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Katmai National Park and Preserve Landcover Mapping Spectral Database Modeling and Final Map Compilation

Natural Resource Technical Report NPS/KATM/NRTR—2003/003

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National Park Service Katmai Landcover Mapping
Spectral Database Modeling and Final Map Compilation

1.0 Spectral Database and Calculated Map Classes

Landsat TM 7 data were acquired from the Eros Data Center and orthorectified by RGI, Inc. These images were corrected for illumination by Geographic Resource Solutions (GRS) who also conducted the spectral classification. Initial spectral classification efforts centered on analysis of supervised training sets. Unique spectral signatures were identified and assigned vegetation attributes according to the available field data. Subsequent processing generated unsupervised signatures. These signatures were evaluated and assigned attributes according to their similarity to the original supervised training sets. The resulting group of supervised and unsupervised signatures were evaluated for spectral/environmental consistency and compiled to form a spectral database.

Map classes were calculated for each signature based the vegetation attributes in the spectral database and a rule set that followed Viereck,et.al (1992) class breaks and naming conventions. The calculated map classes were intended to correspond to the important ecological types encountered in the study area. As a result the 1300+ signatures which were found in the spectral database were grouped into 37 calculated map classes. These calculated map classes were:

White Spruce: Wdlnd
White Spruce:Open
Stunted Spruce:Wdlnd
Stunted Spruce:Open
Mixed Deciduous-Conifer:Wdlnd
Mixed Deciduous-Conifer:Closed
Mixed Deciduous-Conifer:Open
Balsam Poplar:Wdlnd
Birch:Wdlnd
Mixed Deciduous:Wdlnd
Balsam Poplar: Open
Birch:Open
Mixed Deciduous:Open
Balsam Poplar: Closed
Birch:Closed
Mixed Deciduous:Closed
Tall Shrub:Open:Alder
Tall Shrub:Open:Alder-Willow
Tall Shrub:Open:Mix
Tall Shrub:Open:Willow
Tall Shrub:Closed:Alder
Tall Shrub: Closed:Alder-Willow
Tall Shrub:Closed:Mix
Tall Shrub:Closed:Willow
Low Shrub:Open :Mix
Low Shrub:Open:Alder-Willow
Low Shrub:Closed Mix
Dwarf Shrub
Herbaceous:Forb
Herbaceous:Graminoid
Herbaceous:Moss
Lichen
Sparse Vegetation
Barren
Snow/Glacier
Water
Terrain Shadow

For a complete discussion on the spectral classification, please refer to: Katmai National Park and Preserve Landcover Mapping Project Final Report – December 16, 2002 as prepared by GRS.

2.0 Signature Database Edits

After completion of the spectral classification, the spectral database was provided to National Park Service (NPS) Landcover Mapping Program for review. There are a variety of errors that can be associated with the results of spectral classification. They can be expected to include:

1) Field data can be erroneous or incorrectly interpreted. This will result in the incorrect assignment of class type to a signature. Observer error is especially problematic in “shoulder” ranges where one type name changes to another type name. Minor variation in observer estimates of cover at these shoulder ranges can result in major changes in signature naming.

2) Signatures can perform well in a limited area or self classify however extension of the signature throughout the study area can result in misclassification. This is especially true in woodland and open canopy classes where understory has a larger role in determining spectral reflectance at the site.

3)Due to restrictions in field time/money and logistical constraints it was not possible for field teams to visit all areas and vegetation types within the Park. Subsequent visits to the Park provided additional data however they were not available in time for the spectral processing.

During NPS review of the spectral database, additional field data were used together with high altitude aerial photography to verify calculated map class types throughout the study area. As a result of this review, a number of modifications were adopted. Initial edits were performed on the spectral database and signatures were reassigned to class types based on interpretation of the available field data. Several classes were determined to be unreliable and were lumped. The Dwarf Shrub mapping class, which is a dominant type throughout the study area, was split in an effort to identify the diversity of this class. Similarly a wet graminoid/forb class was developed from the herbaceous classes to represent the extensive wet herbaceous areas within the study area.

One signature (trsite-id **=** 3604) appeared to represent a variety of field data types and could not be satisfactorily reassigned to any one map class. The pixels used in this signature came from a ridge crest that was significantly modified by the illumination correction. Because the signature came from both the shadowed and illuminated sides of the hill, the minor misregistration of the DEM used in the illumination correction had a large impact on this training set. Pixels assigned to this signature were removed from the classification and values for those pixels were reassigned based on a 3x3 majority filter.

