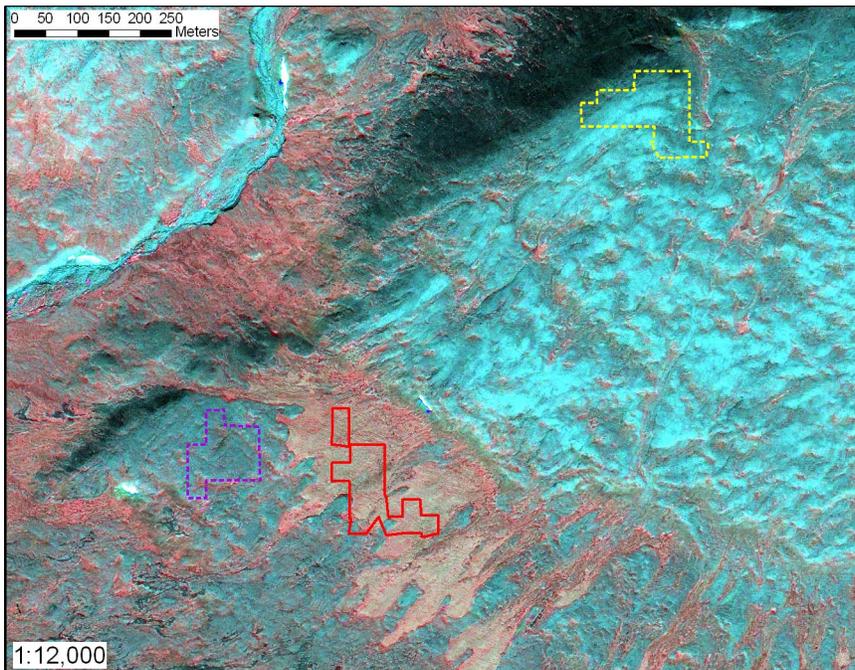


Figure 30. View showing Alpine Wet Sedge Meadow (solid red) and adjacent Alpine Dryas Dwarf Shrub (dashed purple) and Alpine Acidic Barrens (dashed yellow), Noatak National Preserve, Alaska. (Image ID Awsm1)

Figure 31. View showing Alpine Wet Sedge Meadow (solid red) and adjacent Alpine Mafic Barrens (dashed yellow), Noatak National Preserve, Alaska. (Image ID Awsm2)

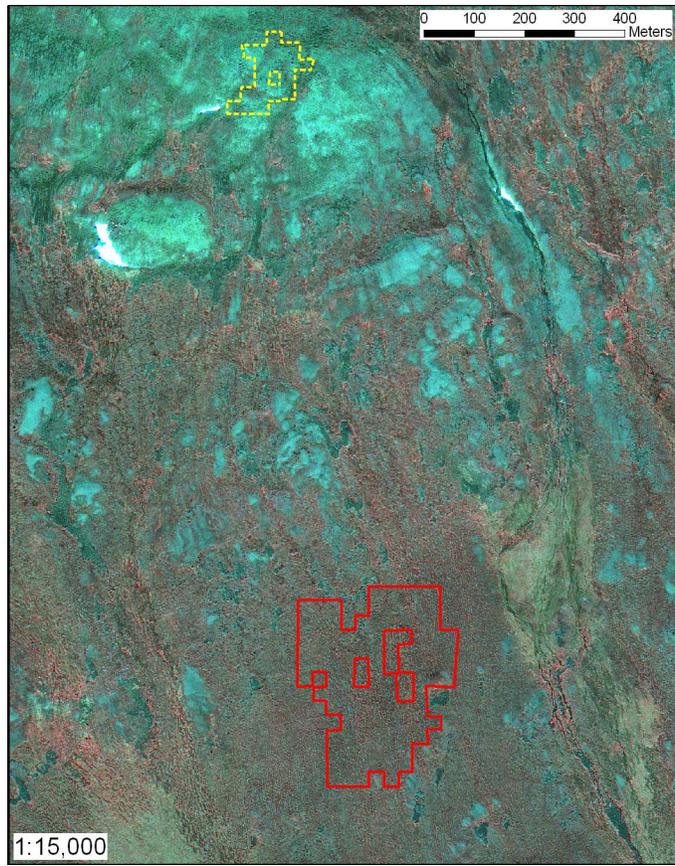


Figure 32. Close-up of Alpine Wet Sedge Meadow (solid red), showing the detailed signature of this map ecotype when it features nonsorted stripes as a microtopographic feature, Noatak National Preserve, Alaska. (Image ID Awsm4)



Lowland Birch-Ericaceous-Willow Low Shrub

This map ecotype includes both Lowland Birch-Willow Low Shrub and Lowland Birch-Ericaceous Low Shrub. This map ecotype occurs at lower elevations throughout ARCN on thaw basins, solifluction deposits, thick loess deposits, hillside colluvium, and in abandoned riverine environments and bogs. Figure 33 provides an oblique aerial view of this map ecotype (A) in a bog showing an example of the ecotype Lowland Birch-Ericaceous Low Shrub with sparse cover of black spruce (*Picea mariana*), and located directly adjacent to Lowland Ericaceous Shrub Bog (B). Figure 34 is the IKONOS satellite representation of the same site in early July. The dark pink to red color is representative of this type in early- to mid-summer when the graminoids and deciduous shrubs are fully green. In late summer and early fall the graminoids have begun to senesce,

and the leaves of deciduous shrubs have turned to fall colors, lending to a brownish signature (Figures 35 and 36). Figure 35 depicts this map ecotype when it occurs in a thaw basin dominated by *Sphagnum*, wet sedges, and ericaceous shrubs. When this map ecotype occurs in thaw basins it may be associated with frost polygons, creating the pattern observed in Figure 35. At a larger scale, as depicted in Figure 36, it can be seen that the pattern is composed of darker spots (polygon centers with surface water) and lighter colored linear features arranged in a checkerboard pattern (in this case disjunct polygon rims). Figure 37 depicts this map ecotype on an older moraine, showing an example of the ecotype Lowland Birch-Willow Low Shrub. The pinkish-orange to tan color is distinctive of this map ecotype when it features a low open willow and dwarf birch canopy.



Figure 33. Aerial photograph of the map ecotype Lowland Birch-Ericaceous-Willow Low Shrub (see also Image ID Lbewls2) taken July 30, 2007. The image depicts an example of the ecotype Lowland Birch-Ericaceous Low Shrub with sparse cover of *Picea mariana* (A), and adjacent Lowland Ericaceous Shrub Bog (B), Kobuk Valley National Park, Alaska. (Image ID Lbewls_air)

Figure 34. View showing Lowland Birch-Ericaceous-Willow Low Shrub (solid red) and adjacent Lowland Ericaceous Shrub Bog (dashed purple), Kobuk Valley National Park, Alaska. (Image ID Lbewls2)

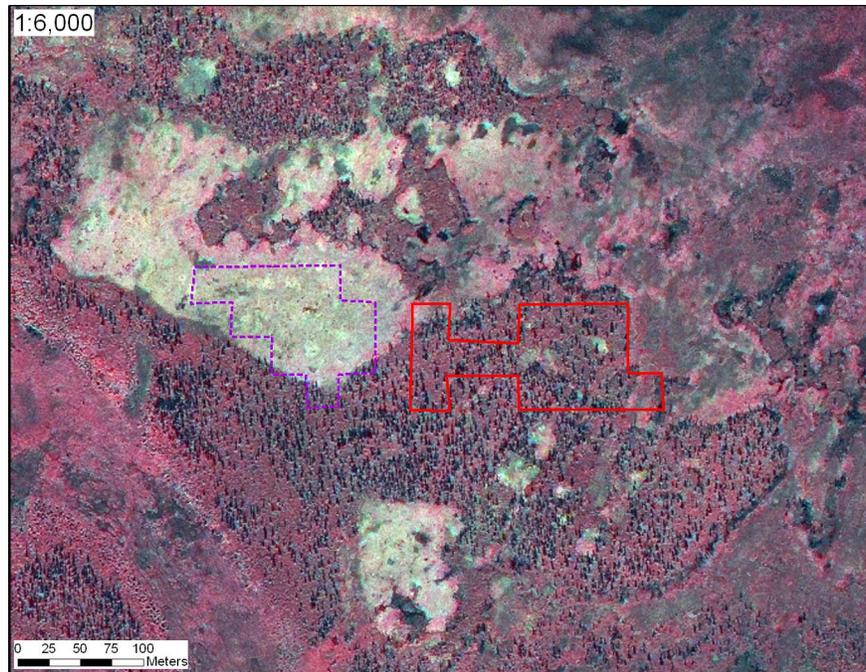
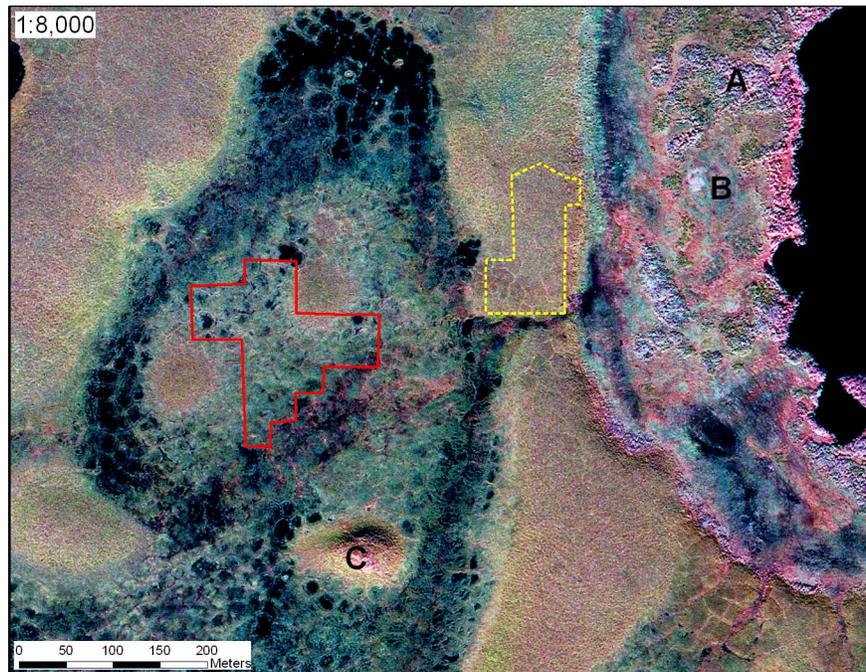


Figure 35. View showing Lowland Birch-Ericaceous-Willow Low Shrub (solid red) in a *Sphagnum*-dominated thaw basin and adjacent Upland Dwarf Birch-Tussock Shrub (dashed yellow). The grainy pink tone on the far right side of the image (A) represents adjacent lowland areas dominated by low willows, ericaceous shrubs, and moist sedges, while the brown to bluish tone (B) represents the map ecotype Lowland Sedge Fen. The bright pink signature on the small island near the center of the image (C) represents the map ecotype Upland Birch-Ericaceous-Willow Low Shrub on a pingo, Cape Krusenstern National Monument, Alaska. (Image ID Lbewls1)



Lowland Birch-Ericaceous-Willow Low Shrub

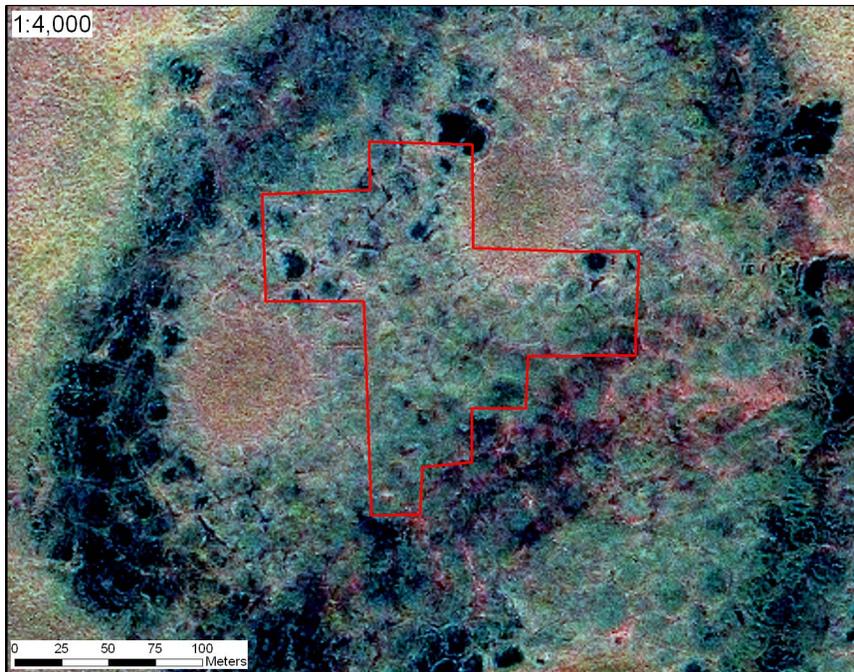


Figure 36. Close-up of Lowland Birch-Ericaceous-Willow Low Shrub (solid red) showing the details of the microfeature disjunct frost polygon rims, Cape Krusenstern National Monument, Alaska. (Image ID Lbewls4)

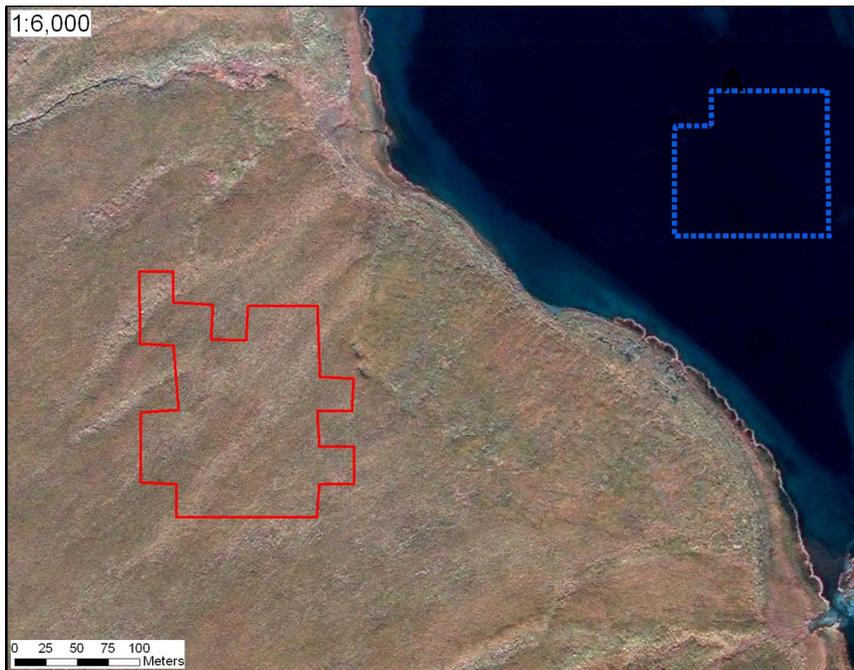


Figure 37. View for the map ecotype Lowland Birch-Ericaceous-Willow Low Shrub (solid red) showing an example of the ecotype Lowland Birch-Willow Low Shrub. The dashed blue polygon represents an example of adjacent Lowland Lake, Gates of the Arctic National Park, Alaska. (Image ID Lbewls3)

Lowland Black Spruce Forest

This map ecotype is common at lower elevations in GAAR and KOVA, but does not occur in NOAT, CAKR, or BELA. Typical geomorphic features on which this map ecotype occurs include hillside colluvium, thick loess deposits, moraines, and abandoned riverine environments. Figure 38 shows an oblique aerial view of this map ecotype in Kobuk Valley National Park. The IKONOS representation of this same site is provided in Figure 39. The typical signature for this map

ecotype is a grainy black color with flecks of white and pink (Figures 39 and 40). At sites with a more open black spruce overstory, the signature is dominated by red to pink tones, with black spruce showing up as flecks of black (Figure 41). Common adjacent ecotypes include Upland Alder-Willow Tall Shrub, Upland Birch-Ericaceous- Willow Low Shrub, and Riverine Alder or Willow Tall Shrub (Figures 39 and 40).

Figure 38. Aerial photograph of the map ecotype Lowland Black Spruce Forest (see also Image ID Lbsf3) taken July 27, 2007, Kobuk Valley National Park, Alaska. (Image ID Lbsf_air)



Lowland Black Spruce Forest

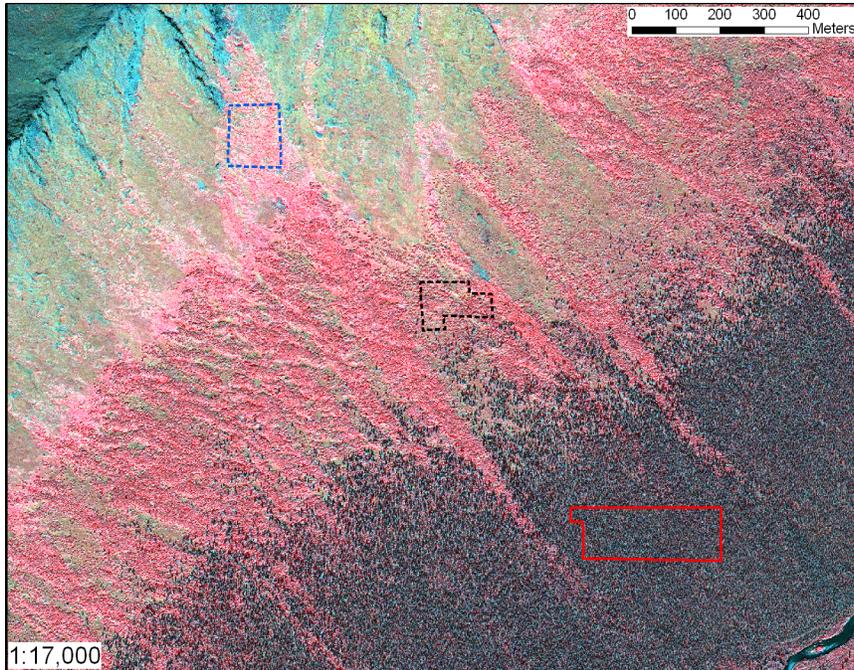


Figure 39. View showing Lowland Black Spruce Forest (solid red) and adjacent Upland Alder-Willow Tall Shrub (dashed black) and Upland Birch-Ericaceous-Willow Low Shrub (dashed blue), Kobuk Valley National Park, Alaska. (Image ID Lbsf3)

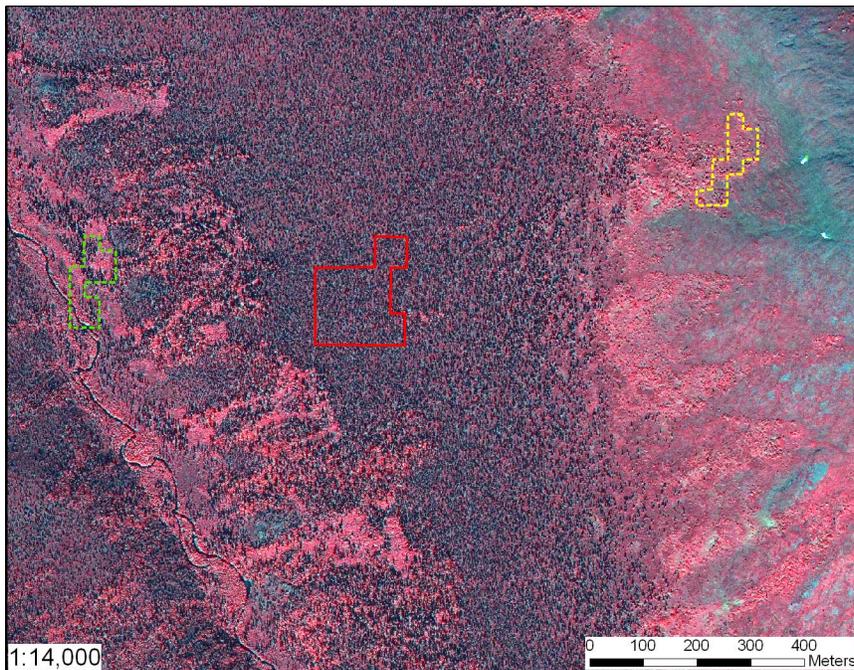
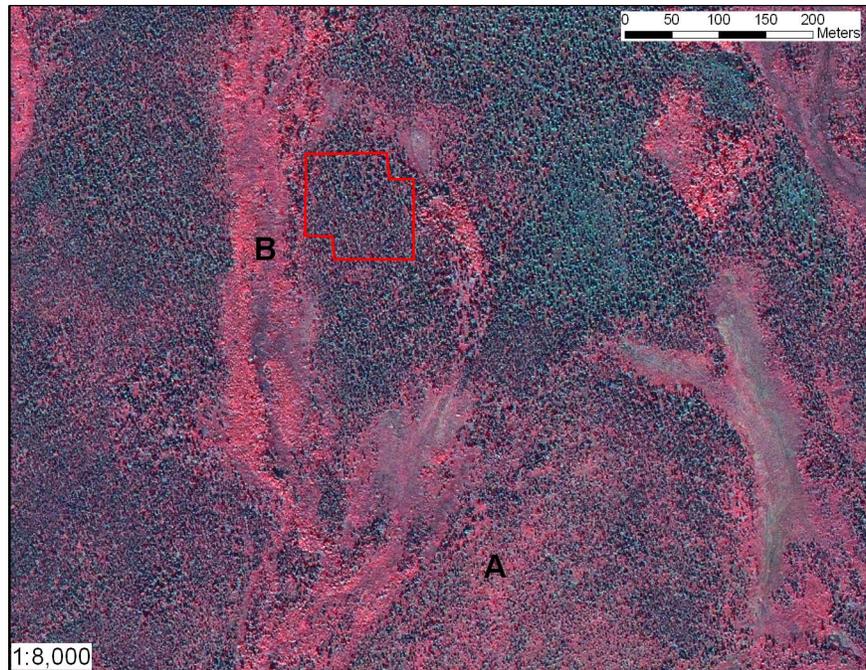


Figure 40. View showing Lowland Black Spruce Forest (solid red) and adjacent Upland Birch-Ericaceous-Willow Low Shrub (dashed yellow) and Riverine Alder or Willow Tall Shrub (dashed green), Kobuk Valley National Park, Alaska. (Image ID Lbsf2)

Figure 41. View showing Lowland Black Spruce Forest (solid red). The red to dark pink signature with flecks of black (A) represents areas of black spruce woodland (<25% black spruce cover), while the bright pink signature (B) represents adjacent Lowland Willow Low Shrub. Kobuk Valley National Park, Alaska. (Image ID Lbsf1)



Lowland Ericaceous Shrub Bog

This map ecotype occurs in bogs, drained lake basins, thaw basins, and abandoned riverine environments. Figure 42 shows an oblique aerial photograph of this map ecotype in a bog located in a thermokarst basin. The IKONOS representation of this same site is provided in Figure 43. Note the sharp contrast between the characteristic yellowish signature of Lowland Ericaceous Shrub Bog, dominated by *Sphagnum* sp., *Eriophorum russeolum*, and *Carex limosa*, and the dark pink to red of the adjacent map ecotype Lowland Birch-Ericaceous-Willow Low Shrub, dominated by *Vaccinium uliginosum*, *Betula nana*, and *Ledum decumbens*. Figure 44 provides an example of this map ecotype in a bog located in a drained lake basin and surrounded by Upland Birch-Ericaceous-Willow Low Shrub. The highly variable signature of

this map ecotype in Figure 44 is related to microfeatures, namely low-centered, low relief, high-density ice wedge polygons. In Figure 45, the training polygon symbolized with a dashed red outline provides an example of the signature of this map ecotype when associated with ice wedge polygons. The dark to bright green signatures are the polygon centers dominated by *Sphagnum* sp. and having variable amounts of surface water. The light pink polygon rims surround the centers and are dominated by *Eriophorum vaginatum* and ericaceous shrubs. The training polygon symbolized with a dashed yellow outline provides an example of the signature of this map ecotype where microfeatures are lacking. The darker green signature of this training polygon is indicative of the higher proportion of surface water present at this site.

