Segmentation Guidance for NPS Vegetation Inventories

Executive Summary

Segmentation uses an “object oriented” paradigm. Unlike raster based image processing, the relationship, context, and juxtaposition all influence the segmentation. One potential cost savings of segmentation is the computer-generated line work of imagery and the “export to shapefile” function in segmentation software. This is an alternative to the time-consuming task of traditional heads-up digitizing. Pixels are image elements, grid based squares of metric size, and a single digital number (DN) value for each pixel makes up a raster dataset. Typically, the DN of the pixel represents the amount of light reflected back to the satellite/aerial sensor. In segmentation, groups of pixels with similar DN values are “segmented” to form objects. These objects are “clusters” of pixels with similar DN values forming GIS polygons. The imagery and the color balancing of adjacent strips greatly influence these objects and the resulting line work. Segmentation is not a “silver bullet” technology. It may be an efficient source of line work generation to build GIS polygons, but it can easily over divide the landscape into too many polygons, requiring an interpreter to merge similar polygons. The effort to merge polygons by an image interpreter can take significant time, often negating the potential cost savings of the tool. If used with caution and by a trained and experienced user, segmentation can be an efficient method of generating line work, especially in larger parks. Regardless of the source, the line work must be evaluated by a competent photo interpreter or image analyst for quality. This evolves into the development of the “mental model” or “mapping model” described in the 12-step guidance.

Segmentation is a specialty of image processing. It can be relatively expensive software and required significant training to generated results that are more efficient than traditional heads-up digitizing. It is a subset of the Imagery Guidance, and the Imagery Guidance should be consulted for general imagery concepts. The step by step guidance (12-step) described for the Vegetation Inventories should be referenced for context and the five goals of scoping, taxonomic development, digital mapping, accuracy assessment, and complete product DVD.
See: http://science.nature.nps.gov/im/inventory/veg/Guidance.cfm

Step 7 in the 12 step is to conduct “**Image Processing and Segmentation or Other Analyses**.” The lessons learned for the segmentation tool are included in this document.

Generation of Landscape Polygons – "Line work"

- Line work needs to support the appropriate taxonomic hierarchy of "alliance" or "association" depending on the one-to-one relationship of imagery to these finer vegetative levels of detail. The finest levels of detail are not supported in the vegetation inventories; they are too expensive, and they are beyond the level of management decision making in most cases. Parks can "buy up" to this detail if they choose. Consult the NPS Vegetation Inventory Program Botanist to discuss. "Groups" are higher (coarser) than alliances and may be appropriate in some cases.
- The NPS has had a number of false starts with segmentation. It is a deep and complicated software and there is a special skill set to harness this tool. Overly split landscapes will generate a tremendous workload in the GIS, attribution, and accuracy assessment steps later. Getting the right level of segmentation is an art, and several case studies follow to illuminate this challenge.
- To review and to determine needs, look at imagery archives, and to learn more about the imaging systems and sources, the NPS maintains several web pages that include a glossary and explanation of concepts at: http://www.nps.gov/gis/remote_sensing/

Taxonomic Levels related to Scale

- "Group" versus "Alliance / Association" floristic levels for NPS
    - Because this level is under the canopy, many remote sensing applications will not capture the needed detail, and field sampling is required to verify and characterize these community members by species, density, cover percentage, etc.
    - These types need to make both ecological sense and have a landscape affinity or distinct signature in imagery products.
    - For questions regarding the taxonomic classification level, please contact the NPS Vegetation Inventory Program Botanist.

I&M Lessons Learned

Example 1: Great Sand Dunes Example

The Great Sand Dunes National Park sits in a mixed ownership matrix of Federal State and private land in Southwest Colorado. US Forest Service and Bureau of Land Management Lands, a US Fish and Wildlife Refuge, and the National Park share a common fire planning unit, and that unit was the basis of the vegetation inventory effort for that park. Figure 1 shows the broad mix and landscape span of this matrix of ownership. The inventory and mapping team used a combination of ERDAS ecological modeling, object oriented segmentation and classic aerial photo interpretation to characterize the landscape.