All edits were performed in a systematic and repeatable manner with no manual pixel editing. A brief summary of the reclassification of the spectral database is provided below. New map classes are described according to the original calculated map classes that were assigned to class. Individual spectral signatures that were reassigned to a new class are indicated by the number (trsite-id) in parenthesis. As a result a final set of 21 landcover map classes was adopted.

Closed Spruce Forest White Spruce:Closed

Open Spruce Forest = White Spruce:Wdlnd, White Spruce:Open, Dwarf Shrub (51058), Mixed Deciduous-Conifer:Wdlnd (51010, 51020), Herbaceous:Forb (80807), Stunted Spruce:Open (10311), Stunted Spruce:Wdlnd (3050)

Spruce Woodland = see winter mask descriptions.

Cottonwood/Poplar Forest = Balsam Poplar Closed, Balsam Poplar Open, Mixed Deciduous Open (53021, 53030, 53058, 57039), Birch:Closed (80815)

Birch Forest = Birch Closed, Birch Open, Mixed Deciduous:Closed (80712), Mixed Deciduous (10098), Mixed Deciduous:Open (51024, 51031, 55037), Tall Willow (80804) outside of spruce mask.

Mixed Deciduous/Conifer Forest = Mixed Deciduous-conifer:Wdlnd, Mixed Deciduous-Conifer:Open, Mixed Decidiuous-conifer:Closed

Tall Alder Shrub = Tall Shrub:Closed:Alder, Tall Shrub:Open:Alder, Balsam Poplar:Wdlnd (81011, 10047, 10174, 10215, 51045, 51048, 55057), Birch:Wdlnd (80534, 80520, 80509, 10169), Mixed Deciduous:Wdlnd (10154, 53013, 53022), Balsam Poplar:Open (80707, 10158, 10176), Mixed Deciduous:Open (10160), Balsam Poplar:Closed (10187), Birch:Open (80705), Tall Shrub:Open:Alder-Willow (81224, 81107, 51101, 51117, 53003, 53020, 53024, 53045, 53077, 55003, 55010, 55047, 55121, 55128, 55135, 55167, 55175, 55026, 57010, 57023,), Tall Shrub:Open:Willow (80710, 10155, 80817), Tall Shrub:Closed:Alder-Willow (80818, 80714, 80716, 80527, 80603, 81116, 81114, 81110, 80728, 10262, 81002, 55086, 55129), Tall Shrub:Closed:Mix (3704, 10140), Tall Shrub:Open:Mix(53086, 57116, 57174), Tall Willow Shrub (80804) in spruce mask but not willow mask, Tall Shrub:Open:Alder (57090, 57137) on slopes greater than 10% and in shadow mask.

Tall Willow Shrub = Tall Shrub:Open:Willow, Tall Shrub:Closed:Willow, Birch:Wdlnd (80813, 51054, 51100, 53012, 55056, 55122), Balsam Poplar:Open (80704), Mixed Deciduous:Wdlnd (51005, 55044, 55109), Mixed Deciduous-Conifer:Wdlnd (51006, 51028, 53037), Tall Shrub:Open:Alder-Willow (51081, 51082, 53014, 53018, 55063, 55102)

Low Willow Shrub = LowShrub:Open:Willow, Low Shrub:Open:Mix (81230), Low Shrub:Open:Alder-Willow (55096)

Mixed Low/Dwarf Shrub = Low Shrub: Closed:Mixed, Low Shrub:Open:Mix, Low Shrub Open:Willow (10161, 10132)

Dwarf Shrub = Dwarf Shrub, Low Shrub:Open:Mix (1084, 10295, 10300), Herbaceous:Forb (55078), Low Shrub:Open Willow (55108)

Dwarf Shrub/Mesic Herbaceous = Dwarf Shrub (80624, 10072, 10089, 80525, 80519, 81218, 10081, 80610, 81205, 81210, 80609, 80614, 80613, 80617, 81127, 80628, 80619, 81120, 80604, 53016, 53029, 55029, 55093, 55138, 55139, 55207, 57002, 57020, 57002, 57031, 57121) These classes were initially chosen using search criteria that reselected dwarf shrub classes where the dws was less than the herbaceous and the herbaceous was greater than 40%. Additional selection through interpretation was performed. White Spruce Woodland (80510, 81215, 80412, 80607)