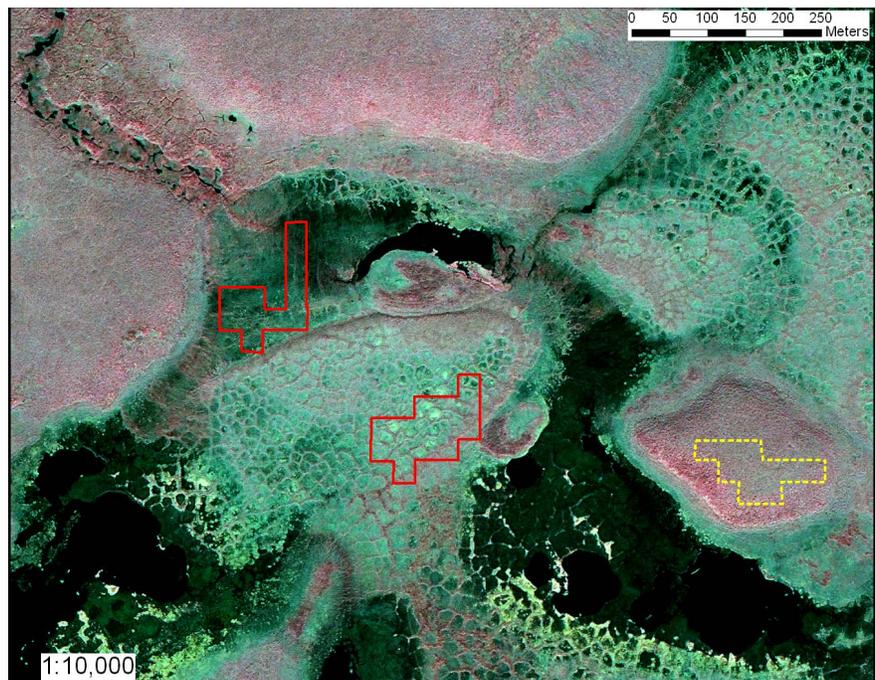


Figure 42. Aerial photograph of the map ecotype Lowland Ericaceous Shrub Bog (see also Image ID Lesb3) taken July 30, 2007, Kobuk Valley National Park, Alaska. (Image ID Lesb_air)

Figure 43. View showing Lowland Ericaceous Shrub Bog (solid red) and adjacent Lowland Birch-Ericaceous-Willow Low Shrub (dashed green), Kobuk Valley National Park, Alaska. (Image ID Lesb3)



Figure 44. View showing training polygons Plot_GID 30055 (solid red, lower right) and Plot_GID 30058 (solid red, upper left) for Lowland Ericaceous Shrub Bog and adjacent Upland Birch-Ericaceous-Willow Low Shrub (dashed yellow), Noatak National Preserve, Alaska. (Image ID Lesb2)



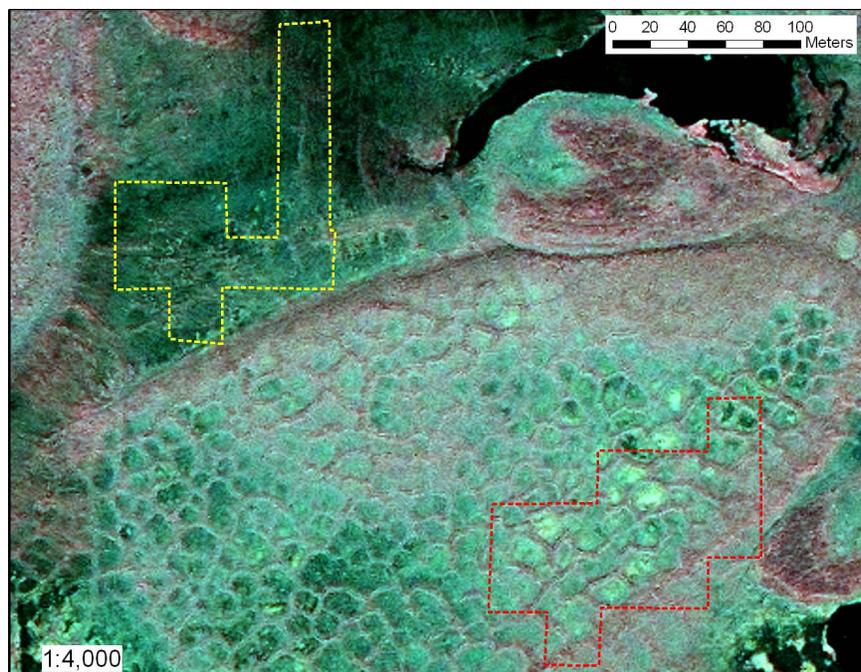


Figure 45. View showing training polygons Plot_GID 30055 (lower right) and Plot_GID 30058 (upper left) for Lowland Ericaceous Shrub Bog. This image shows the microtopography variations within this ecotype: the dashed red polygon includes low-centered, low relief, high-density polygons, while the dashed yellow polygon lacks these features, Noatak National Preserve, Alaska. (Image ID Lesb1)

Lowland Sedge Fen

This map ecotype includes both the ecotypes Lowland Sedge Fen and Lowland Sedge-Willow Fen, the two ecotypes differing primarily in the abundance of willows. This map ecotype is located throughout ARCN on flat terrain. This map ecotype commonly occurs in thaw basins and drained lake basins, abandoned riverine environments, and fens. Figure 46 provides an oblique aerial view of this map ecotype in a string bog located in Cape Krusenstern National Monument. Figure 47 depicts the IKONOS view of this same site with two directly adjacent training polygons of this map ecotype and shows the characteristic dark green to brown signature. Pinkish tones are indicative of higher low willow cover, and represent the primary difference in signature between Lowland Sedge Fen and Lowland Sedge-Willow Fen ecotypes (Figure 48). In Figure 48, the bright pink, wavy, linear features running horizontally across the image

are the microfeature strang. This map ecotype is often associated with ice wedge polygons as in Figure 49, which provides an example of this map ecotype featuring high-centered, low-relief polygons. In Figure 49, the bluish-green polygonal features are the polygon centers, while the dark linear features are the troughs, filled with water, that surround each polygon. Pinkish tones indicate slightly drier areas with higher low shrub cover such as the directly adjacent Upland Dwarf Birch-Tussock Shrub. Figure 50 depicts this map ecotype in Gates of the Arctic National Park and Preserve in mid-September. The tan to gray signature is characteristic of this map ecotype later in the season when the sedges have senesced and the willow leaves have turned to fall colors. Pink tones indicate high cover of ericaceous shrubs and dwarf birch, such as in the adjacent Upland Birch-Ericaceous-Willow Low Shrub.

Figure 46. Aerial photograph looking north of the map ecotype Lowland Sedge Fen (foreground) taken July 14, 2003 (see also Image ID Lfs1 and Lfs2), Cape Krusenstern National Monument, Alaska. (Image ID Lsf_air)



Lowland Sedge Fen

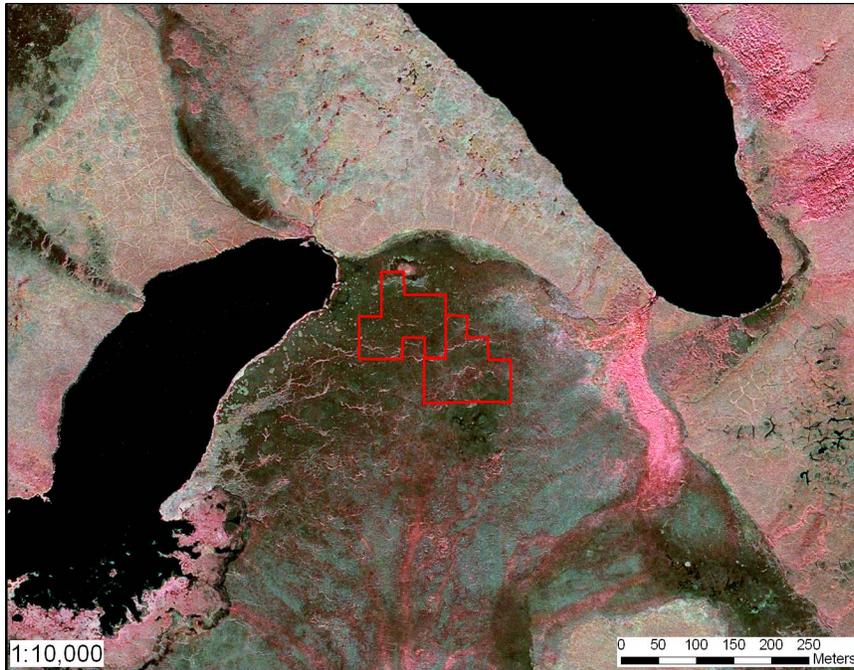


Figure 47. View showing training polygons Plot_GID 31836 (solid red, upper left) and Plot_GID 31838 (solid red, lower right) for Lowland Sedge Fen, Cape Krusenstern National Monument, Alaska. (Image ID Lsf1)

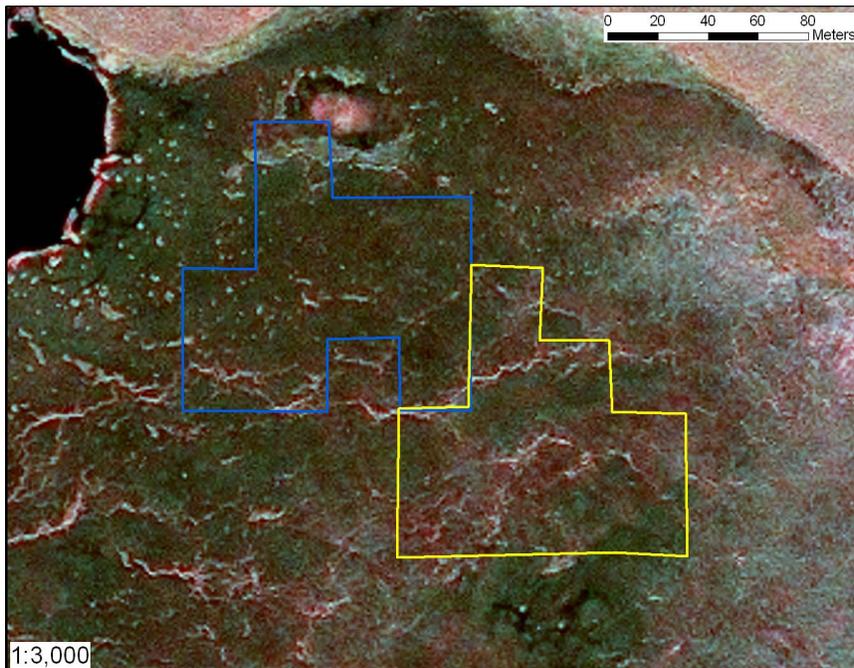
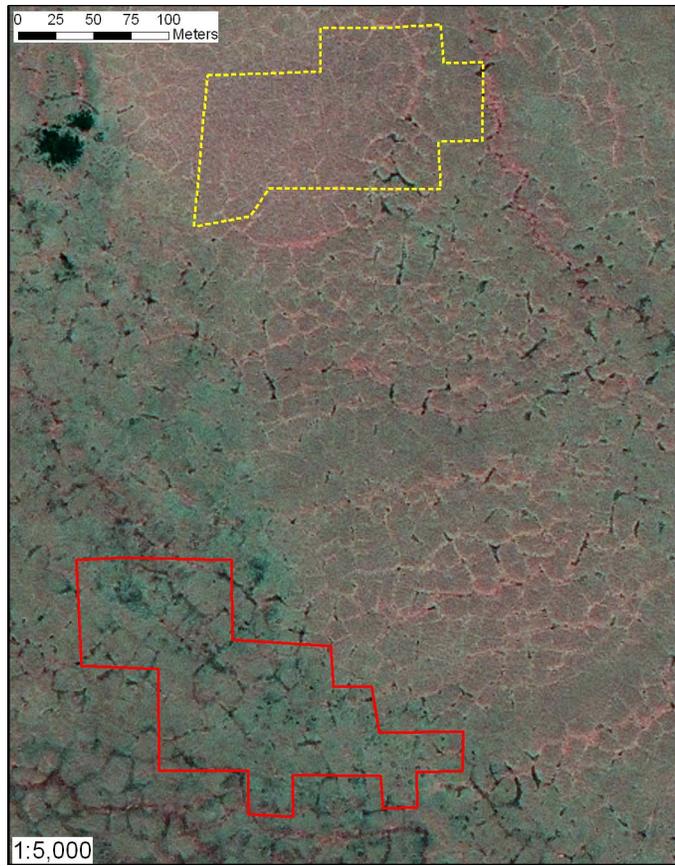


Figure 48. Close-up of training polygons Plot_GID 31836 (upper left) and Plot_GID 31838 (lower right) for Lowland Sedge Fen showing examples of this map ecotype with willows as co-dominant with sedges (solid yellow) and without (solid blue), Cape Krusenstern National Monument, Alaska. (Image ID Lsf2)

Figure 49. View showing an example of Lowland Sedge Fen (solid red) with the microfeature high-centered, low-relief polygons. Adjacent Upland Dwarf Birch-Tussock Shrub is symbolized with a dashed yellow outline, Cape Krusenstern National Monument, Alaska. (Image ID Lsf3)



Lowland Sedge Fen

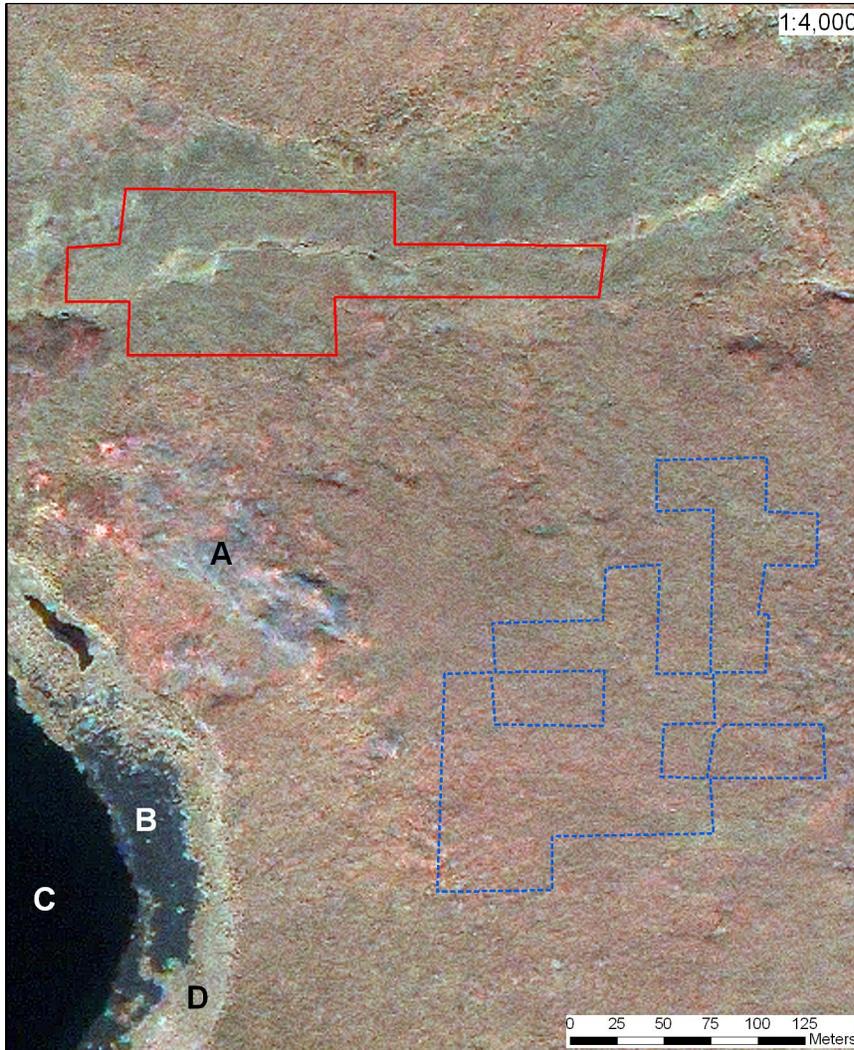


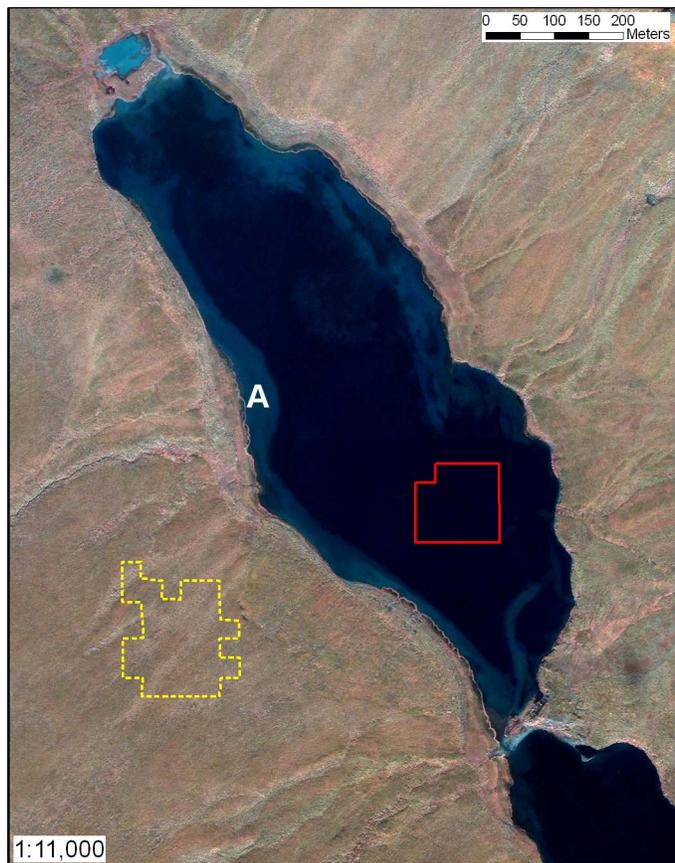
Figure 50. View showing Lowland Sedge Fen (solid red) and adjacent Upland Birch-Ericaceous-Willow Low Shrub (dashed blue). The gray-pink signature (A) represents adjacent alpine dwarf ericaceous shrub with high cover of bare ground and rock fragments, the stippled dark signature (B) represents Lacustrine Barrens, the solid black (C) is Lowland Lake, and the tan signature (D) is another example of the map ecotype Lowland Sedge Fen, Gates of the Arctic National Park, Alaska. (Image ID Lsf4)

Lowland Lake

This map ecotype comprises the majority of the lakes in ARCN. The characteristic signature of Lowland Lake is dark blue to black for deep sections of lakes such as training polygon 32560 in Figure 51. Shallow lakes and those portions of deep lakes with shallower waters are characterized by a light blue tone (A, Figure 51). The

signature of this map ecotype is very similar to that for Alpine Lake. Consistent spectral diagnostic characteristics separating these two lake types are lacking. The best strategy for distinguishing between these types may be to use a digital elevation model in conjunction with satellite imagery.