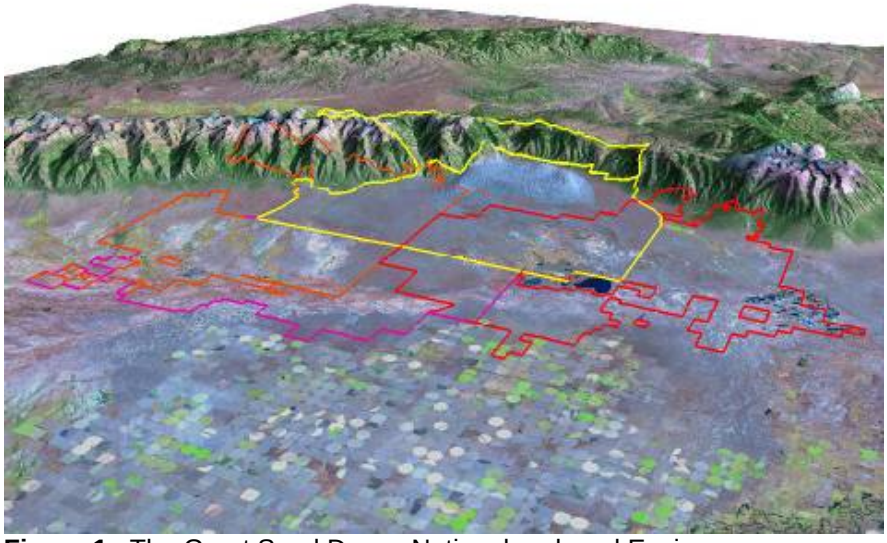

Figure 1. The Great Sand Dunes National park and Environs

Digital CIR and Segmentation Line work

The US Fish and Wildlife Service collected Color Infrared (4-band) imagery over the lower elevation areas or the valley of Great Sand Dunes NP. They did not image the entire project area due to the ceiling limit of 10K for the aircraft. Orthorectification was accomplished using ERDAS Imagine. Although initially promising, the color banding in the imagery was a challenge (see arrows, Figure 2a), and the segmentation clearly indicates strong influence of that banding in Figure 2b below.

Although the segmentation was computer-generated, significant efforts to generate realistic representations of the landscape were still needed. In 2008-9, Denver area Bureau of Reclamation GIS staff and USGS checked all the polygon data with Accuracy Assessment guidelines, map type and unit adjustments from field notes and observations to assemble a final database for the vegetation inventory products.

See figures 2a and 2b, next page.