Dwarf Shrub/Bryophyte = Herbaceous Moss

Mesic Herbaceous = Herbaceous Forb, Herbaceous:Graminoid, Birch:Wdlnd (10183, 57009), Mixed Deciduous Open (80801), Mixed Deciduous Wdlnd (57074), Tall Shrub:Open:Alder (57107, 57061) Tall Shrub Closed Alder (57013), Tall Shrub:Open:Willow (1045, 1049, 10175), Tall Shrub:Closed:Willow (1077, 10108)

Wet Herbaceous = Forb:Herbaceous/Wet (except for 2102,80807), Herbaceous:Forb with Major_class **=** Forb:Dry:Mesic (10301), Tall Shrub:Open:Alder (57090, 57137) on slopes less than 10% and outside of the shadow mask. Dwarf Shrub(81211, 55048, 55064)

Lichen = Lichen

Sparse Vegetation = Sparse Vegetation

Barren = Barren

Snow/Glacier = Snow/Glacier

Water = Water

Shadow/Unclassified = Shadow/Unclassified

Clump/Eliminate processing was performed after reclassification to remove single pixels from the classification. If a pixel was surrounded on all sides by dissimilar pixels, the pixel was reassigned to the majority map class in a 3x3 window surrounding the single pixel (see below: 4.0 Final Processing and Minimum Mapping Unit)

3.0 Ecological Interpretation and Modeling

Spectral classification provides an important first interpretation of satellite images according to the various “colors” of the image. However map making generally includes ecological interpretations that rely on analyst knowledge of the study area. Ecological interpretation is generally incorporated in the digital map making process through ancillary data or models that are used together with the results of spectral analysis. The following discussion describes various postprocessing models that were applied to the results of the spectral evaluation and reclassification by NPS.

1) **Water mask**

Significant confusion between water, conifer, shadow and wet herbaceous was noted during review of the spectral database. In an effort to successfully classify herbaceous areas during spectral analysis a pronounced misclassification of water was produced. In addition a slope mask had been used in generating the spectral database to minimize water misclassification in shadows. The slope mask had resulted in artifacts between DEM tiles within water areas and in areas of steep shoreline. A water mask was developed from the images used in the analysis to overcome these problems.

This water mask was derived from a summation of bands 4 and 5. Both these bands are very sensitive to water absorption. Band 4 by itself was unsatisfactory since sedimentation produced too much variability in the water threshold. Band 5 by itself was unsatisfactory since solid water (ice and glacier) was as absorptive of band 5 as liquid water. However the sum of these bands provided an index with a reliable threshold for the discrimination of liquid water bodies from the surrounding solid land. Shadow areas within the mask remained problematic as they could not be distinguished from water and a slope mask was developed from the available DEM that identified slopes over 10°. Areas of the water mask that occurred on slopes >10° were eliminated. The resulting water mask was merged with the classification. Figure 1a-d compares the original classification with the the results of the water mask for selected areas within the study area.

