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Grand Teton National Park: NAIP Imagery Analysis Procedures Report

Background:

NASA, the USGS, and NOAA are all sources of free remotely sensed data available to federal agencies and educational institutions. Following their model the Farm Service Agency (Ogden, UT) has been leading a recent program in fine resolution image acquisition for the United States termed the National Aerial Imagery Program (NAIP). Initially developed as a method of tracking national crop coverage; the utility of the dataset has been noted by a variety of groups. The advantages of the program include a high quality, both geometrically and radiometrically, dataset that is being collected on a fairly timely basis for some applications, on the order of 3 to 5 years, and at fine spatial resolution of 1m. WyGISC has previously tested the utility of the dataset for land cover mapping in Wyoming. The purpose of this project that developed the following procedure is to provide the Park with a method of monitoring that can be performed by the resources currently available. The Park and technology have recently been enabled to deal with a large volume of data as provided by the NAIP program. The Park GIS section uses both ERDAS and ESRI geospatial software and the procedure developed relied on these two alone while providing a superior high resolution dataset for monitoring.

Below is part of a monitoring tool I developed for Grand Teton National Park.   The park needed an efficient method of monitoring the effects of Global Warming to park habitat resources.   Concerns of park biologists ranged from changing fire regimes to declining aspen distribution, glacier retreat, alpine-treeline shifts, and insect infestation events.

The technique uses free remotely sensed imagery that is being collected every few years by federal agencies. The technique creates a biomass monitoring tool for the Inventory and Monitoring (I&M) Programs of the Park. Geospatial analysis of the data includes Park-wide statistical tests and appending the biomass values to the park I&M vegetation stand delimitation layer. The biomass layer is generated with sophisticated statistical spatial neighborhood analysis of biophysical features derived from the remotely sensed data at 1 meter spatial resolution. I and a small group of collaborators call this technique the spectral-spatial metrics analysis approach.

Methods:

In the following methods I will outline the steps taken as to allow Park staff to repeat the processing performed. All steps performed in ERDAS except those that are underlined. It is assumed that at each step the results are verified by viewing the step-products and the data metadata in ERDAS or ESRI and by spot checking specific cell values in the input and output files as appropriate.

Methods steps follow:

1. Import NAIP county mosaics of natural color and color infrared orthophotographs into ERDAS Imagine format.
2. Use Layer Stack command to combine NIR, red, green, and blue bands in that order into one four band file. Keep track of band combination order. *Original 3 band ERDAS versions of the county mosaics can be deleted at this point.*
3. Create a park boundary buffered subset of the 4 band orthophotographs in ERDAS format (metrics themselves require at least half the metrics window width, in this case fifteen meters or pixels, a buffer for administrative or user requirements may also be included). In the test case the window was set visually/manually by viewing the 4 band orthophotographs with the park boundary and using the Inquire Box function to define a subset. The Subset command is used with the input of 'From Inquire Box' activated to define the subset definition.
4. Using the Model Maker utility run a set of ERDAS graphical models (*.gmd files) to produce spectral-spatial metrics from 4band:
    a. Run Normalized Difference Vegetation Index (NDVI) model to produce 16bit NDVI from NDVI and Red bands generated in step2. Input needs to be defined as floating point. Product should be defined as 16bit float-single format.
    b. Run 30 pixel window standard deviation of NDVI model. Product should be defined as 16bit, float-single format.
    c. Run 30 pixel window mean of NDVI model. Product should be defined as 16bit, float-single format.
    d. Run Brightness model (all band average produced). Product should be defined as 8 bit, continuous format.
    e. Run 30 pixel window standard deviation of image Brightness. Product should be defined as 8 bit, continuous format.
    f. Run 30 pixel window mean of image Brightness. Product should be defined as 8 bit, continuous format.
    g. Use LayerStack command to combine NDVI 30m window mean and standard deviation, and Brightness 30m window mean and standard deviation into one 4 band file.
    h. Use Subset command and Inquire Box in Viewer to remove edge pixels (at least 30) of layer generated from step g. Product is the Spectral-Spatial layer that can be saved for repeat analysis all previous step products can be deleted.
5. Use Unsupervised Classification tool to create an ISODATA algorithm derived cluster file from the Spectral-Spatial metric information. In this case the Spectral-Spatial metric information was

too large for either the computer being used, the computer software possibly including ERDAS, or both and the Spectral-Spatial Metrics were converted to 2m pixels from 1m using the Degrade command. The Degrade function is 2. The degraded 4band Spectral-Spatial Metrics are essentially the average of four pixels at a time across the data. The 2m degraded product was analyzed with Isodata to reduce data dimensionality. Isodata parameters included generation of a signature file, initializing clusters along a Principal Component with the data Statistics, and 100 clusters generated.