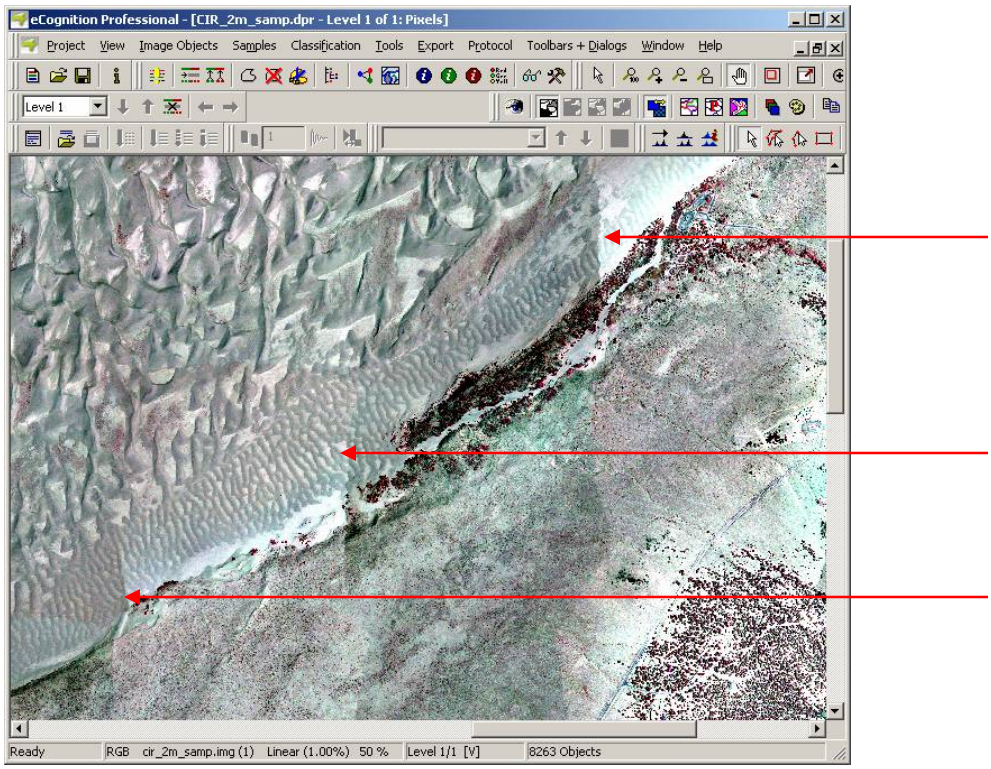

Figure 2a. Screenshots of CIR imagery, some color banding in the dunefield, wash, and woodland transition zone (see arrows).

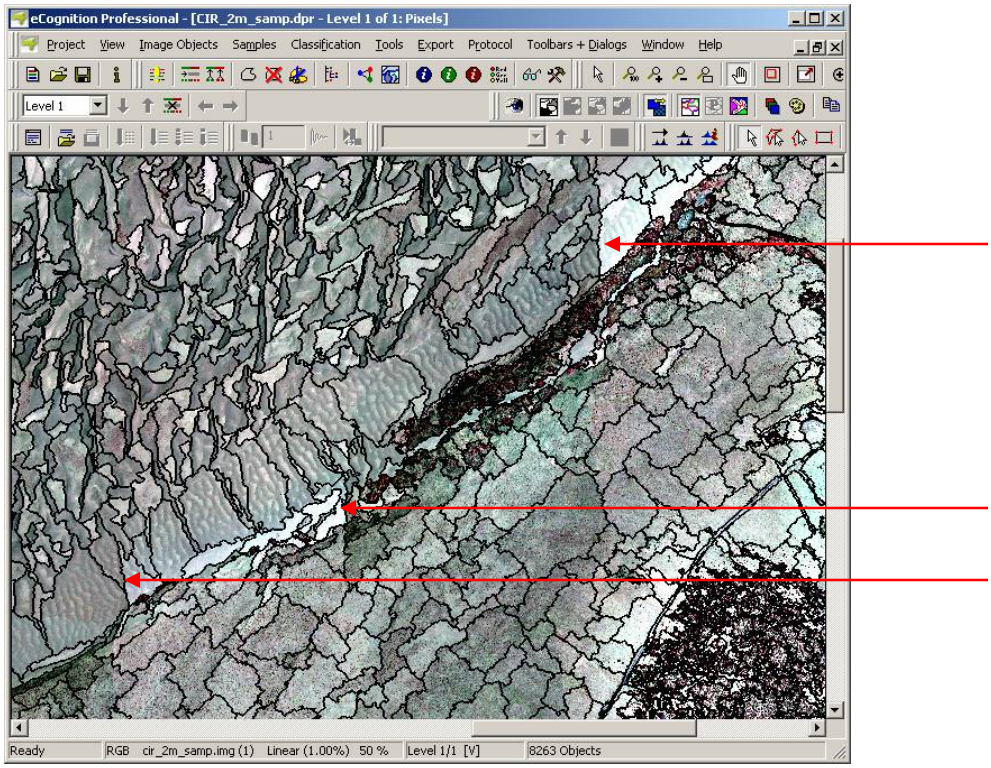

Figure 2b. Screenshots of CIR imagery. Color banding in the segmentation outputs of the dunefield, wash, and woodland transition zone.

Example 2: Arches NP Segmentation Experience

The Northern Colorado Plateau Network had the USGS Rocky Mountain Geographic Science Center staff prepare a segmentation example in the Arches NP vegetation inventory effort. To compare to classic photo-interpretation, several levels of segmentation were run. The challenge was to bring sufficient clarity to the black brush type on the plateaus, recognizing that this environment was a high contrast, low plant cover example. This "Rock Park" example does illustrate the value of picking the appropriate level of segmentation, and that an overly split product is simple to produce (segmentation level 1-2 for example) and expensive to map, attribute and complete an accuracy assessment later. The segmentation below (Figure 3) was generated at segmentation level 5. The results of the segmentation were imported into ERDAS Imagine software and polygons were reduced to a minimum mapping unit of 0.5 hectares. The rasterized edges of the polygons were smoothed in ArcGIS to create a final product for the black brush on the plateaus.