Figure 1a: Original Classification

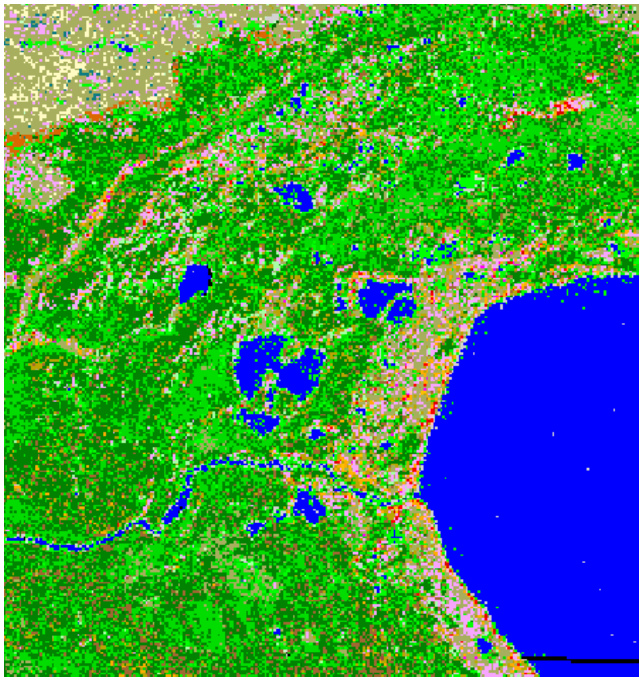
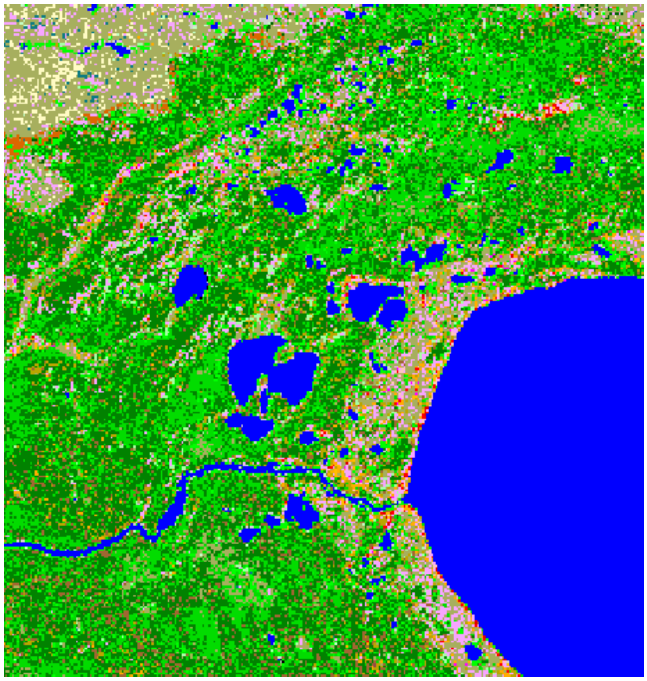