Figure 51. View showing Lowland Lake (solid red) and adjacent Lowland Birch-Ericaceous-Willow Low Shrub (dashed yellow). Lighter tones of blue (A) represent areas of shallower water along the shoreline, Gates of the Arctic National Park, Alaska. (Image ID LI1)



Riverine Alder or Willow Tall Shrub

This map ecotype includes both the ecotypes Riverine Moist Willow Tall Shrub and Riverine Alder Tall Shrub. This map ecotype is common in active and inactive riverine environments along braided and meandering rivers. Figure 52 provides an example of a closed stand of this map ecotype in Kobuk Valley National Park displaying a typical bright pink signature for this type. Areas within the training polygon with a finer texture (A) are those areas dominated by alder, while those areas with a coarser texture (B) are co-dominated by alder and willow. When the canopy is more open (C), riverine silts and sands show through the

canopy, creating a mottled signature of bright pink shrub canopies and bluish silts and sands. Another common variation on the signature of this map ecotype is associated with white spruce (D). Typical adjacent map ecotypes include Riverine Barrens (E) and Riverine Water (F). Figure 53 depicts this map ecotype featuring an open canopy of willows. A dense understory of *Equisetum arvense* leads to the dark green tones that underlie the typical pink signature of this map ecotype. Other common adjacent types include Riverine White Spruce-Willow Forest (A), Riverine Poplar Forest (B), and Riverine Barrens (C).

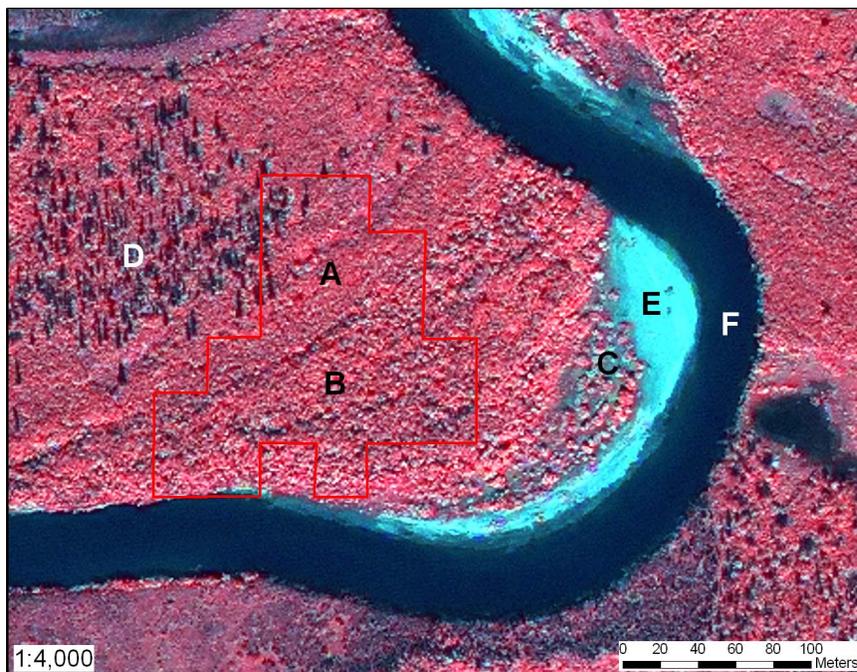
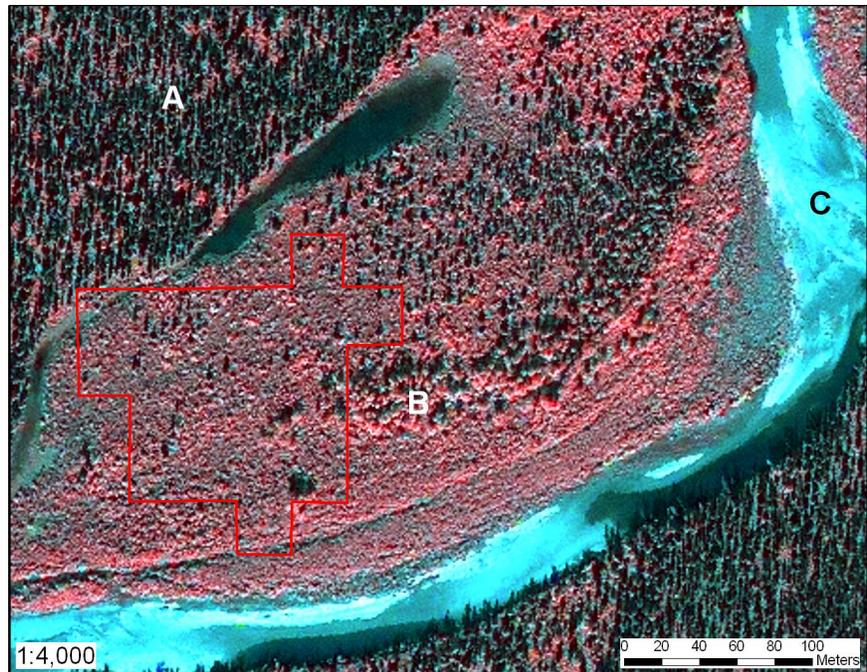


Figure 52. View for Riverine Alder or Willow Tall Shrub (solid red), showing examples within the same training polygon of the signature for areas dominated by tall alder only (A), and areas where alder and willow are codominant (B). The training polygon is representative of this map ecotype with a closed tall shrub canopy, while the area directly adjacent (C) is representative of this map ecotype with an open tall shrub canopy (pink signature) with high cover of riverine sands and silts (intermingled bluish signature). The bright pink signature with flecks of dark green (D) represents areas of white spruce with a tall alder or willow understory. Riverine barrens is indicated by the bright cyan signature (E), and Riverine Water by the dark blue signature (F). Kobuk Valley National Park, Alaska. (Image ID Rawts2)

Figure 53. View for Riverine Alder or Willow Tall Shrub (solid red) with a dense understory of *Equisetum arvense*. The dark green signature with spots of pink (A) represents adjacent Riverine White Spruce-Willow Forest, the bright pink with flecks of dark green (B) adjacent Riverine Poplar Forest with white spruce regeneration, and the bright blue (C) Riverine Barrens, Noatak National Preserve, Alaska. (Image ID Rawts1)



Riverine Barrens

This map ecotype occurs on braided and meandering river bars that are frequently flooded and scoured. The high cover of coarse fragments and riverine silts and sands lend to the bright cyan signature that is distinctive of this map ecotype even at smaller spatial scales (Figure 54). Alpine barren areas often feature a similar signature (A). However, Riverine Barrens occur in a narrow, meandering pattern that is more or less continuous across the

landscape, while alpine barren areas occur as discrete masses or dissected ridges. At a larger spatial scale, individual seasonally flooded river channels are discernable (Figure 55). The darker blue signature running through the center of the training polygon represents Riverine Water (A). Common adjacent map ecotypes include Riverine Dryas Dwarf Shrub (B), and Riverine White Spruce-Willow Forest (C).

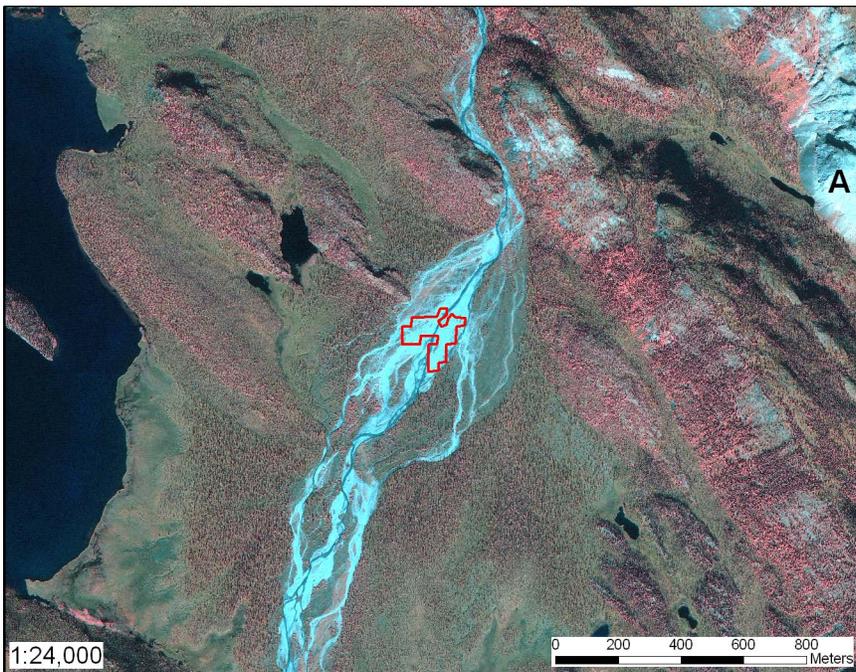
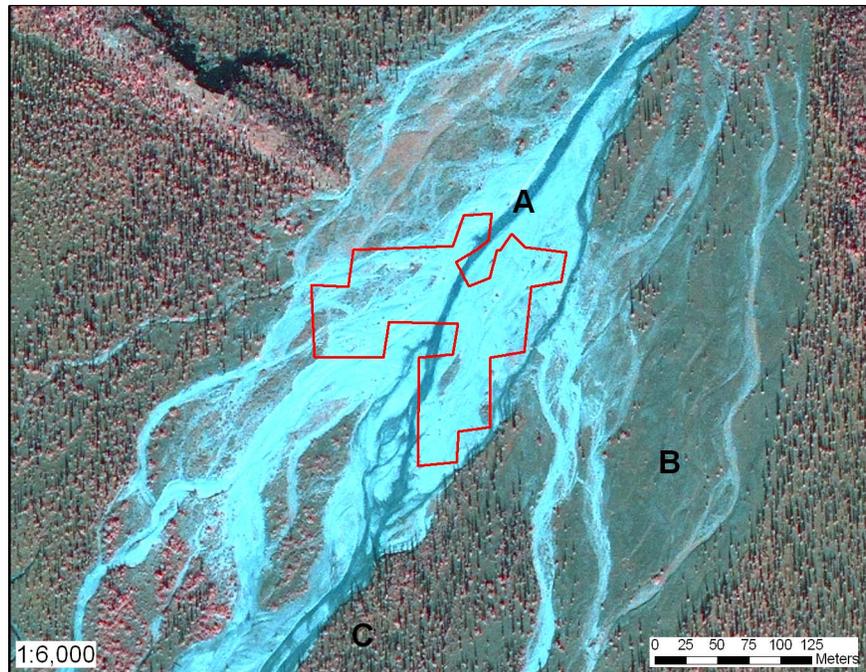


Figure 54. Overview of Riverine Barrens (solid red) contrasting this map ecotype with a nearby alpine barren area (A), Gates of the Arctic National Park, Alaska. (Image ID Rb2)

Figure 55. View for Riverine Barrens (solid red), showing adjacent map ecotypes types Riverine Water (A), Riverine Dryas Dwarf Shrub (B), and Riverine White Spruce-Willow Forest (C), Gates of the Arctic National Park, Alaska. (Image ID Rb1)



Riverine Birch-Willow Low Shrub

This map ecotype occurs along meandering rivers throughout the boreal zone of ARCN. It typically occurs adjacent to Riverine Alder or Willow Tall Shrub (A), Riverine Water (B), and Riverine Barrens (C) (Figure 56). When willows are more

prominent in the canopy than birch the signature is a brighter tone of pink (Figure 57, green polygon). When the reverse is true, and birch is more prominent, the signature features more green to brown tones (Figure 57, yellow polygon).

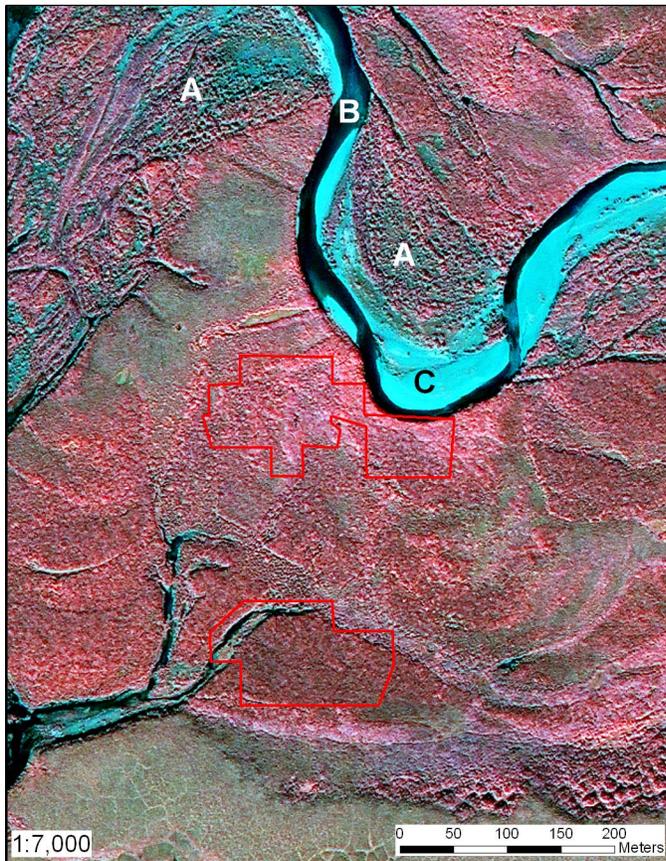
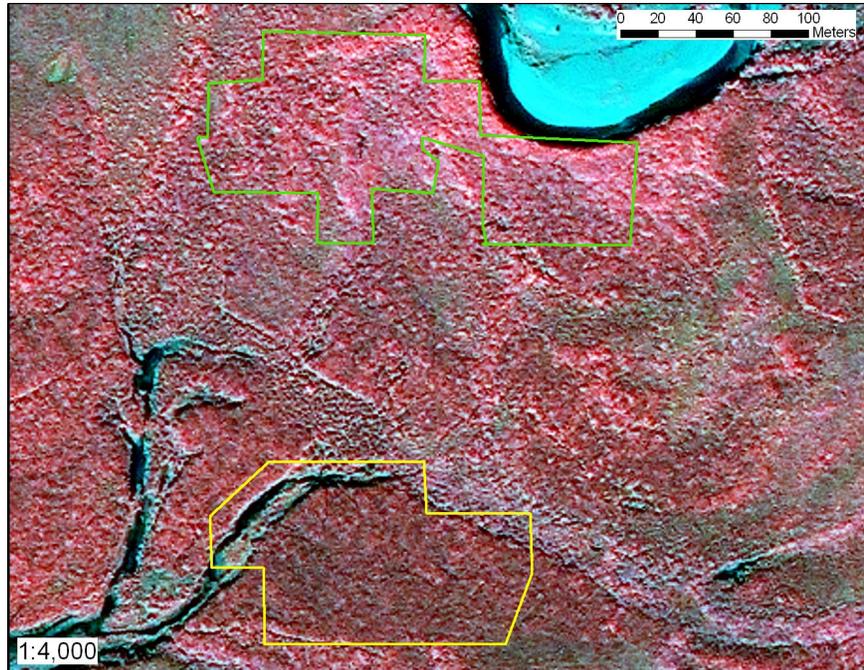


Figure 56. View showing training polygons Plot_GID 31783 (solid red, upper) and Plot_GID 31784 (solid red, lower) for Riverine Birch-Willow Low Shrub. Common adjacent types include Riverine Alder or Willow Tall Shrub (A), Riverine Water (B), and Riverine Barrens (C), Cape Krusenstern National Monument, Alaska. (Image ID Rbwls2)

Figure 57. Close-up of training polygons Plot_GID 31783 (upper) and Plot_GID 31784 (lower) for Riverine Birch-Willow Low Shrub. This image shows examples of this map ecotype with willows as dominant (solid green) and with dwarf birch as dominant (solid yellow), Cape Krusenstern National Monument, Alaska. (Image ID Rbwls1)



Riverine Dryas Dwarf Shrub

This map ecotype occurs along braided and meandering rivers primarily on inactive fluvial surfaces, including river terraces, interfluves, or flat banks. Figure 58 depicts this map ecotype located in an inactive channel on a stream terrace. Common adjacent map ecotypes include Riverine Willow Low Shrub (dashed

black) located on more recently active fluvial surfaces, and Upland Dwarf Birch-Tussock Shrub (dashed yellow), located on abandoned riverine environments. The typical signature of this map ecotype is a slate blue color (Figure 59). Pink tones may indicate a higher percentage of ericaceous shrubs.

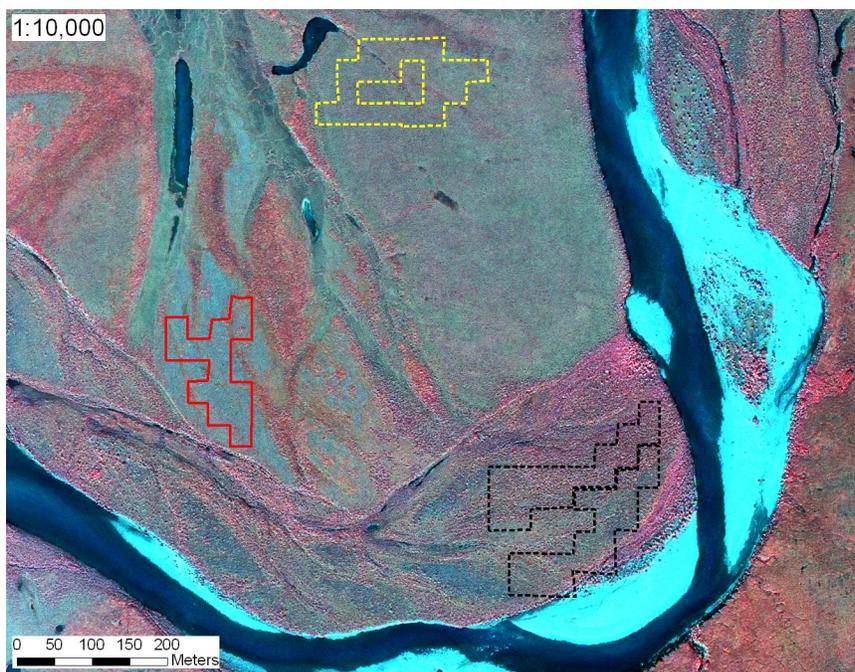


Figure 58. View showing Riverine Dryas Dwarf Shrub (solid red) and adjacent Riverine Willow Low Shrub (dashed black) and Upland Dwarf Birch-Tussock Shrub (dashed yellow), Noatak National Preserve, Alaska. (Image ID Rdds1)

Figure 59. Close-up of Riverine Dryas Dwarf Shrub (solid red), Noatak National Preserve, Alaska. (Image ID Rdds2)



Riverine Poplar Forest

This map ecotype occurs along braided rivers on active and inactive fluvial surfaces, including levees, interfluves, flat banks, and point bars. Figure 60 provides an aerial view of this map ecotype (A) and adjacent sites dominated by tall willow (B), and white spruce (C). The IKONOS image of the same site is provided in Figure 61. The signature for this map ecotype is typically bright pink with a coarse-grained texture. The signature of this map ecotype at early seral stages, when

the trees are more like tall shrubs, is bright pink, with a fine-grained texture, similar to sites dominated by tall willows and alder (no image available). At this stage the signature of Riverine Poplar Forest is easily confused with the signature of Riverine Alder or Willow Tall Shrub. The texture of the signature becomes coarser with the age as the canopies of individual *Populus* grow to a larger size (Figure 62). See also Figure 53 in the Riverine Alder or Willow Tall Shrub description.