6. Use visual analysis of the cluster layer and orthophotographs in a 'Linked' set of viewers to label the clusters on a relative scale of biomass values. The clusters should already be relatively ordered by vegetation biomass and life form as a result of choosing a Principal Component Axis to initialize the Isodata statistics. Use the Park Inventory and Monitoring (I&M) Vegetation Stand layer and field plot data to corroborate the visual image interpretation. Confusing areas can be field visited. I keep track of the cluster interpretation in they layer's associated Raster Attribute Editor. I added two columns to the layer's attribute table one as Short-Integer labeled Code, the other was a string attribute 50 characters wide for 'Description'. The clusters were labeled to the following relative scale:

     1)   Less than 1% cover e.g. bare ground, water
     2)   Minimal cover, < 1%
     3)   Low cover, < 5%
     4)   Low shrub cover, < 10%
     5)   Medium shrub cover, < 20%
     6)   High shrub cover, > 20%
     7)   Low tree cover, < 25%
     8)   Medium tree cover, < 40%
     9)   High cover
     10)   Maximum cover
     11)   Maximum cover – wet areas.

7. Use the recode command to convert the 100 cluster file to the numerically coding noted above. Label and color code the recode output using the Raster Attribute Editor. Results are shown below in Figures 1 and 2.

8. Desired minimum mapping units (MMU) beyond the single pixel level can be generated by using the Clump and then Sieve commands.

9. Analysis of the data can include many uses. The park-wide statistics of the 11 classification classes can be generated for available years of orthophotographs and park-wide comparisons of the data could use a Chi-Square test to the class histograms across years. On a stand basis the Park I&M vegetation layer can be compared to the classified layer. Further, in ESRI we can intersect the vegetation layer to the classified data to produce a Zonal Statistics table that collects desired attributes such as the median classified value per stand. These tables of stand statistics can then be used as a monitoring tool for those years with available imagery. A Join or Append can be used to attribute the Park I&M Vegetation layer if desired, see figure 3.