Figure 1b: Final Classification with water mask



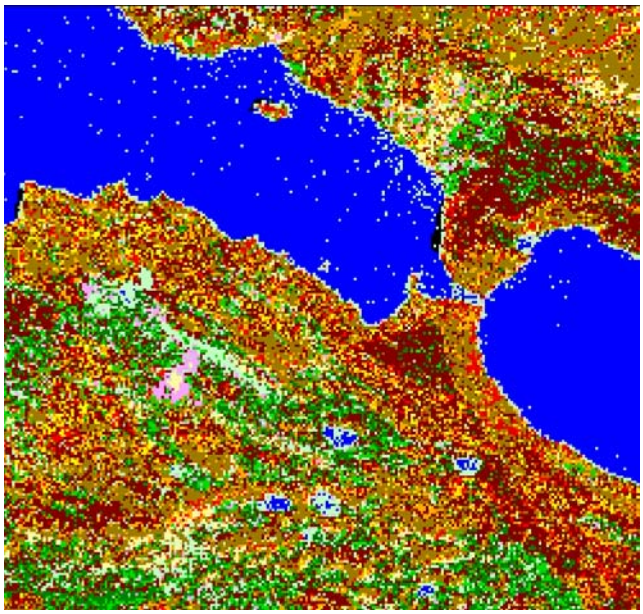


Figure 1c: Original Classification

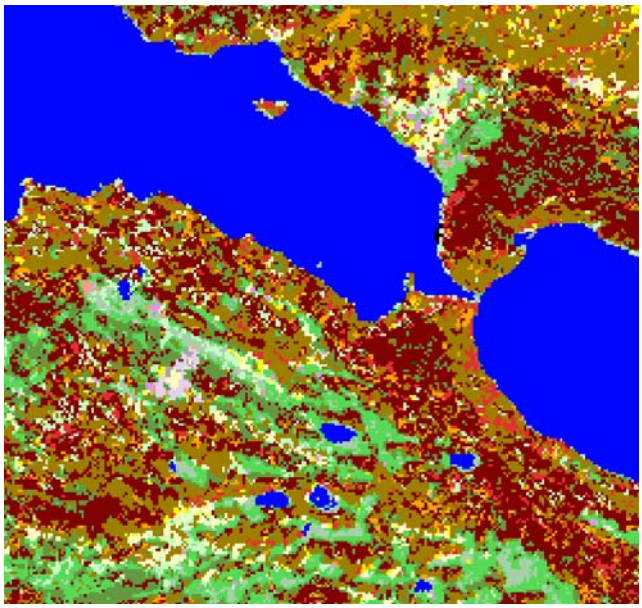


Figure 1d: Final Classification with water mask

4) **Winter image masks**

As mentioned above water and conifer can be confused spectrally. In fact a broad range of wet vegetation types (bog, wet herbaceous) are generally misclassified using only spectral information. A winter image for the study area (path 71, row 19, January 3,1999) was purchased and coregistered with the existing classified product. Initial evaluation of the image revealed significant shadowing from large mountains due to the low sun angle. Band 1 provided the best penetration of these shadow areas and was selected for analysis. Thresholds were evaluated in areas where known dense conifer stands were confused with wet vegetated areas. A conservative threshold was identified that was most effective in identifying conifer from wet areas and a mask (wintermask) was generated. Figure 2a-d represent the original image, the winter image, the classification before the winter mask and the classification after application of the mask for discriminating dense conifer and mixed conifer/deciduous from wet areas. In addition figures 1c-d also demonstrate areas of winter image conifer correction.

Figure 2a: Original Image

Figure 2b: Winter Image

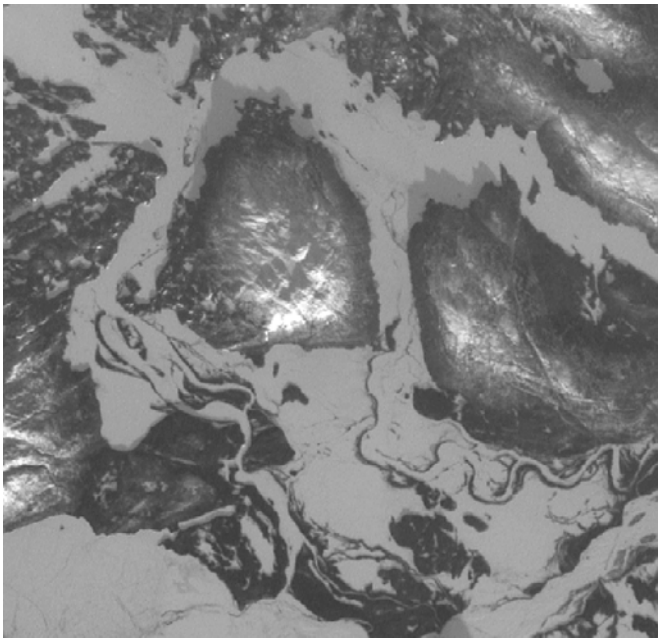


Figure 2c: Original Classification

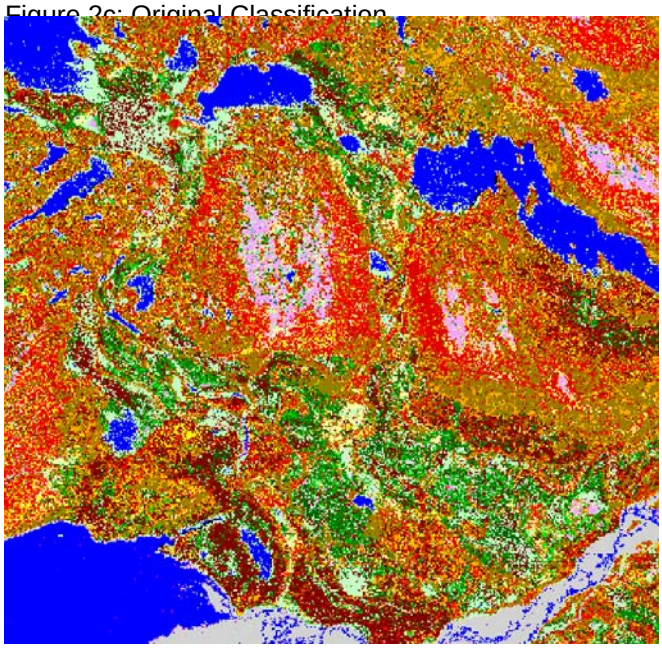
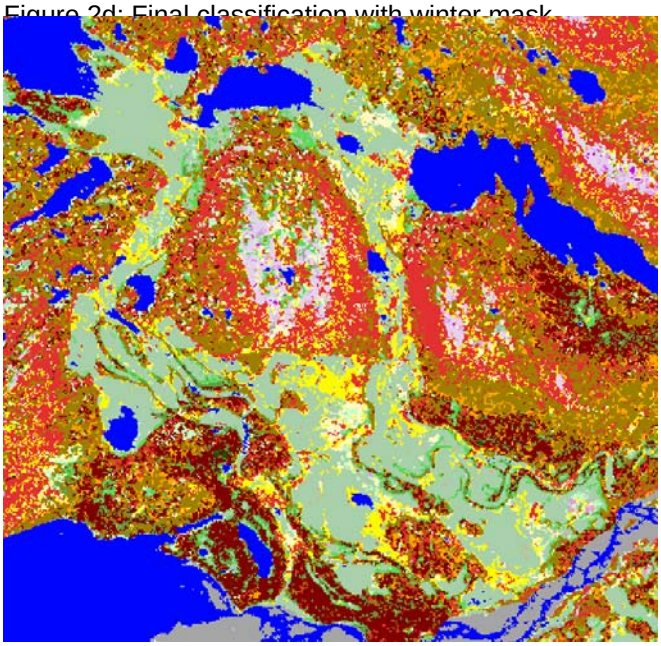