Figure 60. Aerial photograph looking north of the map ecotype Riverine Poplar Forest (A) taken July 26, 2007 (see also Image ID Rpf1 and Rpf2). The signature of this map ecotype may be confused with that of riverine tall alder or willow. The site labeled "B" represents an adjacent site dominated by tall willows and corresponds roughly to the labeling on Figure 62, below. Adjacent Riverine White Spruce-Willow Forest is indicated by "C", Kobuk Valley National Park, Alaska. (Image ID Rpf_air)

Figure 61. View showing Riverine Poplar Forest (solid red) and adjacent Riverine White Spruce-Willow Forest (dashed yellow), Kobuk Valley National Park, Alaska. (Image ID Rpf1)

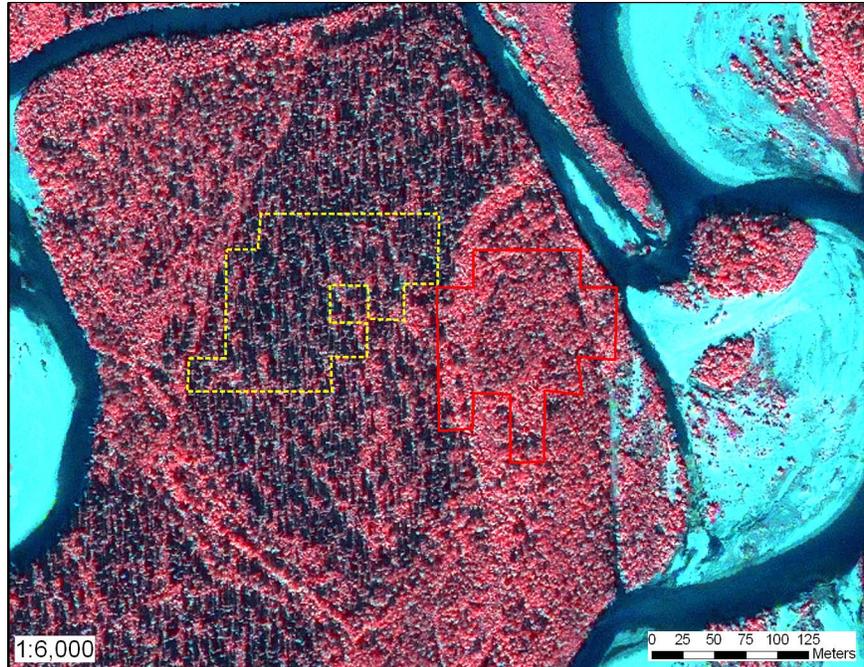
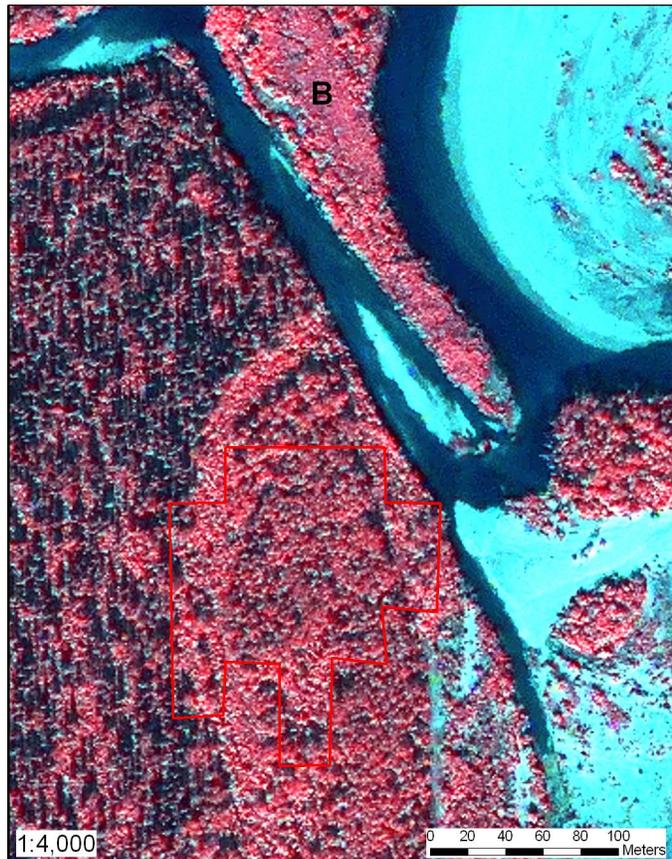


Figure 62. Close-up of Riverine Poplar Forest showing details of the texture of the spectral signature of this map ecotype (solid red training polygon), and a nearby site dominated by tall willows (B, corresponds roughly to labeling on aerial photo above), Kobuk Valley National Park, Alaska. (Image ID Rpf2)



Riverine Water

This map ecotype includes the ecotypes River and Riverine Lake. Rivers occur throughout ARCN and include both upper and lower perennial nonglacial rivers, mountain headwater streams, and lowland headwater streams. Riverine Lakes consist of shallow oxbow lakes that have been cutoff from the actively flowing river through natural depositional processes, but that are occasionally flooded during high water events. The signature of the ecotype river is typically a light to sky blue color (Figure 63). Suspended sediments tend to give the signature a chalky coloration. The sediment load can

vary substantially between rivers and river reaches, and within river reaches variations in water level and season will also affect the sediment load. Suspended sediments are often lacking in Riverine Lakes, lending to the dark blue to black signatures typical of this ecotype (Figure 64). The signature of this map ecotype, particularly Riverine Lake, is very similar to that for Lowland Lake. Consistent spectral diagnostic characteristics separating these two water types are lacking. The best strategy for distinguishing between these types may be to use a physiography map in conjunction with satellite imagery.

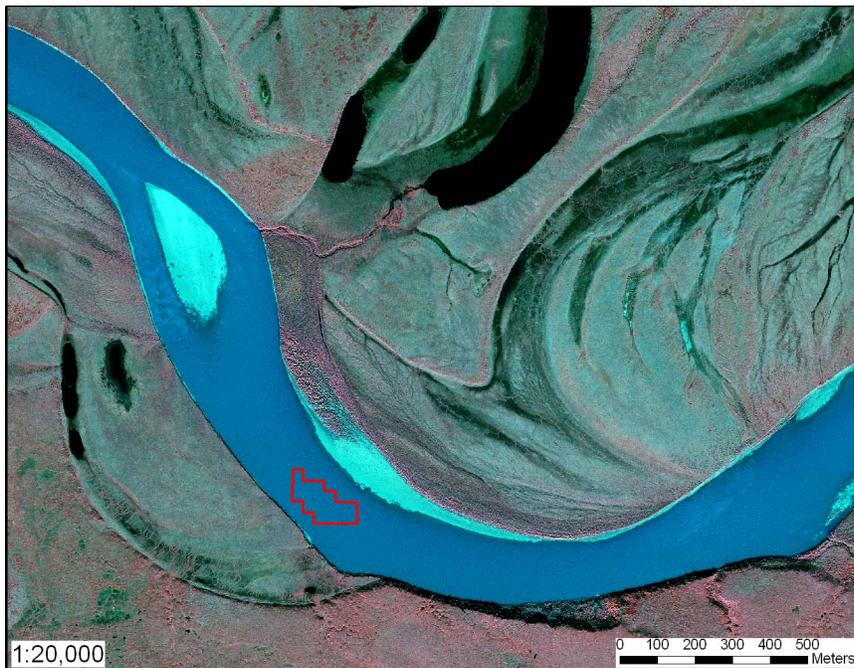
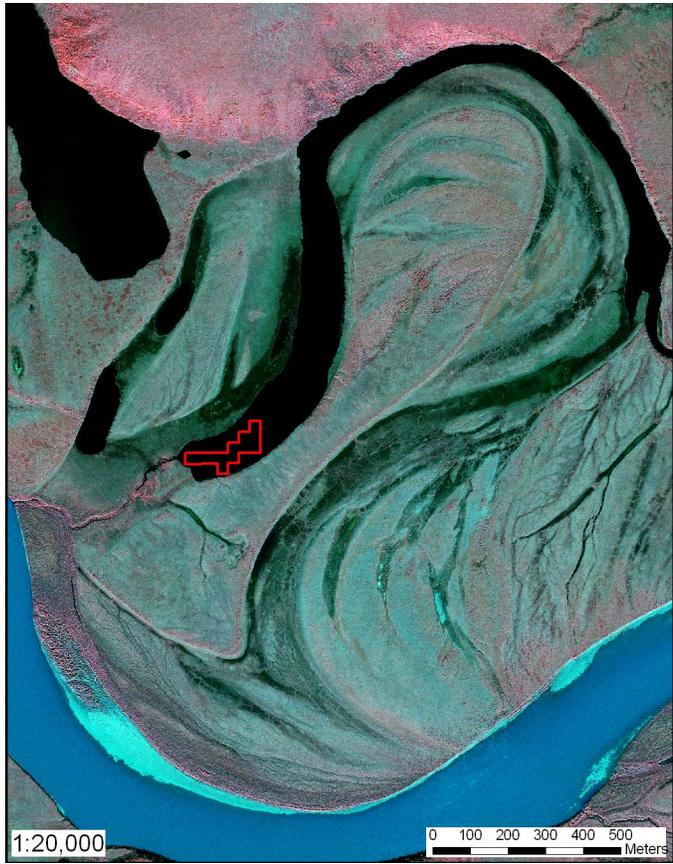


Figure 63. View for map ecotype Riverine Water (solid red) showing an example of the ecotype River, Noatak National Preserve, Alaska. (Image ID Rw2)

Figure 64. View for the map ecotype Riverine Water (solid red) showing an example of the ecotype Riverine Lake, Noatak National Preserve, Alaska. (Image ID Rw1)



Riverine White Spruce-Willow Forest

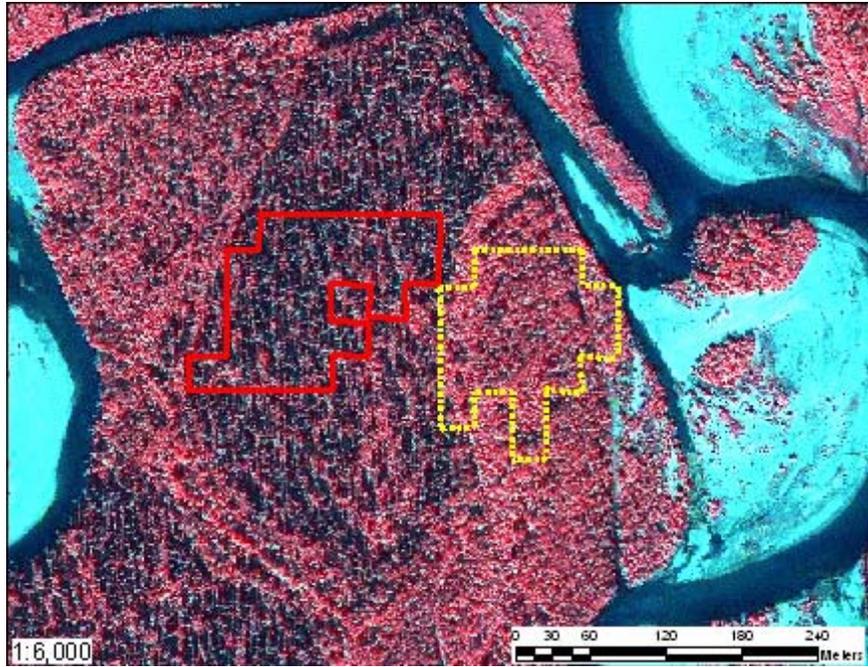
This map ecotype occurs along braided and meandering rivers on interflaves, flat banks, and inactive channels and floodplains. Figure 65 provides an aerial view of this map ecotype (A) and adjacent Riverine Poplar Forest (B). The IKONOS image of the same site is provided in Figure 66. The typical signature for this map ecotype is a mixture of dark green and black spruce crowns and triangular shadows, and

the fine-grained, bright pink signature of the willow crowns. This map ecotype may easily be confused with the map ecotype Upland White Spruce Forest. Consistent spectral diagnostic characteristics separating these two white spruce types are lacking. The best strategy for distinguishing between these types may be to use a physiography map in conjunction with satellite imagery.



Figure 65. Aerial photograph looking north of the map ecotype Riverine White Spruce-Willow Forest (A) and adjacent Riverine Poplar Forest (B) taken on July 26, 2007 (see also Image ID Rwswf1). Kobuk Valley National Park, Alaska. (Image ID Rwswf_air)

Figure 66. View showing Riverine White Spruce-Willow Forest (solid red) and adjacent Riverine Poplar Forest (dashed yellow), Kobuk Valley National Park, Alaska. (Image ID Rwswf1)



Riverine Willow Low Shrub

This map ecotype is common along rivers throughout ARCN, particularly in the arctic region of NOAT, GAAR, and CAKR beyond circumpolar treeline. The map ecotype occurs on active and inactive surfaces along braided and meandering rivers. Figure 67 shows an overview of this map ecotype on an inactive floodplain of the Aniuk River in Noatak National Preserve. The typical signature for this map ecotype is a fine grained pink color. A larger scale view depicts the detailed signature of the two directly adjacent training polygons (Figure 68). Differences in percent cover of willows, including Viereck et al. (1992) closed willow (dashed red) and open

willow (dashed yellow), create the contrasting signatures, including the pink signature (higher willow cover), and the light brown tone (lower willow cover). In Cape Krusenstern National Monument this map ecotype is common along narrow drainages in dissected uplands (Figure 69). The bright pink signature contrasts dramatically with the light tan signature of adjacent uplands. A larger scale view shows the detailed texture of the closed low willow overstory in CAKR (Figure70). Common adjacent types include Riverine Dryas Dwarf Shrub and Upland Dwarf Birch-Tussock Shrub (Figure 67).

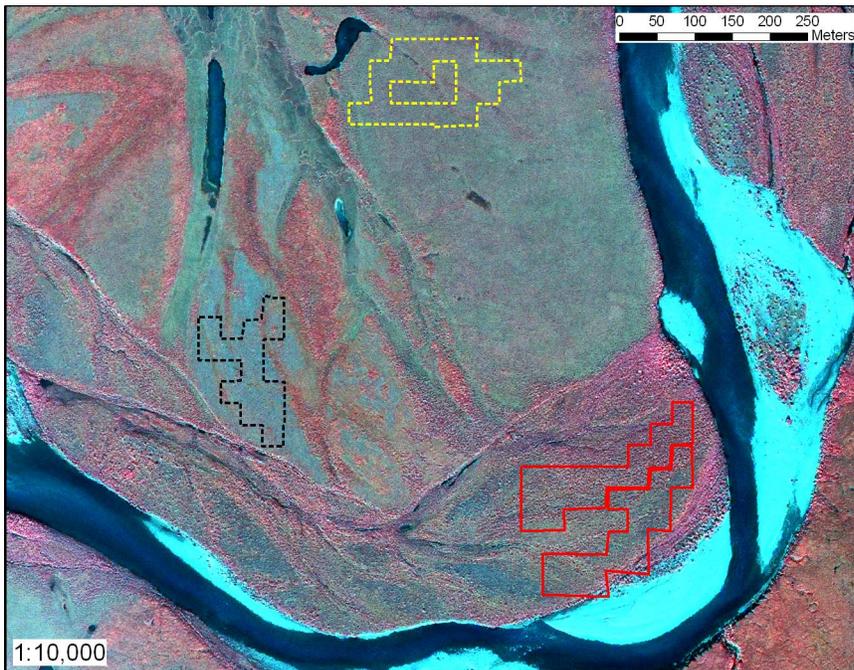


Figure 67. View showing training polygons Plot_GID 30081 (solid red, lower) and Plot_GID 30084 (solid red, upper) for Riverine Willow Low Shrub and adjacent Riverine Dryas Dwarf Shrub (dashed black) and Upland Dwarf Birch-Tussock Shrub (dashed yellow), Noatak National Preserve, Alaska. (Image ID RwlS2)

Figure 68. View showing training polygons Plot_GID 30081 (lower) and Plot_GID 30084 (upper) for Riverine Willow Low Shrub. This image shows the differences within this map ecotype in percent cover of willows, including Viereck et al. (1992) closed willow (dashed red) and open willow (dashed yellow), Noatak National Preserve, Alaska. (Image ID Rwl1s1)

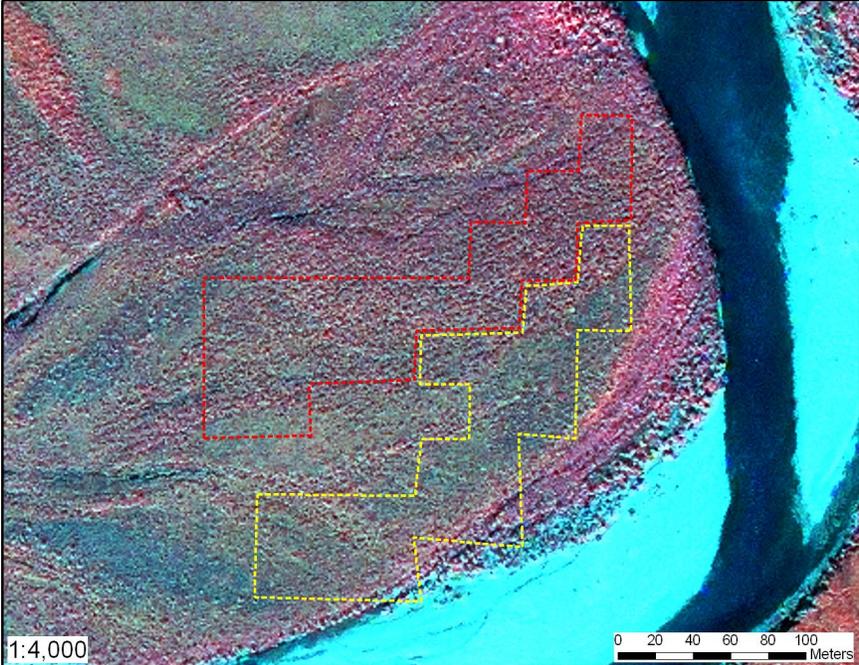


Figure 69. View showing Riverine Willow Low Shrub (solid red) in Cape Krusenstern National Monument, Alaska. (Image ID Rwl3s3)

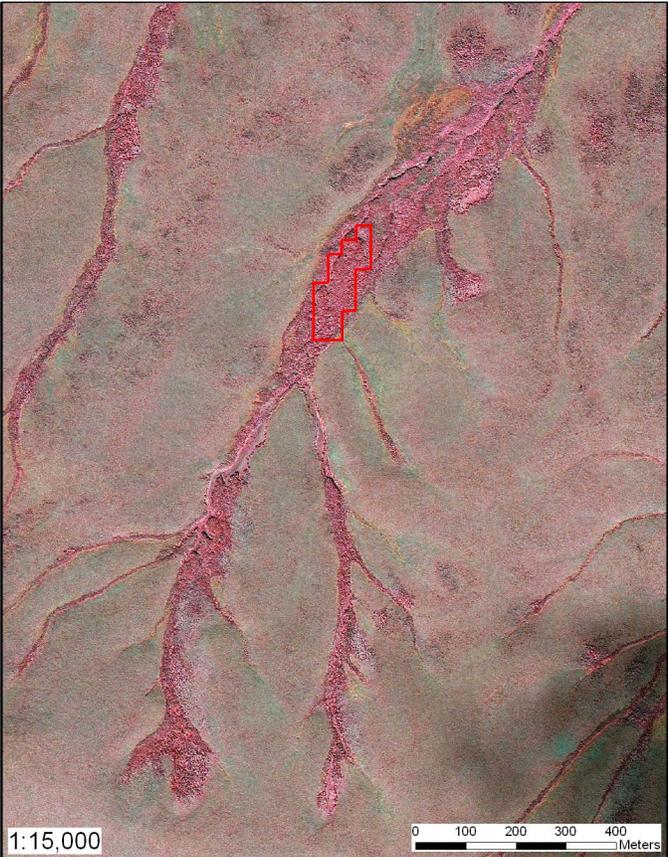




Figure 70. Close-up of Riverine Willow Low Shrub (solid red) showing texture of the closed low willow canopy, Cape Krusenstern National Monument, Alaska. (Image ID Rwl4)

Upland Alder-Willow Tall Shrub

This map ecotype occurs in uplands up to 600 meters in elevation on hillside colluvium, older moraines, solifluction deposits, talus, and thick loess deposits. The height and degree of canopy closure of the alder stand strongly influence the signature of this map ecotype. In more open canopied stands the signature is more strongly influenced by the understory component. For instance, the two polygons in Figure 71 are both training polygons for Upland Alder-Willow Tall Shrub. The training polygon with the dashed red outline represents a closed alder stand with the alders well over one and a half meters in height. In this polygon the alders form a dense, robust canopy with a coarse-grained, bright pink signature. The yellow dashed polygon is an open alder stand with the alders just barely one and a half meters in height, and an understory dominated by dwarf and low ericaceous shrubs. In this polygon, the dull pink, smooth signature represents the low and dwarf shrub understory, which is showing through the open alder canopy. The slightly brighter pink, coarser-textured signature in this polygon represents areas of denser alder cover. Figure 72 provides an oblique aerial photograph of an open stand of this map ecotype on a hillside directly adjacent to Alpine Dryas Dwarf Shrub. The IKONOS image of the same site is provided in Figure 73. Similar to above, the characteristic signature for this map ecotype is bright pink. In Figure 73, this map

ecotype is differentiated from adjacent low shrub types by the color and texture of the signature. The Upland Alder-Willow Tall Shrub has a bright pink, coarse-grained signature that is representative of the tall broad alder canopies. The Upland Willow Low Shrub has a finer-grained texture resulting from the smaller shrub canopies, and is a duller pink with tones of brown and green, indicative of the high cover of *Equisetum arvense* (dashed yellow, lower) and dwarf birch (dashed yellow, upper). Figure 74 provides a broad-scale view of this map ecotype showing common adjacent ecotypes on lower (Lowland Black Spruce Forest) and upper (Upland Birch-Ericaceous-Willow Tall Shrub) slope positions. Figure 75 provides a larger scale view of this same training polygon showing the details of the IKONOS signature. At this site the alder is clustered in dense stands (bright pink, coarse-texture signature) with open areas dominated by *Spiraea beauverdiana* and *Calamagrostis canadensis* (smooth tan to salmon signature). The bright pink signature of this map ecotype is very similar to a number of deciduous tree and tall shrub types, including Riverine Poplar Forest and Riverine Alder or Willow Tall Shrub. Consistent spectral diagnostic characteristics separating these types are lacking. The best strategy for distinguishing between these types may be to use a physiography map in conjunction with satellite imagery.