    a. Verification of the layer and generating of field sample updates can be accomplished as part of the regular I&M sampling missions.
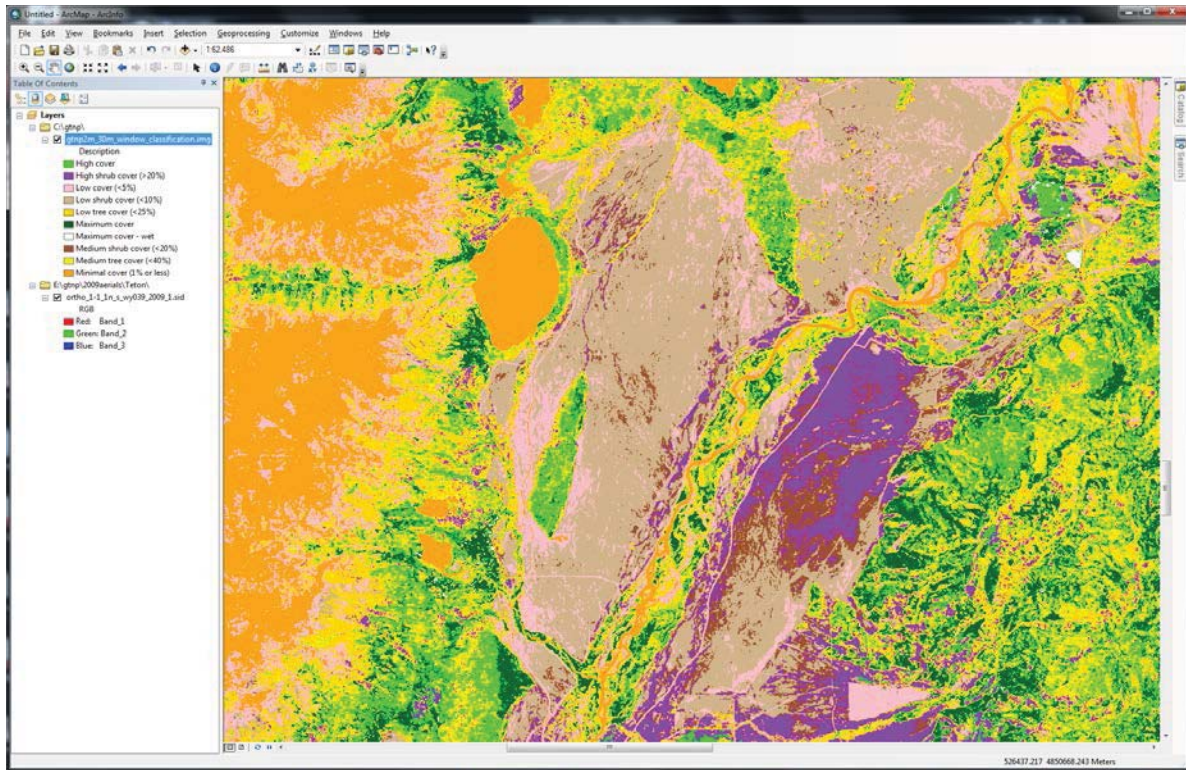
Figure 1. The Spectral-Spatial Metrics based classification of cover for an area of the Park.
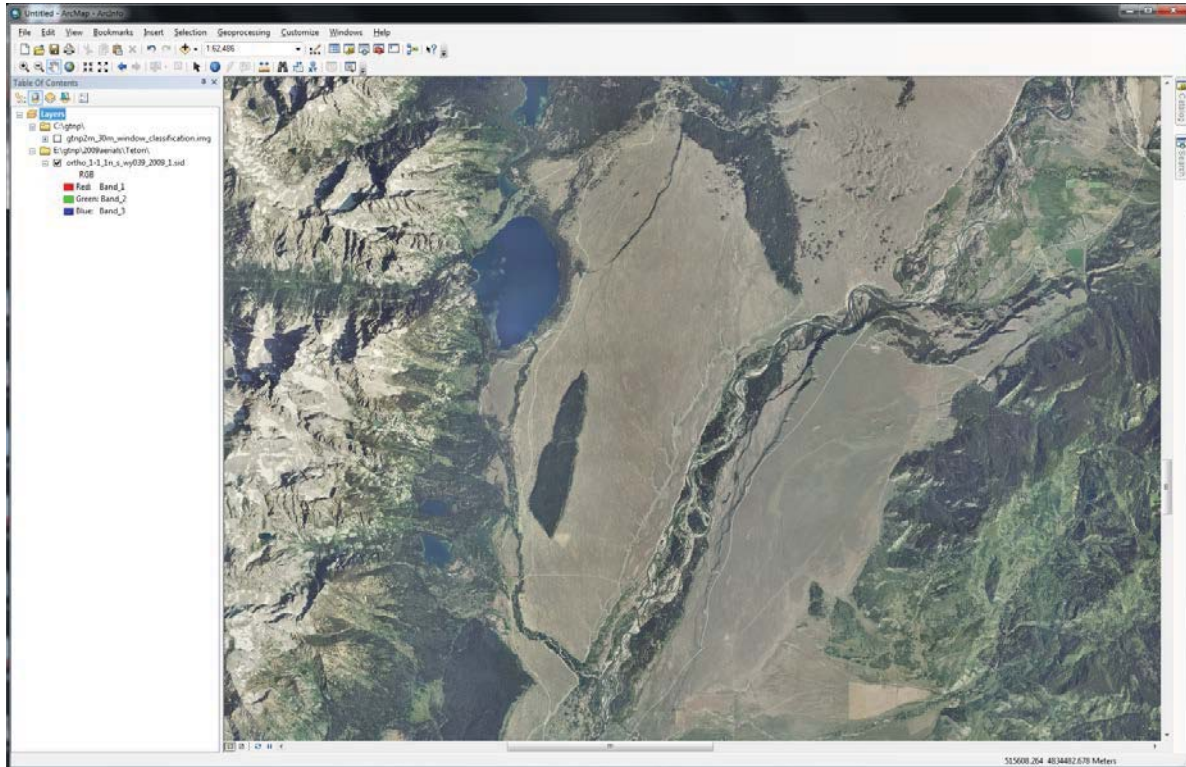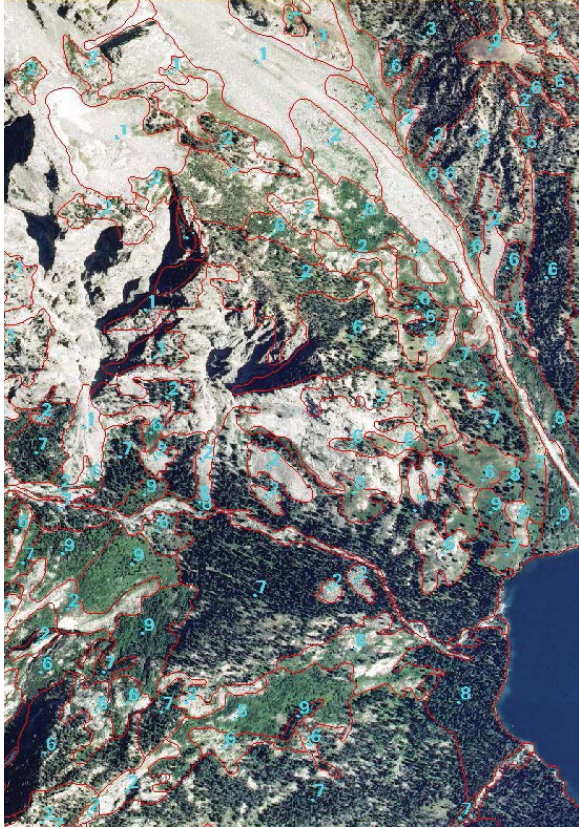

Figure 2 NAIP natural color orthophotograph mosaic acquired in 2009.

Figure 3. An area of the Park showing the NAIP natural color orthophographs and the Inventory and Monitoring Vegetation Stand database. Numbers represent the median class value for each stand.