Figure 2d: Final classification with winter mask



During evaluations it became apparent that a breakpoint could be identified that would allow areas of lower density conifer and deciduous cover to be identified and another mask (wintermask2) was generated. The winter image masks were used together for additional reclassification as described below:

Conifer Woodland: Dwarf shrub:conifer woodland, conifer and mixed deciduous areas that occurred in wintermask2 and not in wintermask were reclassified as conifer woodland. Dwarf shrub:conifer woodland that occurred in wintermask was reclassified as open conifer. Dwarf shrub conifer woodland that occurred outside of either mask area was reclassed to dwarf shrub. Masking used to remove conifer was compromised by topographic shadowing in the winter image and resulted in wintermask2 areas that were known through field work and photo interpretation to have no conifer (see 5-Nospruce Masks below). An additional postprocessing spruce mask was used in this area to eliminate spruce misclassification.

Birch/Balsam Poplar: In the original classification balsam poplar appeared more widely in upland, nonriparian, areas than were indicated by the field data. Balsam poplar which occurred in wintermask2 was evaluated versus that which occurred outside of the mask. Birch that occurred outside of wintermask2 was generally in floodplains. A review of existing field data suggested that the balsam poplar outside wintermask2 should be recoded to alder and birch recoded to willow.

4) **Shadow Mask**
The illumination correction that was used to preprocess the satellite imagery appeared to have successfully minimized the impact of terrain shadow on spectral classification. However in areas of extreme topography some problems were still noted. In particular herbaceous, water and mixed shrub classes were represented erroneously in areas of dark shadow.

A mask was generated by level slicing that corresponded to dark areas in the image (Figure 3a-b). Slope was used to separate the steep shadow areas from the confusing water bodies and other dark objects and the resulting output was used as a shadow mask. The graminoid/forb, wet graminoid/forb and mixed shrub pixels that fell within the shadow mask were extracted from the image and reclassified (Figure 3c). The graminoid/forb and wet graminoid/forb that were within the shadow mask were reclassified based on photo interpretation as sparse. The mixed shrub was reclassified as alder. Water was reclassified as unknown. These reclassified pixels were then merged with the classified image, replacing the original classification values.

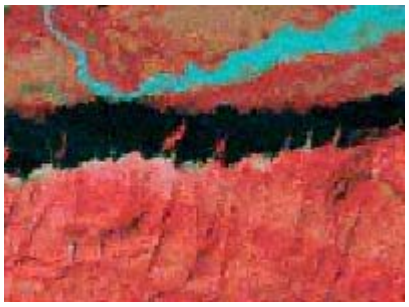


Figure 3a: Original Image

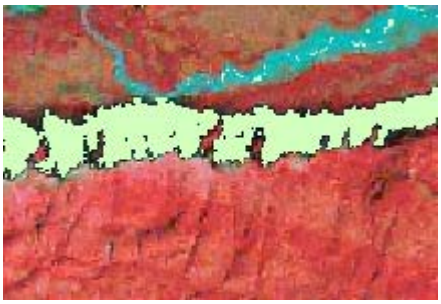


Figure 3b: Shadow areas

Figure 3c: Class extraction

A 3x3 majority filter was applied to unknown pixels in the final classification to reduce the occurrence of this class.