Upland Alder-Willow Tall Shrub

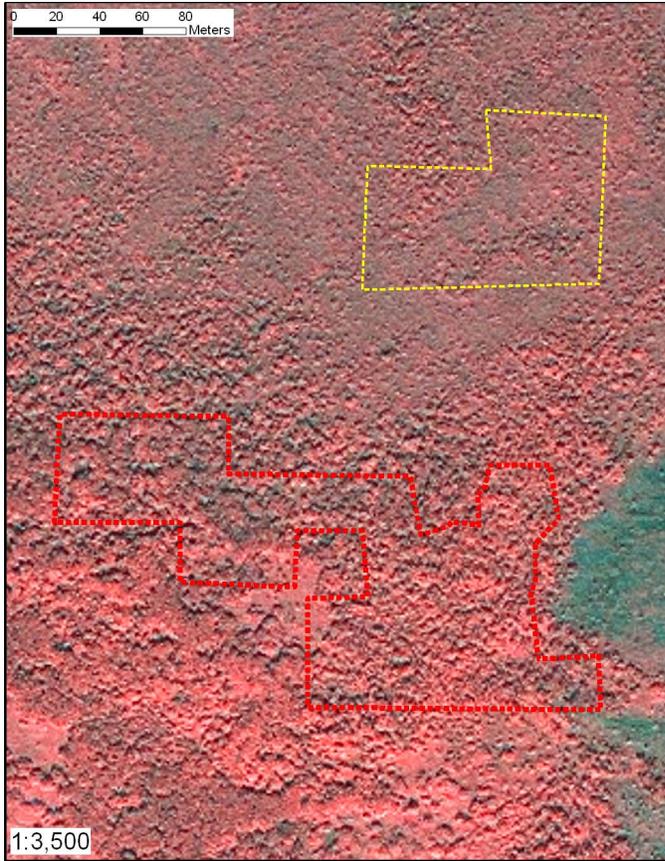


Figure 71. Close-up of training polygons Plot_GID 32040 (upper) and Plot_GID 32042 (lower) for Upland Alder-Willow Tall Shrub, showing differences within this map ecotype in percent cover of alders, including Viereck et al. (1992) closed tall alder (dashed red) and open tall alder (dashed yellow), Kobuk Valley National Park, Alaska. (Image ID Uawts2)

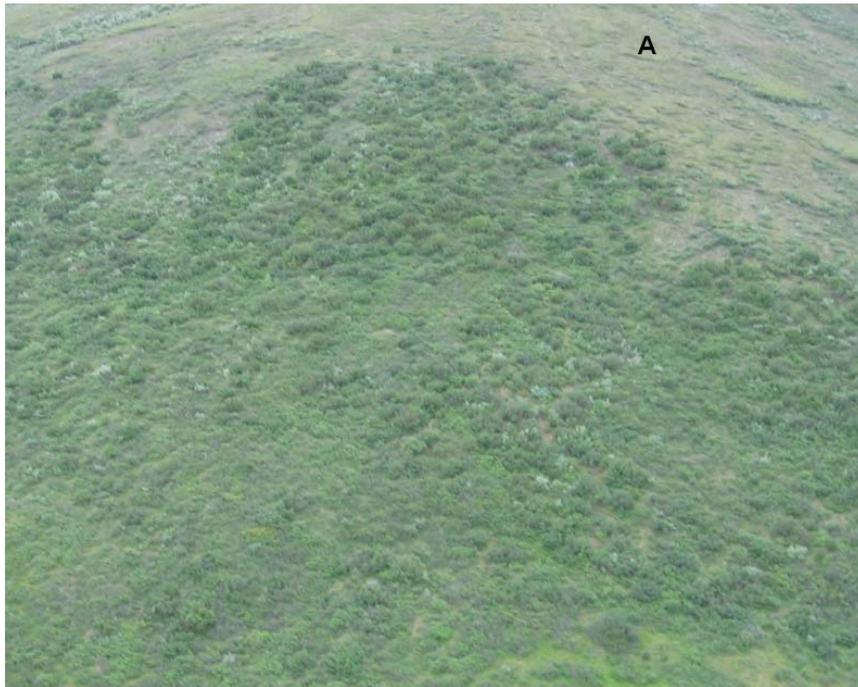


Figure 72. Aerial photograph looking north of the map ecotype Upland Alder-Willow Tall Shrub (see also Image ID Uawts1) and adjacent Alpine Dryas Dwarf Shrub (A) taken July 22, 2006. The image depicts this map ecotype with an open alder canopy. Noatak National Preserve, Alaska. (Image ID Uawts_air)

Figure 73. View showing Upland Alder-Willow Tall Shrub (solid red) and adjacent Upland Willow Low Shrub (dashed yellow) and Alpine Dryas Dwarf Shrub (A), Noatak National Preserve, Alaska. (Image ID Uawts1)

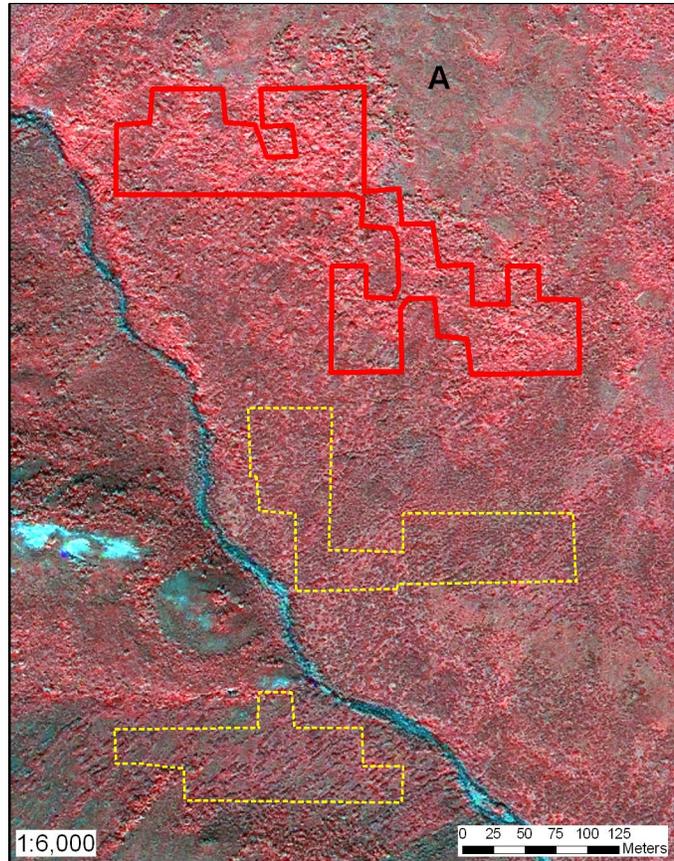
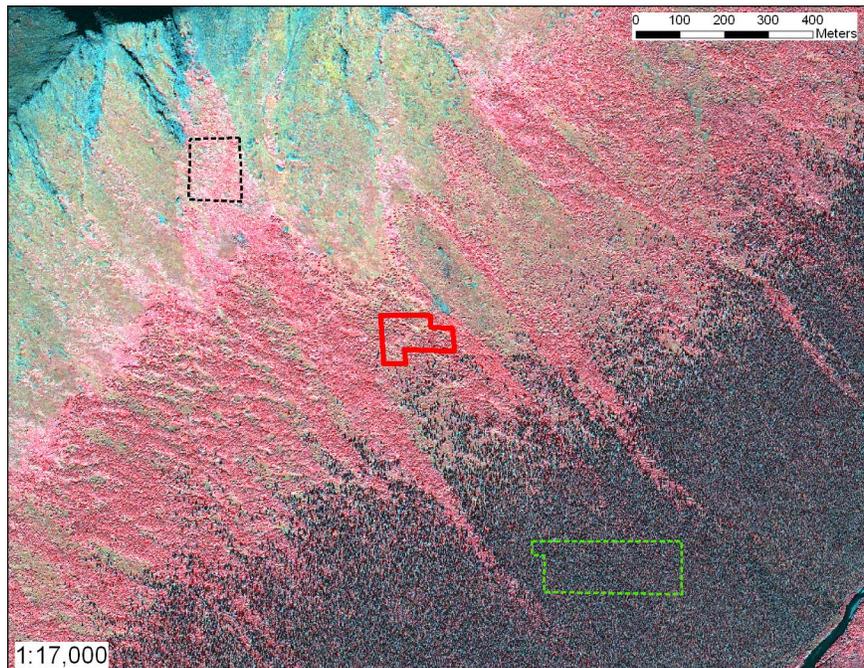


Figure 74. View showing Upland Alder-Willow Tall Shrub (solid red) and adjacent Upland Birch-Ericaceous-Willow Tall Shrub (dashed black) and Lowland Black Spruce Forest (dashed green), Kobuk Valley National Park, Alaska. (Image ID Uawts3)



Upland Alder-Willow Tall Shrub

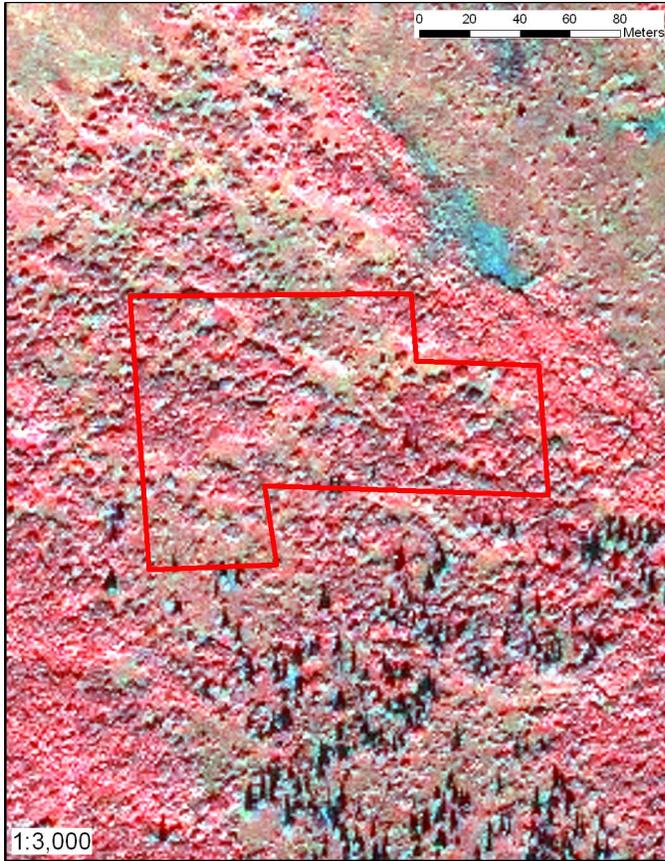


Figure 75. Close-up of Upland Alder-Willow Tall Shrub (solid red), Kobuk Valley National Park, Alaska. (Image ID Uawts4)

Upland Birch-Ericaceous-Willow Low Shrub

This map ecotype occurs in uplands throughout ARCN, and commonly occurs on hillside colluvium, older moraines, solifluction and loess deposits. This map ecotype includes three ecotypes: Upland Birch-Ericaceous Low Shrub, Upland Birch-Willow Low Shrub, and Upland Spirea Low Shrub. Given the diversity of ecotypes aggregated into this single map ecotype, the spectral signature is diverse, and strongly dependent on the dominant low shrub species. For instance, the site depicted in the oblique aerial photograph in Figure 76 is an example of this map ecotype with a strong ericaceous low shrub component. The typical signature for this map ecotype is red to dull pink when dominated by ericaceous shrubs (Figure 77). The stippled texture in

Figure 77 reflects the microfeature mineral cored mounds, which were abundant at this site. Figure 78 provides an overview of this map ecotype when it features a strong low willow component. The tan to gray signature is characteristic of this map ecotype later in the season when the willow leaves have turned to fall colors, and the sedges have begun to senesce. A larger-scale perspective shows the details of the spectral signature (Figure 79). Frost boils and sorted frost polygons result in the alternating pink and tan pattern observed in this image. Occasionally this map ecotype is dominated by *Spiraea beauverdiana* as depicted in Figure 80. The characteristic signature is a fine-textured, light pink color.

Figure 76. Aerial photograph of the map ecotype Upland Birch-Ericaceous-Willow Low Shrub (foreground) taken July 21, 2006 (see also Image ID Ubewls1). The image depicts this map ecotype with a strong ericaceous shrub component. (Image ID Ubewls_air)



Upland Birch-Ericaceous-Willow Low Shrub

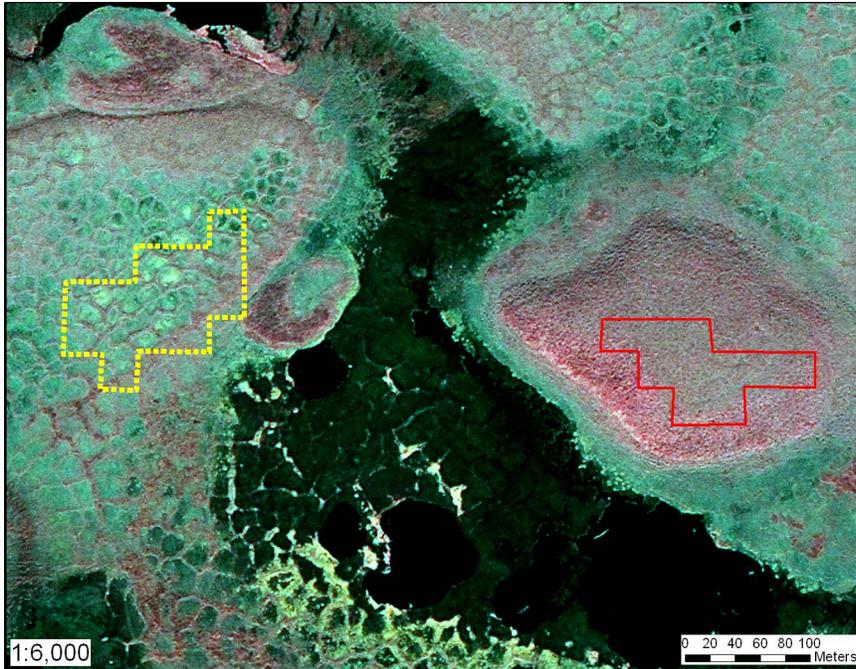


Figure 77. View showing Upland Birch-Ericaceous-Willow Low Shrub with a strong ericaceous shrub component (solid red) and adjacent Lowland Ericaceous Shrub Bog (dashed yellow), Noatak National Preserve, Alaska. (Image ID Ubewls1)

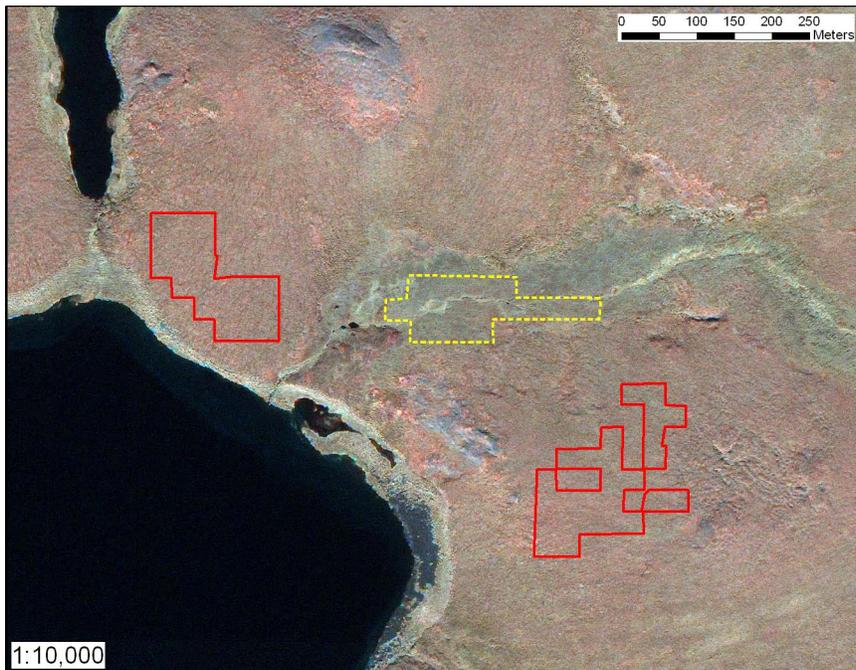


Figure 78. Overview of training polygons Plot_GID 32645 (solid red, far right) and Plot_GID 32541 (solid red, far left) for Upland Birch-Ericaceous-Willow Low Shrub and adjacent Lowland Sedge Fen (dashed yellow), Gates of the Arctic National Park and Preserve, Alaska. (Image ID Ubewls3)

Figure 79. Close-up of training polygon Plot_GID 32541 (solid red) for Upland Ericaceous-Willow Low Shrub showing an example of this map ecotype with a strong low willow component, Gates of the Arctic National Park and Preserve, Alaska. (Image ID Ubewls4)

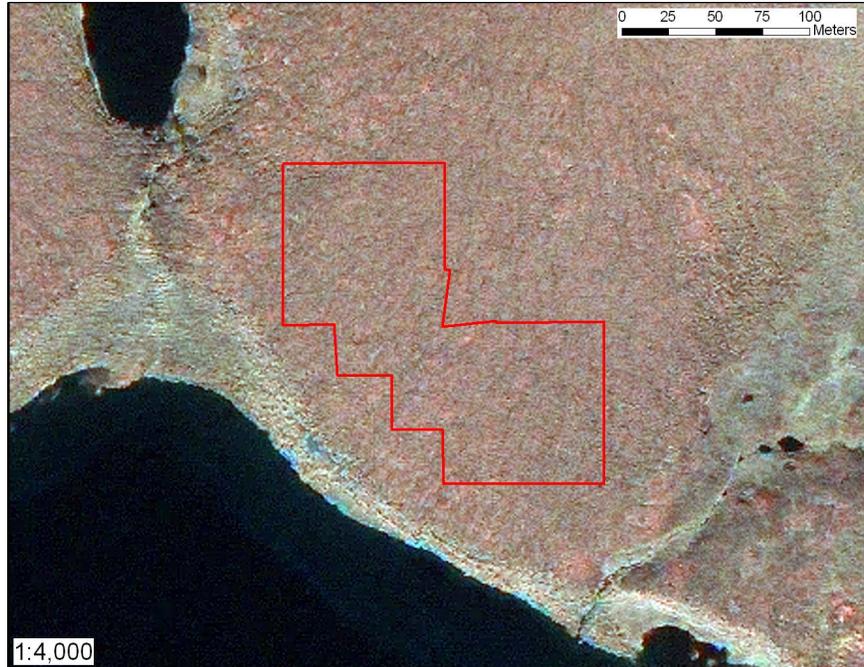
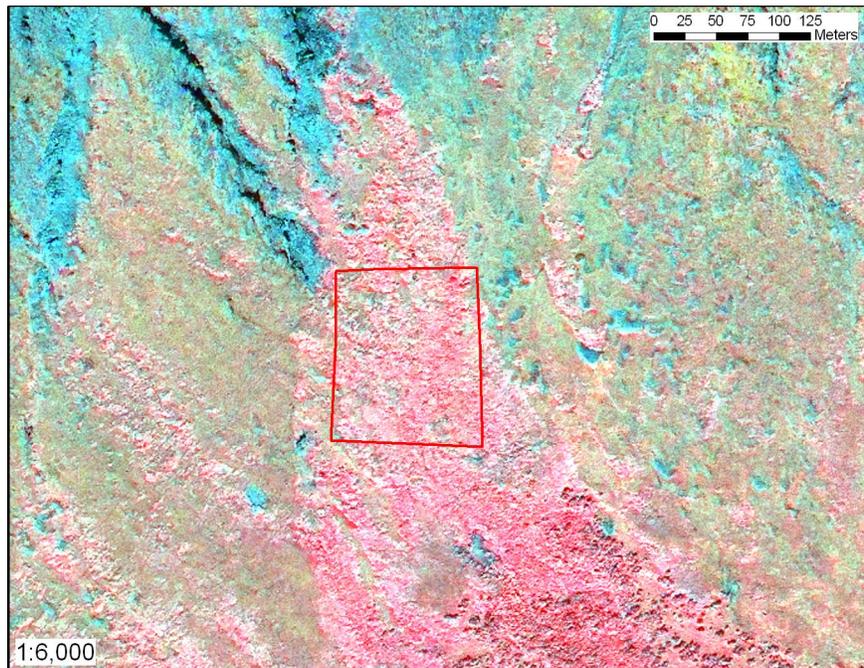


Figure 80. View for Upland Birch-Ericaceous-Willow Low Shrub (solid red), showing an example of this map ecotype with high cover of *Spiraea beauverdiana*, Kobuk Valley National Park, Alaska. (Image ID Ubewls2)



Upland Dwarf Birch-Tussock Shrub

This map ecotype is the most abundant in ARCN, and is found on moderate to gentle slopes at elevations averaging 250 meters. The signature of this map ecotype varies depending on the relative proportion of the low shrubs *Betula nana* and *Ledum decumbens*, and the tussock forming sedge *Eriophorum vaginatum*. For instance, Figure 81 provides an oblique aerial view of this map ecotype in Kobuk Valley National Park. The IKONOS representation of this same site is provided in Figure 82. The signature in the training polygon 31979 is characterized by two dominant signatures, a bluish signature (A), indicating areas dominated by *Eriophorum vaginatum*, and a pink signature (B) indicating areas co-dominated by *Eriophorum vaginatum*, *Betula nana*, and *Ledum decumbens*.

In Cape Krusenstern National Monument this map ecotype is common along ridge crests and upper slope positions in rolling, dissected uplands (Figure 83). Figure 84 shows the details of the texture of this signature when *Eriophorum vaginatum* is dominant, and tussocks are abundant. The typical signature in the above case is a minute stippling caused by the tussocks. When *Betula nana* and *Ledum decumbens* are dominant, *Eriophorum vaginatum* cover is relatively low, and tussocks are uncommon, the texture of the signature is smooth and fine-grained (Figure 85). When the above situation is true the signature of this map ecotype may be confused with that of Upland Birch-Ericaceous-Willow Low Shrub.



Figure 81. Aerial photograph of the map ecotype Upland Dwarf Birch-Tussock Shrub (foreground) taken July 26, 2007 (see also Image ID Udbts3), Kobuk Valley National Park, Alaska. (Image ID Udbts_air)

Figure 82. View showing Upland Dwarf Birch-Tussock Shrub (solid red). The bluish signature (A) indicates areas of this map ecotype dominated by *Eriophorum vaginatum*, while the pink signature (B) indicates areas co-dominated by *Eriophorum vaginatum*, *Betula nana*, and *Ledum decumbens*. Kobuk Valley National Park, Alaska. (Image ID Udbts3)

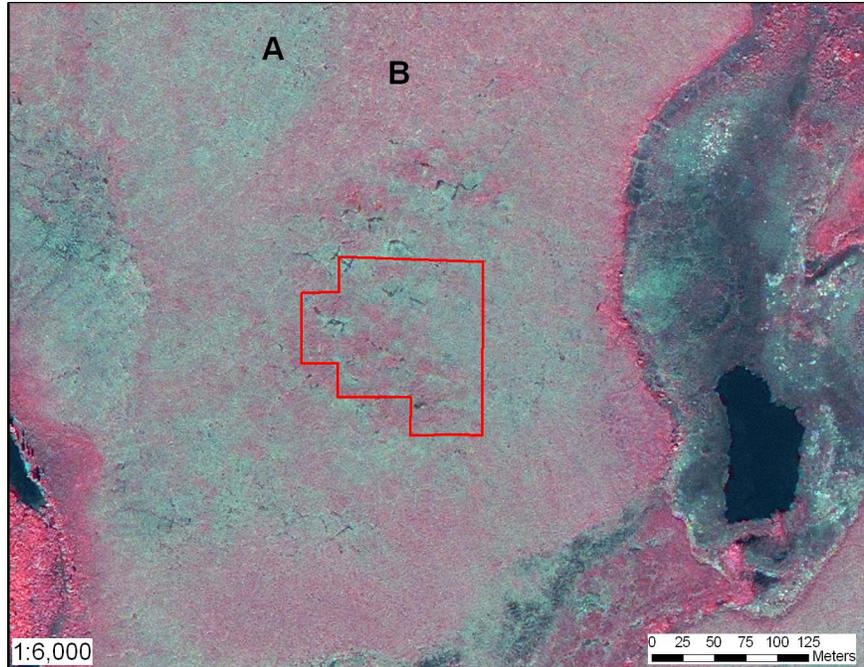
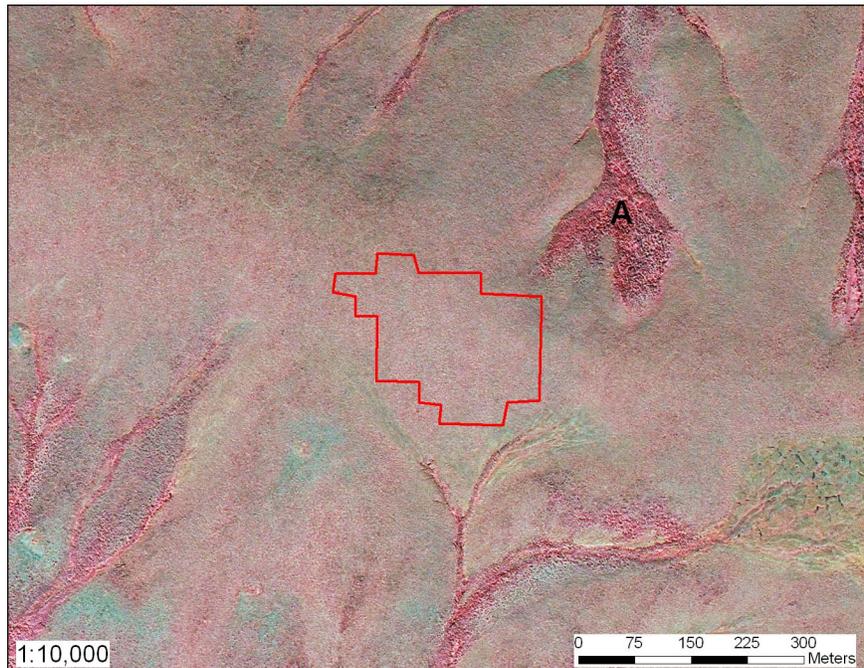


Figure 83. View showing Upland Dwarf Birch-Tussock Shrub (solid red) and adjacent Riverine Willow Low Shrub (A) in dissected uplands of Cape Krusenstern National Monument, Alaska. (Image ID Udbts2)



Upland Dwarf Birch-Tussock Shrub

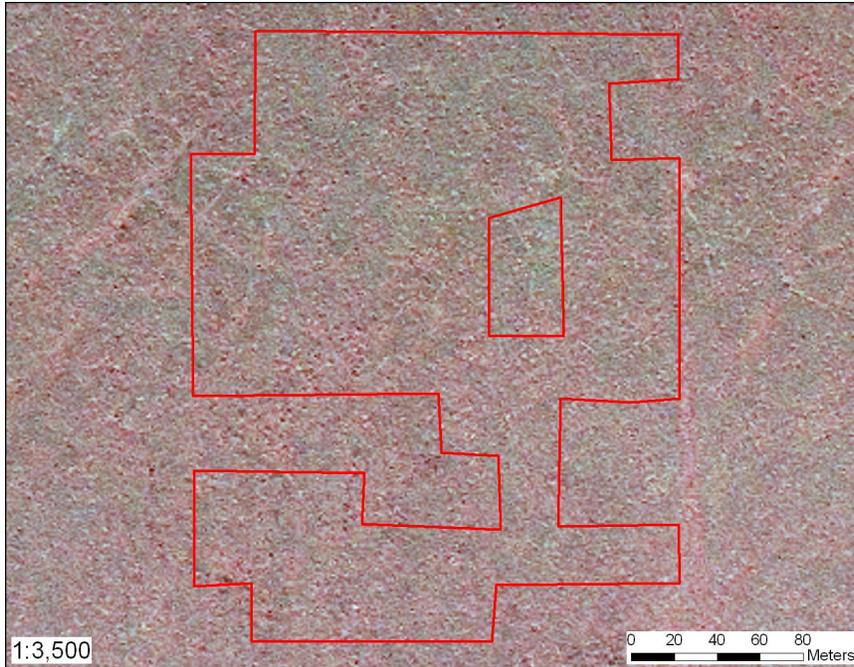


Figure 84. Close-up of Upland Dwarf Birch-Tussock Shrub (solid red) showing details of the texture of this signature when *Eriophorum vaginatum* is dominant and tussocks are abundant, Cape Krusenstern National Monument, Alaska. (Image ID Udbts1)

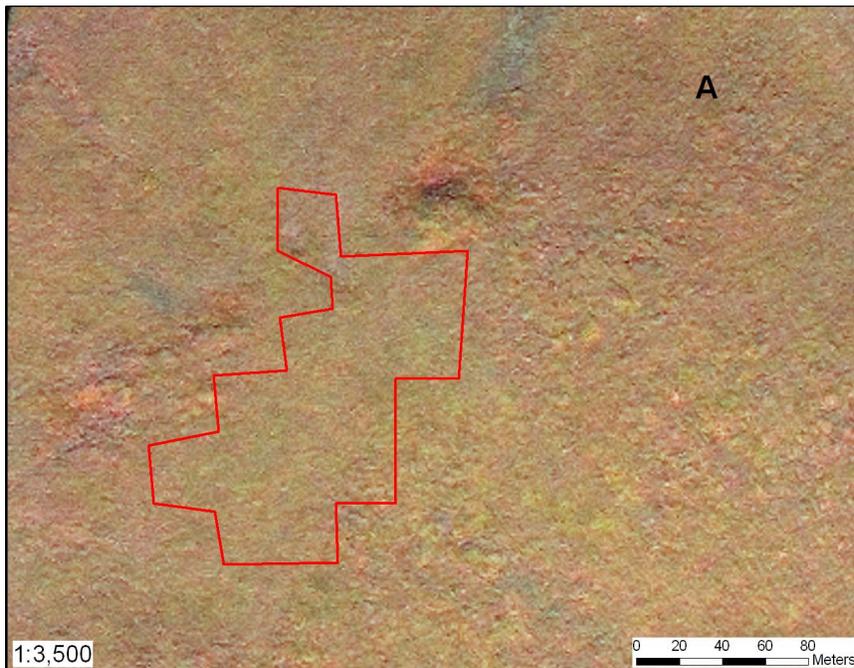


Figure 85. Close-up of Upland Dwarf Birch-Tussock Shrub (solid red) showing the detailed texture of this signature when the low shrubs *Betula nana* and *Ledum decumbens* are dominant, *Eriophorum vaginatum* cover is relatively low, and tussocks are uncommon. The adjacent type (A) is Upland Birch-Ericaceous-Willow Low Shrub, Gates of the Arctic National Park and Preserve, Alaska. (Image ID Udbts4)

Upland Sandy Barrens

This map ecotype encompasses the active portions of the Greater Kobuk Sand Dunes, Little Kobuk Sand Dunes, and isolated smaller exposed dunes in ARCN. Figure 86 provides an oblique aerial view of this map ecotype. The IKONOS image of the same site is presented in Figure 87. The signature, which contrasts sharply with adjacent spruce forests, is a smooth textured, bright white to light gray, and is unique among ecotypes in ARCN. Figure 88 depicts this map ecotype with a series

of transverse sand dunes (A–D) which display a wave-like pattern in the direction of the prevailing easterly winds (in photo from right to left). A series of smaller dunes superimposed on the larger transverse dunes (E–G) occur in the upper left hand corner of Figure 88. The superimposed dunes are the result of secondary winds from the northeast (in photo from upper right to lower left). A closer look provides the details of the morphology of the transverse dunes (Figure 89).

Figure 86. Aerial photograph looking west of the map ecotype Upland Sandy Barrens (foreground) taken July 30, 2007 (see also Image ID Usb1), Greater Kobuk Sand Dunes, Kobuk Valley National Park, Alaska. (Image ID Usb_air)



Upland Sandy Barrens

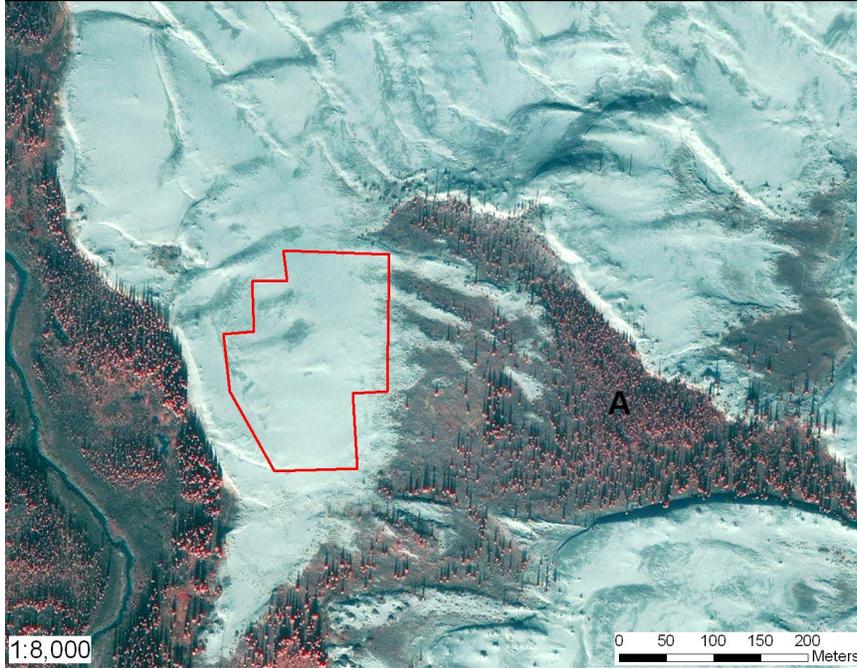


Figure 87. View showing Upland Sandy Barrens (solid red) and adjacent Upland White Spruce-Lichen Woodland (A), Greater Kobuk Sand Dunes, Kobuk Valley National Park, Alaska. (Image ID Usb1)

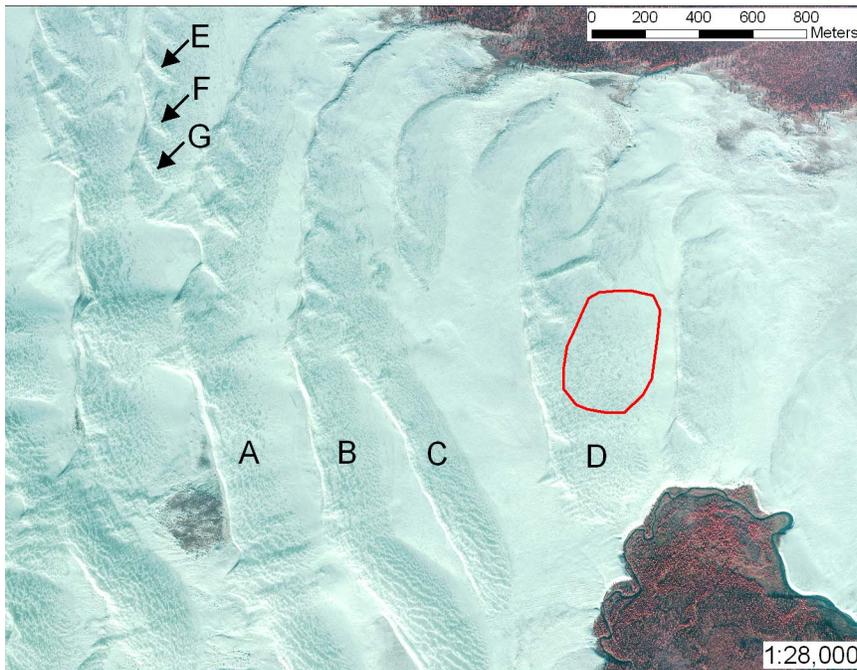
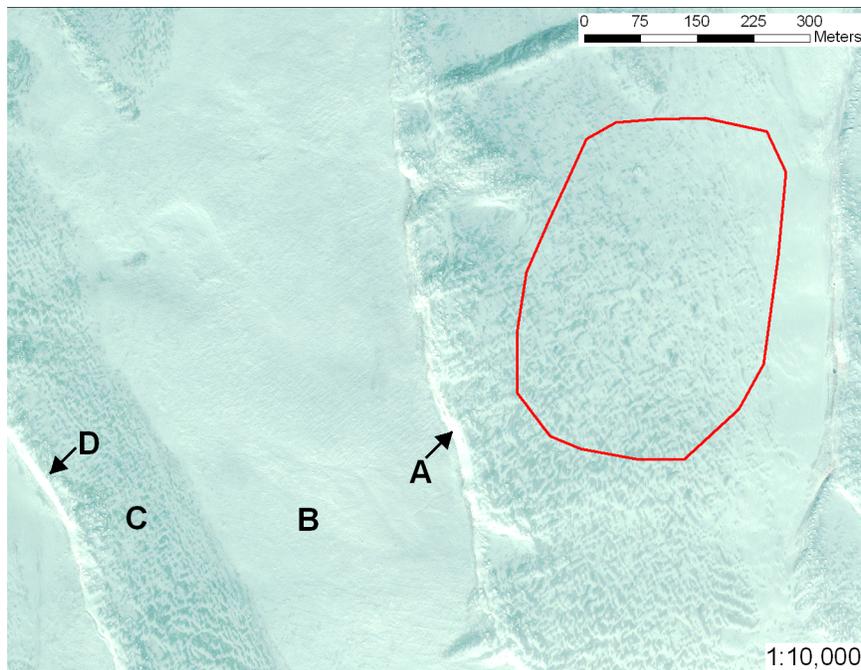


Figure 88. View showing an overview of Upland Sandy Barrens (solid red), a series of adjacent transverse sand dunes (A–D), and a series of smaller dunes superimposed on the larger transverse dunes (E–G), Greater Kobuk Sand Dunes, Kobuk Valley National Park, Alaska. (Image ID Usb2)

Figure 89. View showing close-up of Upland Sandy Barrens (solid red) and morphological components of transverse sand dunes, including slipface (A), interdune (B), stoss slope (C), and crest (D, Greater Kobuk Sand Dunes, Kobuk Valley National Park, Alaska. (Image ID Usb3)



Upland Sedge-Dryas Meadow

This map ecotype is strongly associated with carbonate-rich bedrock types. Surface geomorphology consists of hillside colluvium, older moraine, and re-transported deposits. Periglacial surface features are common, including mineral-cored hummocks, sorted stone stripes, and solifluction lobes. An oblique aerial view of this map ecotype with solifluction lobes is shown in Figure 90. The IKONOS image of the same site is provided in

Figure 91. This map ecotype typically features a dull pink to salmon signature, and often occurs down slope from Alpine Alkaline Barrens. Figure 92 shows this map ecotype directly adjacent to Alpine Alkaline Barrens in Cape Krusenstern National Monument. A larger-scale view provides another example of the signature of this map ecotype with solifluction lobes (Figure 93).



Figure 90. Aerial photograph of the map ecotype Upland Sedge-Dryas Meadow (see also Image ID Usdm2) taken July 31, 2007. The photograph shows an example of this map ecotype with solifluction lobes, Noatak National Preserve, Alaska. (Image ID Usdm_air)

Figure 91. View showing Upland Sedge-Dryas Meadow (solid red) and adjacent Alpine Alkaline Barrens (A), Noatak National Preserve, Alaska. (Image ID Usdm2)

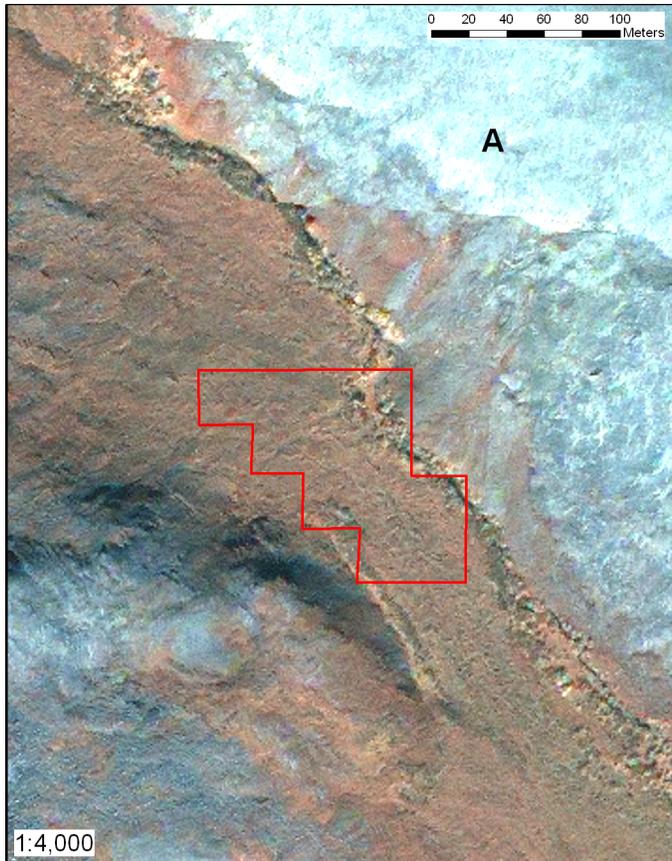
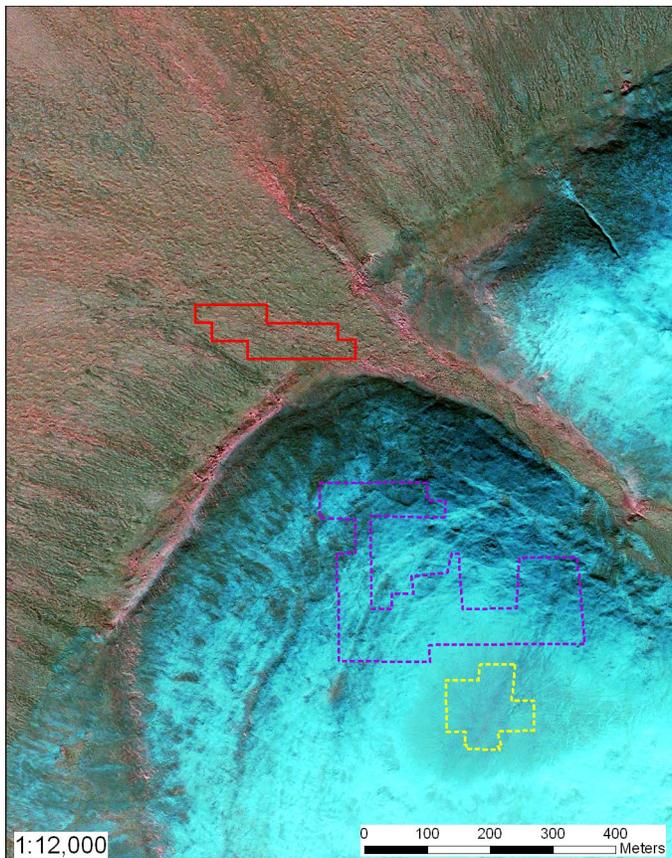


Figure 92. View showing Upland Sedge-Dryas Meadow (solid red) and adjacent Alpine Alkaline Barrens (dashed purple) and Alpine Dryas Dwarf Shrub (dashed yellow), Cape Krusenstern National Monument, Alaska. (Image ID Usdm1)



Upland Sedge-Dryas Meadow

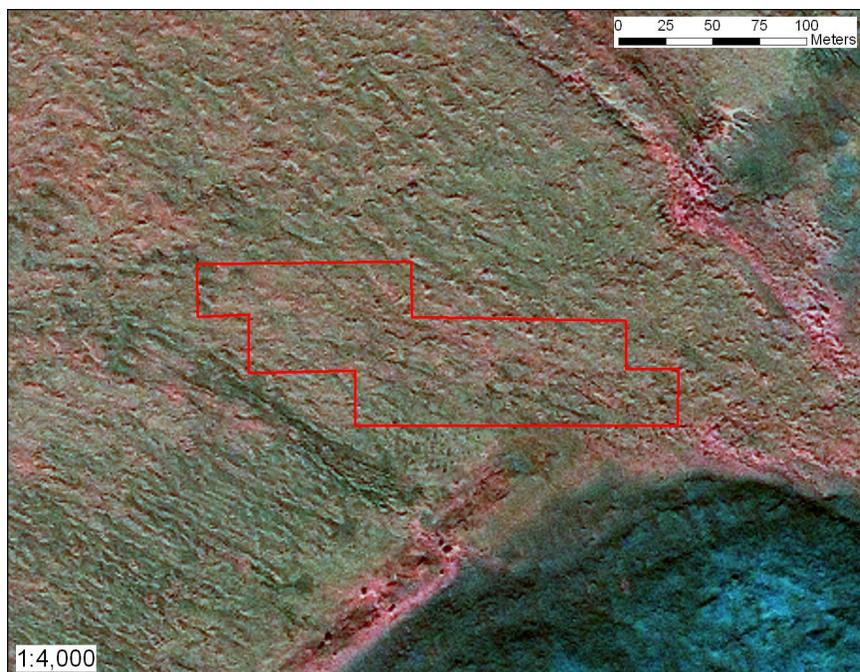


Figure 93. Close-up of Upland Sedge-Dryas Meadow (solid red) showing details of the signature when this map ecotype is associated with solifluction lobes, Cape Krusenstern National Monument, Alaska. (Image ID Usdm3)

Upland Spruce-Birch Forest

This map ecotype is uncommon and occurs on hillside colluvium, eolian inactive sand deposits, older moraines, and older till within the boreal forest zone in KOVA and GAAR. Figure 94 provides an oblique aerial view of this map ecotype on a limestone hillside in Gates of the Arctic National Park and Preserve. This mixed-forest type has a coarse-grained, light pink signature that

is distinctive from pure spruce types, which typically features a fine-grained signature with black tones indicating spruce and darker pink and red tones indicating understory shrubs (Figure 95). The detailed signature shows the pink, coarse-texture reflects the large, roundish tree crowns of the birch, while areas of spruce feature a grainy brownish signature (Figure 96).