5) **Distribution Masks**
Large portions of the study area have no spruce. To minimize spectral misclassification a nospruce polygon was delineated (Figure 4a) manually using field data and photo interpretation. Mixed deciduous/conifer and spruce signatures were not used during spectral classification within the nospruce zone. During subsequent processing spruce and mixed spruce/deciduous that were generated from masking were removed from these areas. A smaller postprocessing nospruce mask was also defined for use with the winter image masking.

Figure 4a: Spruce Masks

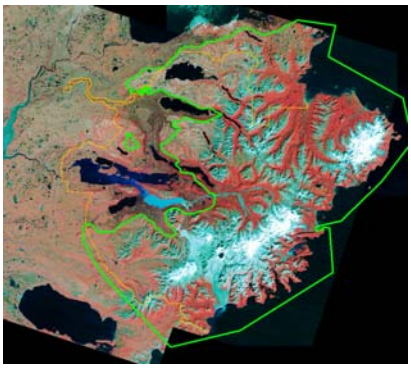


Figure 4b: Birch Mask

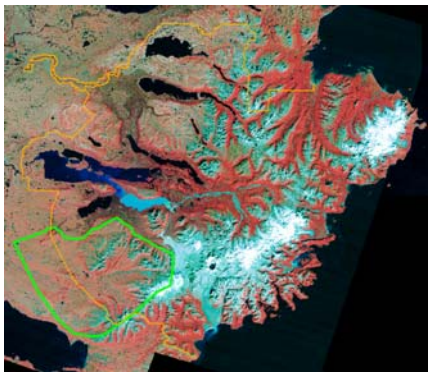
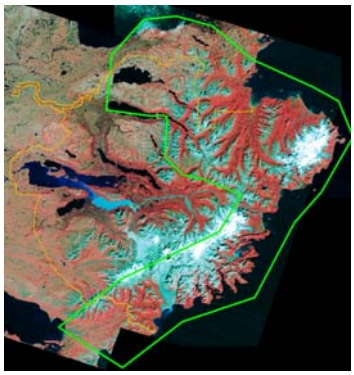


Figure 4c: Balsam Poplar Mask



6) **Birch Mask**
A Birch Mask (Figure 4b) was defined based on field data for the region of the Park where birch was expected to be rare or not to occur. All birch from the original spectral classification was reclassed to alder based on a review of the field data and air photos.

7) **Alder Mask**
Tall Shrub:Open:Alder (57090, 57137) that occurred on slopes less than 10% were reclassed toGram/Forb:Wet while occurrences on slopes greater than 10% were classified as Tall Shrub:Alder.

7)Willow Mask
The Tall Willow (80804) signature produced misclassification with birch and alder in particular regions of the Park. A review of field data and photography indicated confusion with birch outside of the spruce mask. Wtihin the spruce mask signature 80804 was alder except for an area in the southeast of the Katmai River.

9) **Balsam Poplar Mask**
A Balsam Poplar Mask (Figure 4c) was defined during spectral editing. Birch and balsam poplar occurred in mixed stands east of the Aleutians. Although mixed stands are common along the southeast coast they are rare near Cape Douglas. Signature 80712 was taken from a mixed stand on the southeast coast and produced very heterogeneous results on classification especially along the northeast. Two birch signatures (80815 and 80802) also produced a pronounced heterogenous overclassification of birch within the northeast region of the Park. These signatures were extracted from the original classification and clump/eliminate was used to remove groups of less than 3 pixels. These larger groups of birch were felt to represent more reliable classifications. The resulting classification was verified using existing field data and included in the classification.

4.0 Final Processing and Minimum Mapping Unit

A single pixel (30x30m) represents approximately 0.02 acres. Although single pixels may be indicative of variability within more homogeneous areas, they cannot be expected to be reliably classified since the radiance value for that pixel is generally a mixture of adjacent types. It is generally expected that a homogeneous 5x5 pixel area (5.5 acres) is the minimum area that can be reliably classified. The above models were based on signature values rather than mapping classes which introduced single pixel values to the classification. Consequently clump/eliminate processing was used to remove the resulting single pixel values.

As a result heterogeneity based larger pixel grouping (2 pixels and above) is still represented in the final classification. The minimum identifiable feature should be considered to be at least a 5x5 pixel homogeneous area (about 5.5 acres). When using the map it is important to consider size of the subject area and the relative contrast of the surroundings. Evaluation of the map should include consider adjacent types particularly for areas smaller than 5-10 acres.

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