Figure 94. Aerial photograph looking east of the map ecotype Upland Spruce-Birch Forest (see also Image ID Usbf2) taken August 10, 2008, Gates of the Arctic National Park and Preserve, Alaska. (Image ID Usbf_air)



Upland Spruce-Birch Forest

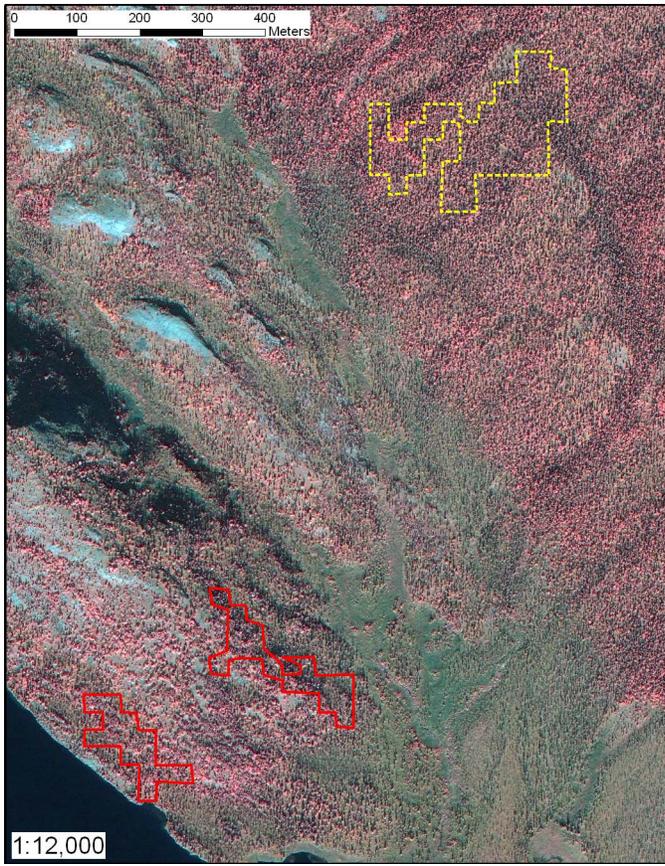


Figure 95. Overview of training polygons Plot_GID 32627 (solid red, upper right) and Plot_GID 32653 (solid red, lower left) for Upland Spruce-Birch Forest and adjacent Upland White Spruce Forest (dashed yellow), Gates of the Arctic National Park and Preserve, Alaska. (Image ID Usbf2)

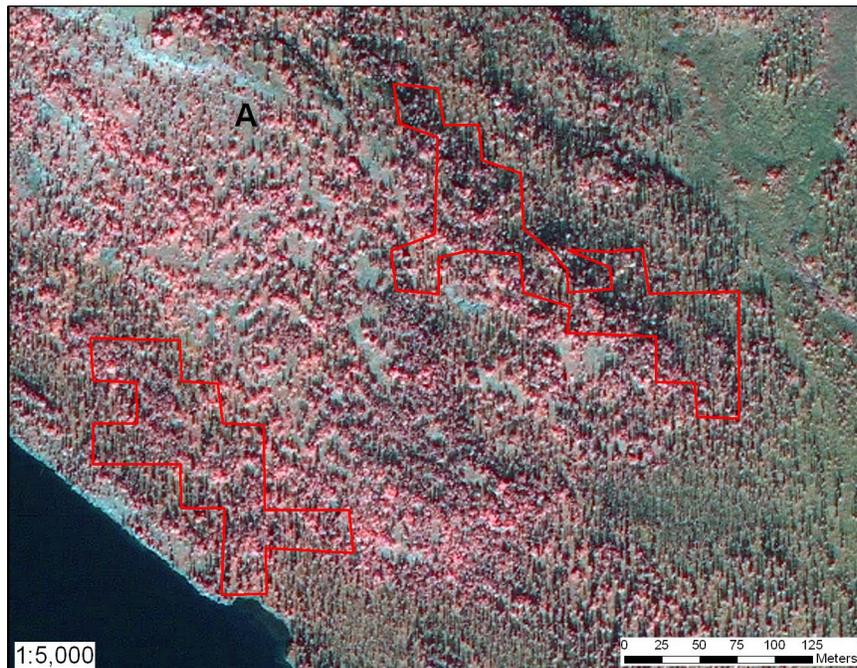


Figure 96. Close-up of training polygons Plot_GID 32627 (solid red, upper right) and Plot_GID 32653 (solid red, lower left) for Upland Spruce-Paper Birch. The signature indicated by "A" is an area of more open canopy and higher cover of exposed limestone bedrock, Gates of the Arctic National Park and Preserve, Alaska. (Image ID Usbf1)

Upland White Spruce-Lichen Woodland

This map ecotype occurs on eolian inactive sand dunes adjacent to the Greater Kobuk Sand Dunes and Little Kobuk Sand Dunes, and isolated smaller exposed dunes in ARCN. These dunes are relatively stable allowing for open stands of white spruce and a thick cover of lichens to develop. Figure 97 provides an oblique aerial view of this map ecotype showing an open white spruce canopy and lichen dominated canopy openings. The IKONOS signature for this map ecotype varies depending upon the degree of forested canopy closure. For instance, Figure 98 depicts this map ecotype with differing degrees of canopy closure, including Viereck et al. (1992) open white spruce forest (solid red training polygon) and white spruce woodland (B). In the

white spruce woodland, the IKONOS signature is influenced to a greater degree by the dense lichen layer, lending a light gray tone to the signature. A larger-scale view shows the details of the signature, including the black to dark green of spruce (A), the bright pink crowns of paper birch and aspen (B), and the dark brown to black triangular shadows of spruce trees (C) (Figure 99). When this map ecotype has an open or closed spruce canopy it may be easily confused with Upland Spruce-Birch Forest or Upland White Spruce Forest. A surficial geology map may be the best means of differentiating Upland White Spruce-Lichen Woodland from the above similar map ecotypes (Figure 100).

Figure 97. Aerial photograph of the map ecotype Upland White Spruce-Lichen Woodland (see also Image ID Uwslw1) taken on June 29, 1990, Kobuk Valley National Park, Alaska. (Image ID Uwslw_air)



Upland White Spruce-Lichen Woodland

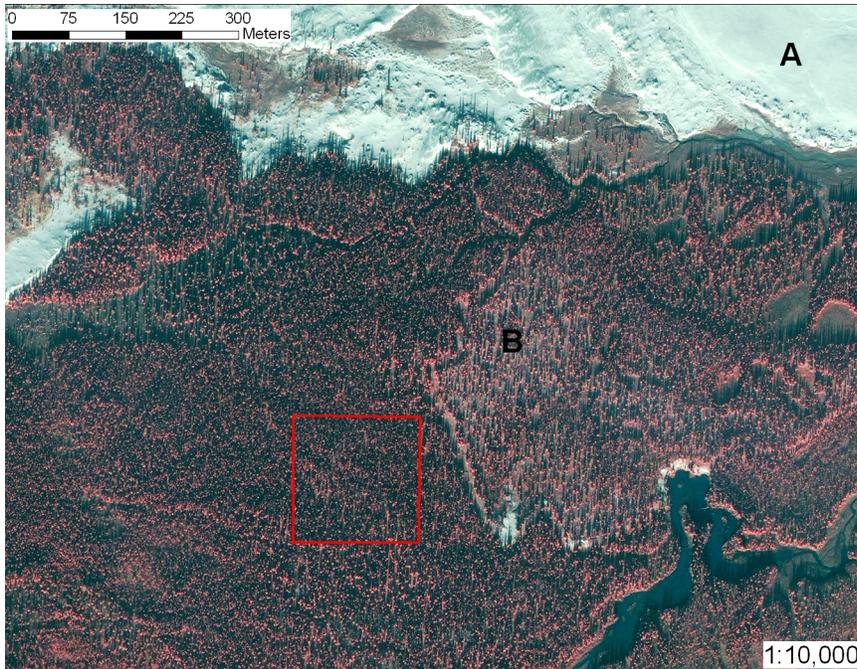


Figure 98. View showing Upland White Spruce-Lichen Woodland (solid red) and adjacent Upland Sandy Barrens (A). The signature varies depending on the degree of canopy closure, including Viereck et al. (1992) open white spruce forest (solid red) and white spruce woodland (B), Kobuk Valley National Park, Alaska. (Image ID Uwslw1)

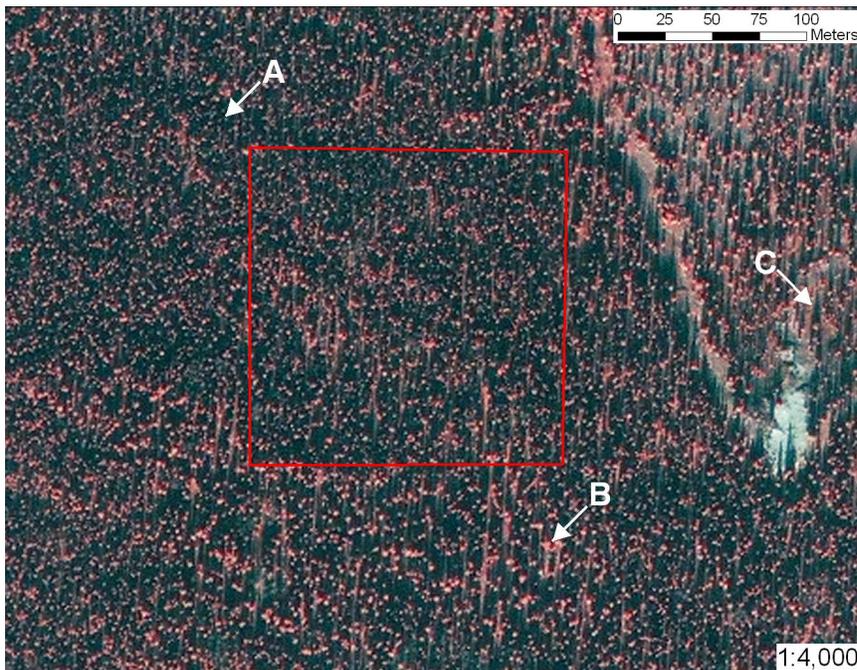
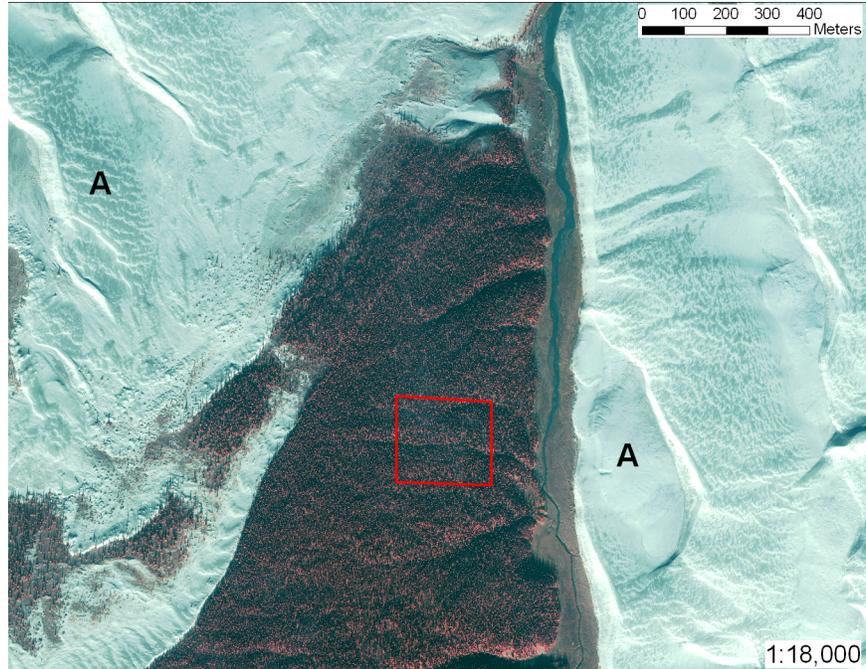


Figure 99. View showing a close-up of Upland White Spruce-Lichen Woodland (solid red). The close-up view reveals the detailed texture and coloration of the signature, including the black to dark green of spruce (A), the bright pink crowns of paper birch and aspen (B), and the dark brown to black triangular shadows of spruce trees (C). Kobuk Valley National Park, Alaska. (Image ID Uwslw2)

Figure 100. View showing an overview of the map ecotype Upland White Spruce-Lichen Woodland with a closed spruce canopy (solid red) and adjacent Upland Sandy Barrens, Kobuk Valley National Park, Alaska. (Image ID Uwslw3)



Upland White Spruce Forest

This map ecotype occurs occasionally throughout ARCN, with the exception of BELA where it is completely absent, and often forms the circumpolar treeline. This map ecotype includes two ecotypes: Upland White Spruce-Ericaceous Forest and Upland White Spruce-Willow Forest. The signature of this map ecotype is variable depending on the degree of forest canopy closure and the understory component. For instance, the photograph provided in Figure 101 shows an oblique aerial view of this map ecotype with a white spruce

woodland vegetation class and an understory dominated by the tall shrub, *Alnus crispa* and the low shrub, *Vaccinium uliginosum*. The IKONOS signature is a fine-grained reddish color with flecks of black and triangular shadows (Figure 102). The brownish-orange tone in Figure 103 reflects the limited shrub cover and high cover of fruiticose lichen (*Cladina stellaris*) in the understory at this stand. In stands with higher canopy cover of conifers, the black tones are more prominent (Figure 104).



Figure 101. Aerial photograph looking east of the map ecotype Upland White Spruce Forest (see also Image ID Uwsf1) taken July 28, 2007. This photo shows an example of this type with a white spruce woodland (Viereck et al. 1992) vegetation class and strong *Vaccinium uliginosum* and *Alnus crispa* shrub component, Gates of the Arctic National Park and Preserve, Alaska. (Image ID Uwsf_air)

Figure 102. View for Upland White Spruce Forest (solid red), showing an example of this map ecotype near timberline with a white spruce woodland (Viereck et al. 1992) vegetation class and strong *Vaccinium uliginosum* and *Alnus crispa* shrub component, Kobuk Valley National Park, Alaska. (Image ID Uwsf1)

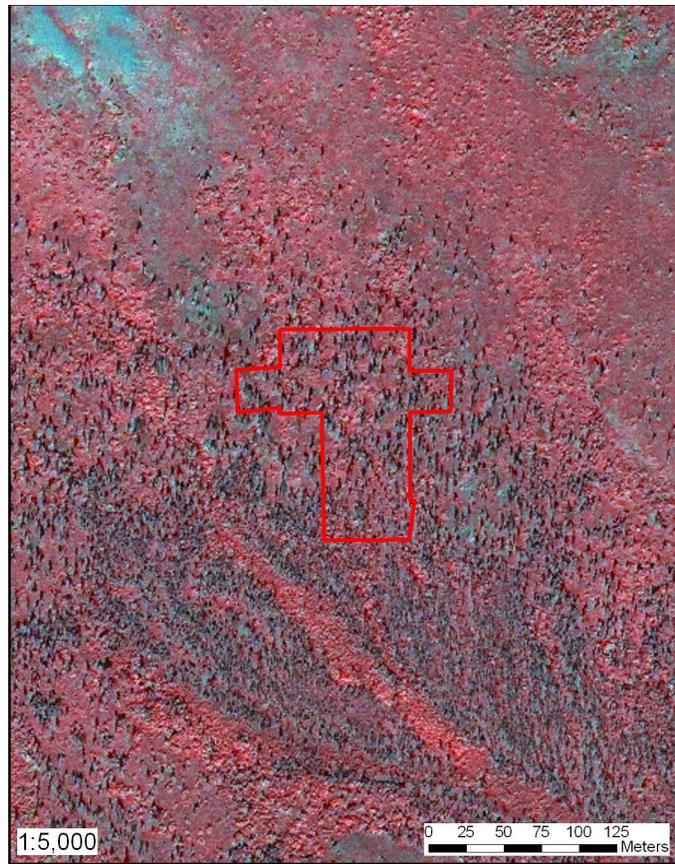


Figure 103. View for Upland White Spruce Forest (solid red), showing an example of this map ecotype with a white spruce woodland (Viereck et al. 1992) vegetation class and strong fruiticose lichen (*Cladina stellaris*) component, Gates of the Arctic National Park and Preserve, Alaska. (Image ID Uwsf3)



Upland White Spruce Forest

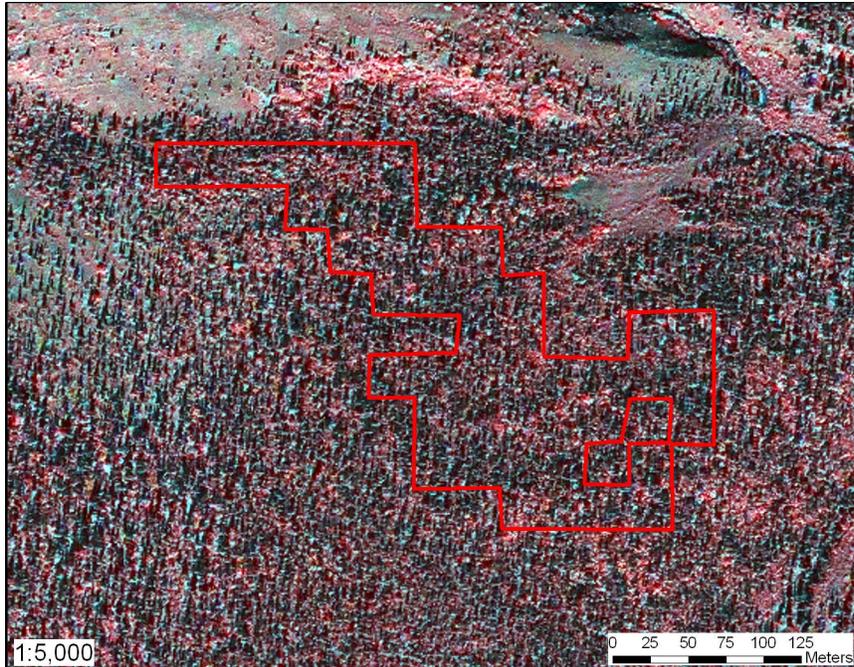


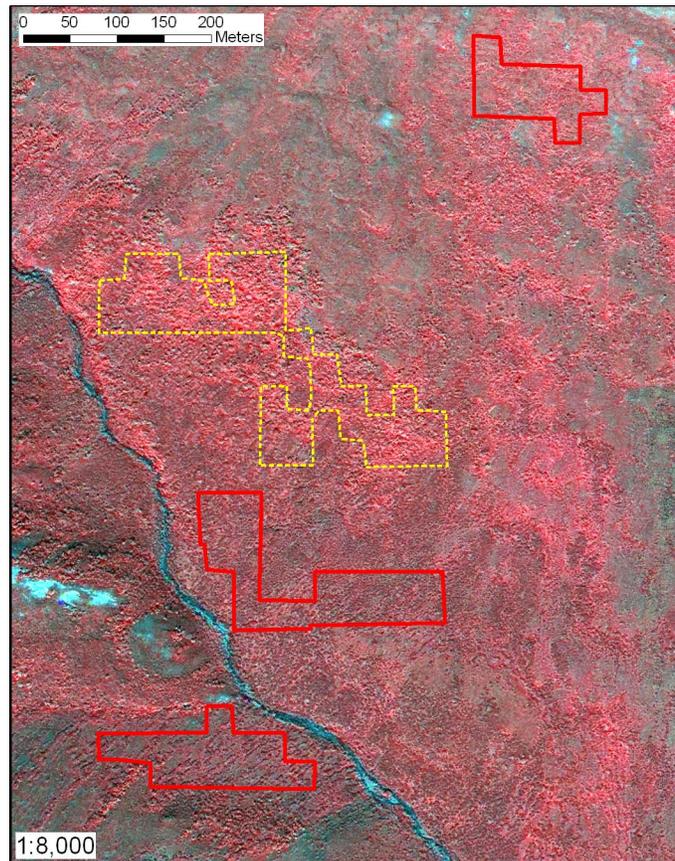
Figure 104. View for Upland White Spruce Forest (solid red) showing an example of this map ecotype with an open white spruce forest (Viereck et al. 1992) vegetation class and strong willow and alder shrub component, Kobuk Valley National Park, Alaska. (Image ID Uwsf2)

Upland Willow Low Shrub

This map ecotype is found throughout ARCN on alkaline parent material on gentle to moderate slopes of hillsides and alluvial fan deposits. Figure 105 provides an overview of three nearby training polygons of this map ecotype and adjacent Upland Alder-Willow Tall Shrub. The characteristic IKONOS signature for this map ecotype is fine-grained and bright pink. This type may be confused with Upland Alder-Willow Tall Shrub, but while both are commonly bright pink, Upland Willow Low Shrub has a finer-grained texture

resulting from the smaller shrub canopies (Figure 106). When dwarf birch co-dominates with low willow the signature takes on a brownish to olive green color (Figure 107). The signature of this map ecotype is very similar to that for Riverine Willow Low Shrub. Consistent spectral diagnostic characteristics separating these two low shrub types are often lacking. The best strategy for distinguishing between these types may be to use a physiography map in conjunction with satellite imagery.

Figure 105. Overview of training polygons Plot_GID 30073 (solid red, upper right), Plot_GID 30068 (solid red, center), and Plot_GID 30048 (solid red, lower left) for Upland Willow Low Shrub and adjacent Upland Alder-Willow Tall Shrub (dashed yellow), Noatak National Preserve, Alaska. (Image ID Uwls2)

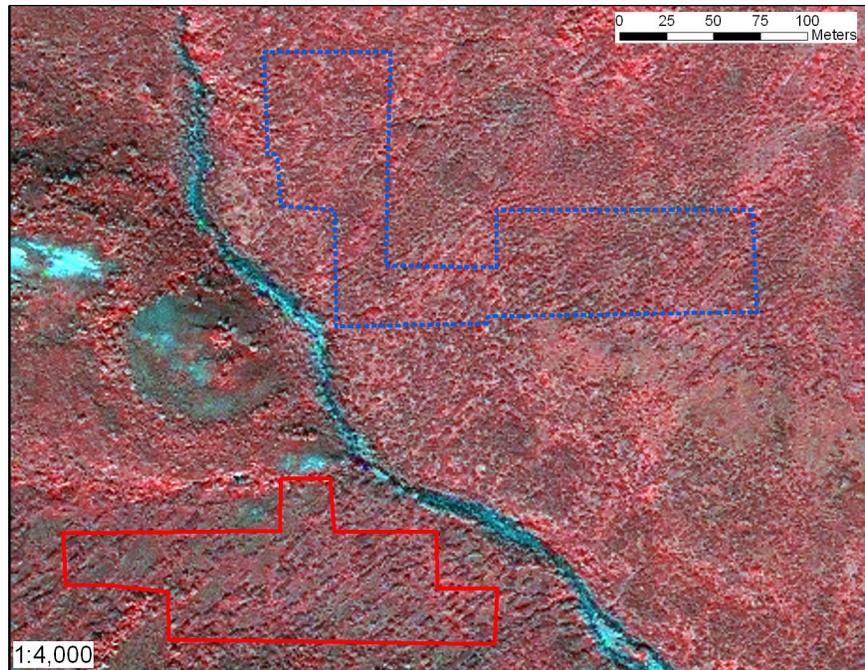


Upland Willow Low Shrub



Figure 106. Close-up of training polygons Plot_GID 30073 (solid red) for Upland Willow Low Shrub and adjacent Upland Alder-Willow Tall Shrub (dashed yellow) showing the contrast between the signatures for upland low and tall willow, respectively, Noatak National Preserve, Alaska. (Image ID Uwls3)

Figure 107. Close-up of training polygon Plot_GID 30048 (lower left) and Plot_GID 30068 (upper right) for Upland Willow Low Shrub showing the detailed signature of this map ecotype when dwarf birch codominates with low willow to form a closed overstory (dashed blue), and when low willow dominates the site forming an open canopy (solid red), Noatak National Preserve, Alaska. (Image ID Uwls1)



Literature Cited

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- Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska Vegetation Classification. Pacific Northwest Research Station, U.S. Forest Service, Portland, OR. Gen. Tech. Rep. PNW-GTR-286. 278 pp.

Appendix 1. Image library crosswalk showing the training polygon Plot GID, IKONOS Image file name, and ImageID for map ecotypes included in the ARCN image library.			
ARCN Abbreviated Map Ecotype Name¹	ImageID²	IKONOS Image	Plot GID³
Alpine Acidic Barrens	Aacb_air		30100
	Aacb1	Or20080629_667	30100
	Aacb2	Or20080913_737	32675
	Aacb3	Or20080629_667	30100
Alpine Alkaline Barrens	Aalb_air		30044
	Aalb1	Or20080906_923	30040
	Aalb2	Or20080906_923	30040 30044*
	Aalb3	Or20060819_051	31919
	Aalb4	Or20060819_051	31919
Alpine Dryas Dwarf Shrub	Adds_air		31904
	Adds1	Or20060830_559	31785* 31787
	Adds2	Or20060830_559	31785 31787*
	Adds3	Or20060819_051	31902* 31904
	Adds4	Or20060819_051	31904
	Alpine Ericaceous Dwarf Shrub	Aeds_air	
Aeds1		Or20070706_802	30001
Aeds2		Or20080807_157	32514 32517*
Aeds3		Or20080807_157	32514
Aeds4		Or20080908_368	32576
Alpine Mafic Barrens	Amb_air1		30263
	Amb_air2		30334
	Amb1	Or20070706_802	30263
	Amb2	Or20080629_667	30334
	Amb3	Or20080629_667	30339
	Amb4	Or20070706_802	30263
Alpine Wet Sedge Meadow	Awsm_air		30319
	Awsm1	Or20080629_667	30319
	Awsm2	Or20080629_667	30349
	Awsm3	Or20080629_667	30319
	Awsm4	Or20080629_667	30349
Lowland Birch-Ericaceous-Willow Low Shrub	Lbewls_air		31964
	Lbewls1	Or20060830_560	31801
	Lbewls2	Or20080707_689	31964
	Lbewls3	Or20080825_687	32643
	Lbewls4	Or20060830_560	31801
Lowland Black Spruce Forest	Lbsf_air		32105
	Lbsf1	Or20080707_689	31975
	Lbsf2	Or20080707_689	32086
	Lbsf3	Or20080820_728	32105

Appendix 1. Continued			
ARCN Abbreviated Map Ecotype Name	ImageID	IKONOS Image	Plot GID
Lowland Ericaceous Shrub Bog	Lesb_air		31966
	Lesb1	Or20070808_133	30055*
			30058
	Lesb2	Or20070808_133	30055
30058*			
Lesb3	Or20080707_689	31966	
Lowland Lake	Ll1	Or20080825_687	32560
Lowland Sedge Fen	Lsf_air		31836
	Lsf1	Or20060819_051	31836*
			31838
	Lsf2	Or20060819_051	31836
			31838*
Lsf3	Or20060808_979	31851	
Lsf4	Or20080913_737	32688	
Riverine Alder or Willow Tall Shrub	Rawts1	Or20080705_005	30169
	Rawts2	Or20080707_689	31947
Riverine Barrens	Rb1	Or20080825_690	32620
	Rb2	Or20080825_690	32620
Riverine Birch-Willow Low Shrub	Rbwls1	Or20060819_053	31783
			31784*
	Rbwls2	Or20060819_053	31783*
			31784
Riverine Dryas Dwarf Shrub	Rdds1	Or20080809_178	30312
	Rdds2	Or20080809_178	30312
Riverine Poplar Forest	Rpf_air		31963
	Rpf1	Or20080707_689	31963
	Rpf2	Or20080707_689	31963
Riverine White Spruce-Willow Forest	Rwswf1	Or20080707_689	32525
	Rwswf_air		32525
Riverine Water	Rw1	Or20070808_134	30042
	Rw2	Or20070808_134	30052
Riverine Willow Low Shrub	Rwls1	Or20080809_178	30081
			30084*
	Rwls2	Or20080809_178	30081*
			30084
Rwls3	Or20060818_556	31908	
Rwls4	Or20060818_556	31908	
Upland Alder-Willow Tall Shrub	Uawts_air		30074
	Uawts1	Or20080707_683	30074
	Uawts2	Or20070711_833	32040
			32042*
	Uawts3	Or20080820_728	32103
Uawts4	Or20080820_728	30074	

Appendix 1. Continued.			
ARCN Abbreviated Map Ecotype Name	ImageID	IKONOS Image	Plot GID
Upland Birch-Ericaceous-Willow Low Shrub	Ubewls_air		30053
	Ubewls1	Or20070808_133	30053
	Ubewls2	Or20080820_728	32101
	Ubewls3	Or20080913_737	32541 32645*
	Ubewls4	Or20080913_737	32541
Upland Dwarf Birch-Tussock Shrub	Udbts_air		31979
	Udbts1	Or20060818_556	31889
	Udbts2	Or20060818_556	31907
	Udbts3	Or20080707_689	31979
	Udbts4	Or20080819_562	32551
Upland Sandy Barrens	Usb1	20060920_174_0080001	32009
	Usb2	20060920_174_0080001	32023
	Usb3	20060920_174_0080001	32023
	Usb_air		32009
Upland Sedge-Dryas Meadow	Usdm_air		32507
	Usdm1	Or20060819_051	31906
	Usdm2	Or20080914_010	32507
	Usdm3	Or20060819_051	31906
Upland Spruce-Birch Forest	Usbf_air		32627
	Usbf1	Or20080825_690	32627 32653*
	Usbf2	Or20080825_690	32627* 32653
Upland White Spruce Forest	Uwsf_air		32111
	Uwsf1	Or20080707_686	32111
	Uwsf2	Or20080807_157	32141
	Uwsf3	Or20080902_963	32561
Upland White Spruce-Lichen Woodland	Uwslw1	20060920_174_0080001	8230
	Uwslw2	20060920_174_0080001	8230
	Uwslw3	20060920_174_0080001	9333
	Uwslw_air		8230
Upland Willow Low Shrub	Uwls1	Or20080707_683	30048* 30068
	Uwls2	Or20080707_683	30048 30068* 30073
	Uwls3	Or20080707_683	30073

*Indicates primary training polygon.

1. See Jorgenson et al. (2009).
2. Abbreviated image name. Refers to images in this report, IDs are included in figure captions, and correspond with IDs in Image Library ThumbsPlus database and geodatabase. Asterisk indicates primary training polygon in image for those images with more than one training polygon.
3. Unique Geographic Identification (GID) number of Jorgenson et al. (2009) training polygons.

Appendix 2. ARCN image library reference image locations by map ecotype.				
ARCN Abbreviated Map Ecotype Name¹	ImageID²	Plot GID³	Latitude (N)⁴	Longitude (W)
Alpine Acidic Barrens	Aacb_air	30100	68.2816535724594	-158.2475749070880
	Aacb1	30100	68.2816535724594	-158.2475749070880
	Aacb2	32675	67.9363639768350	-155.2159534234880
	Aacb3	30100	68.2816535724594	-158.2475749070880
Alpine Alkaline Barrens	Aalb_air	30044	67.7477509983959	-157.1486522999090
	Aalb1	30040	67.7435367186138	-157.1525285954300
	Aalb2	30044	67.7477509983959	-157.1486522999090
	Aalb3	31919	67.1892580246172	-163.2198741620930
	Aalb4	31919	67.1892580246172	-163.2198741620930
Alpine Dryas Dwarf Shrub	Adds_air	31904	67.1940084200511	-163.4420419708340
	Adds1	31785	67.5955622417222	-163.7288137309190
	Adds2	31787	67.5935284909481	-163.7242007859890
	Adds3	31902	67.1873484396405	-163.4353834804060
	Adds4	31904	67.1940084200511	-163.4420419708340
Alpine Ericaceous Dwarf Shrub	Aeds_air	32514	67.5878788594731	-158.2812024610740
	Aeds1	30001	67.4653677018278	-162.3419854641140
	Aeds2	32517	67.5870356651362	-158.2975085656190
	Aeds3	32514	67.5878788594731	-158.2812024610740
	Aeds4	32576	67.3530236083513	-154.7449176121860
Alpine Mafic Barrens	Amb_air1	30263	67.4665636419941	-162.3565582893140
	Amb_air2	30334	68.2901955576372	-158.4366596549390
	Amb1	30263	67.4665636419941	-162.3565582893140
	Amb2	30334	68.2901955576372	-158.4366596549390
	Amb3	30339	68.3025469204352	-158.4471983208790
	Amb4	30263	67.4665636419941	-162.3565582893140
Alpine Wet Sedge Meadow	Awsm_air	30319	68.2759755230237	-158.2572474771280
	Awsm1	30319	68.2759755230237	-158.2572474771280
	Awsm2	30349	68.2794459884842	-158.4297035533850
	Awsm3	30319	68.2759755230237	-158.2572474771280
	Awsm4	30349	68.2794459884842	-158.4297035533850
Lowland Birch-Ericaceous-Willow Low Shrub	Lbewls_air	31964	67.2311563252869	-159.5334040474230
	Lbewls1	31801	67.7452415942929	-163.7773835096170
	Lbewls2	31964	67.2311563252869	-159.5334040474230
	Lbewls3	32643	67.8736215149466	-153.2853458689300
	Lbewls4	31801	67.7452415942929	-163.7773835096170
Lowland Black Spruce Forest	Lbsf_air	32105	67.3794615816014	-159.0489144907950
	Lbsf1	31975	67.2880243192512	-159.2417454512720
	Lbsf2	32086	67.2710066466476	-158.1309333009300
	Lbsf3	32105	67.3794615816014	-159.0489144907950

Appendix 2. Continued.				
ARCN Abbreviated Map Ecotype Name¹	ImageID²	Plot GID³	Latitude (N)⁴	Longitude (W)
Lowland Ericaceous Shrub Bog	Lesb_air	31966	67.2312880098600	-159.5378533178600
	Lesb1	30055	68.0613027491849	-158.7669260143410
	Lesb2	30058	68.0627229545513	-158.7721783652910
	Lesb3	31966	67.2312880098600	-159.5378533178600
Lowland Lake	Ll1	32560	67.8753423017558	-153.2756072743060
Lowland Sedge Fen	Lsf_air	31836	67.1849256213346	-163.6036897464500
	Lsf1	31836	67.1849256213346	-163.6036897464500
	Lsf2	31838	67.1844700401492	-163.6016003737400
	Lsf3	31851	67.6909914276583	-164.0405000451580
	Lsf4	32688	67.9290395325007	-155.0365033224580
Riverine Alder or Willow Tall Shrub	Rawts1	30169	67.9024840080848	-162.5113426477540
	Rawts2	31947	67.2246809715393	-158.5507992492080
Riverine Barrens	Rb1	32620	67.3012738009452	-153.4171094445640
	Rb2	32620	67.3012738009452	-153.4171094445640
Riverine Birch-Willow Low Shrub	Rbwls1	31784	67.4729502582148	-163.7292090438370
	Rbwls2	31783	67.4749306760874	-163.7295904438880
Riverine Dryas Dwarf Shrub	Rdds1	30312	68.0571825468614	-157.8367042890120
	Rdds2	30312	68.0571825468614	-157.8367042890120
Riverine Poplar Forest	Rpf_air	31963	67.2428837462910	-159.6631900135270
	Rpf1	31963	67.2428837462910	-159.6631900135270
	Rpf2	31963	67.2428837462910	-159.6631900135270
Riverine Water	Rw1	30042	68.0303817309704	-158.7152006672080
	Rw2	30052	68.0223513990583	-158.7235313820290
Riverine White Spruce-Willow Forest	Rwswf_air	32525	67.2430594834620	-159.6670541354990
	Rwswf1	32525	67.2430594834620	-159.6670541354990
Riverine Willow Low Shrub	Rwls1	30084	68.0561343556720	-157.8255362528100
	Rwls2	30081	68.0554489935250	-157.8246928061790
	Rwls3	31908	67.3125784305954	-163.3747671351910
	Rwls4	31908	67.3125784305954	-163.3747671351910
Upland Alder-Willow Tall Shrub	Uawts_air	30074	67.7053733410731	-158.9096705032330
	Uawts1	30074	67.7053733410731	-158.9096705032330
	Uawts2	32042	66.9832543072792	-158.9827872224730
	Uawts3	32103	67.3838250329164	-159.0602550330560
	Uawts4	32103	67.3838250329164	-159.0602550330560
Upland Birch-Ericaceous-Willow Low Shrub	Ubewls_air	30053	68.0611141883901	-158.7565674389920
	Ubewls1	30053	68.0611141883901	-158.7565674389920
	Ubewls2	32101	67.3869183345604	-159.0711684331140
	Ubewls3	32645	67.9269758855805	-155.0322556537080
	Ubewls4	32541	67.9293342659027	-155.0447843663810

Appendix 2. Continued.				
ARCN Abbreviated Map Ecotype Name¹	ImageID²	Plot GID³	Latitude (N)⁴	Longitude (W)
Upland Dwarf Birch-Tussock Shrub	Udbts_air	31979	67.2767888842512	-158.5772158724860
	Udbts1	31889	67.3311131818688	-163.4919859964140
	Udbts2	31907	67.3022694532415	-163.3839234545050
	Udbts3	31979	67.2767888842512	-158.5772158724860
	Udbts4	32551	68.0617575147134	-153.7321711596810
Upland Sandy Barrens	Usb_air	32009	67.0977279784385	-159.0181525590650
	Usb1	32009	67.0977279784385	-159.0181525590650
	Usb2	32023	67.0296793220508	-158.7780665749930
	Usb3	32023	67.0296793220508	-158.7780665749930
Upland Sedge-Dryas Meadow	Usdm_air	32507	67.5343258531817	-157.8555088208270
	Usdm1	31906	67.1988972454806	-163.4516993134320
	Usdm2	32507	67.5343258531817	-157.8555088208270
	Usdm3	31906	67.1988972454806	-163.4516993134320
Upland Spruce-Birch Forest	Usbf_air	32627	67.3146720563166	-153.4546694017680
	Usbf1	32653	67.3135267115673	-153.4601994355360
	Usbf2	32627	67.3146720563166	-153.4546694017680
Upland White Spruce Forest	Uwsf_air	32111	67.4772455079918	-159.6068332843600
	Uwsf1	32111	67.4772455079918	-159.6068332843600
	Uwsf2	32141	67.5771600991050	-159.3352059501680
	Uwsf3	32561	67.3444845741024	-154.7091808487020
Upland White Spruce-Lichen Woodland	Uwslw_air	8230	67.0040553631854	-158.8124145763750
	Uwslw1	8230	67.0040553631854	-158.8124145763750
	Uwslw2	8230	67.0040553631854	-158.8124145763750
	Uwslw3	9333	67.0214258530904	-158.8671862277130
Upland Willow Low Shrub	Uwls1	30048	67.7014953701696	-158.9104026205270
	Uwls2	30068	67.7032706032846	-158.9083414016570
	Uwls3	30073	67.7080975580337	-158.9036654290880

1. See Jorgenson et al. (2009)
2. Abbreviated image name. Refers to images in this report, IDs are included in figure captions, and correspond with IDs in Image Library ThumbsPlus database and geodatabase.
3. Unique Geographic Identification (GID) number of primary training polygon in the image.
4. Locations for each reference image were calculated using the ArcToolbox "Feature to Point" tool, which determined the centroid (Lat./Long, decimal degrees, NAD83 Alaska Albers) of the training polygon(s) depicted in each image. For those images with multiple training polygons, the centroid of the primary training polygon in the image was used to denote the image location.

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National Park Service
U.S. Department of the Interior



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