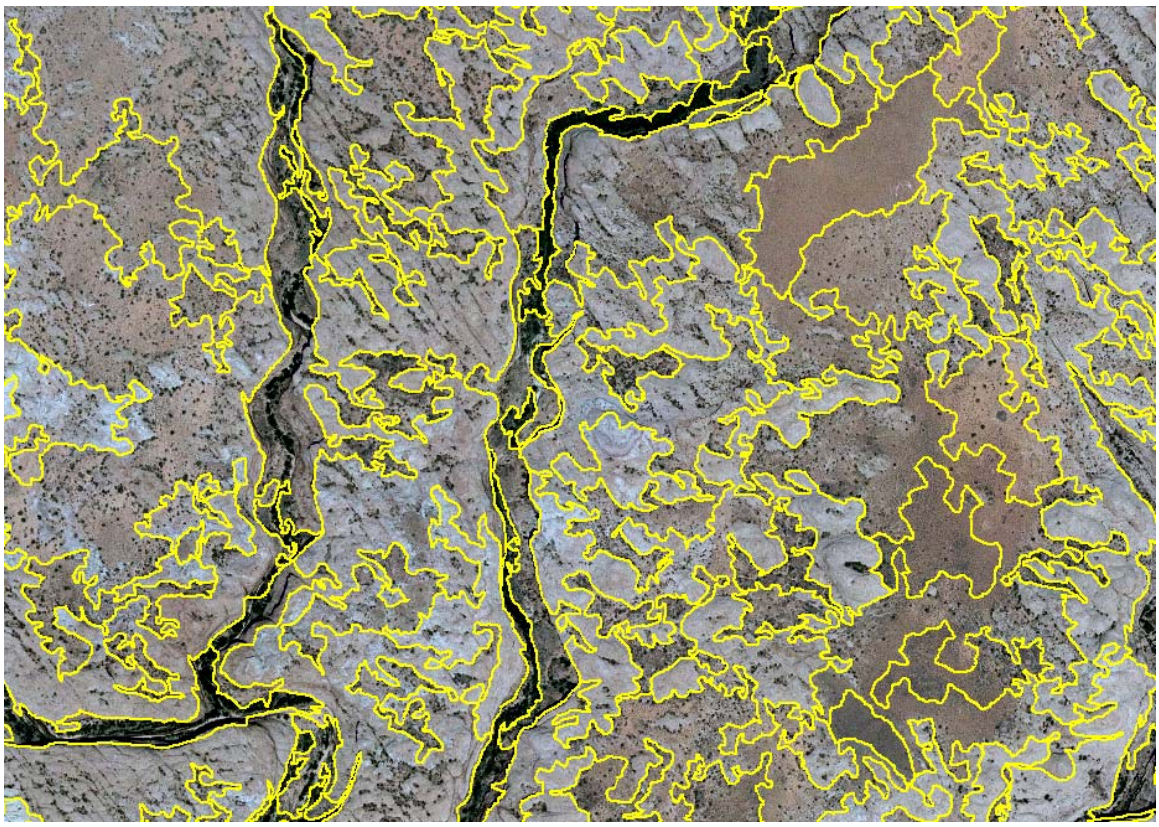

Figure 3. "Rock Park" Arches NP Segmentation Level 5; black brush

Summary – Great Sand Dunes and Arches National Parks
Both the Arches NP and Great Sand Dunes NP experience have parallel lessons learned, including:

- No specific object oriented software or technique is superior
- Use of the tools and how they can contribute shows limited promise as an alternate to the photo-interpretation method.
- When to use Object-oriented, when to go back to GIS, and when to use photo-interpretation depends on project complexity, size, and landscape contrast.

Our lessons learned include the sense that technological fixes are not going to resolve the collection of quality data or attribution of those data. The efficient download of shapefiles from segmentation is a powerful economic incentive; however, classical methods may still have a role in the future of park unit land imaging and doing operational mapping in determining vegetation community types.

Segmentation is a tool that can dovetail with other tools. The selection and tool use choices may involve using photo-interpretation, spatial modeling in ERDAS or in the GIS, getting the line work back to the GIS, and having detail that is appropriate to management decisions is the real goal. Keep it simple at first. Get experienced users to help evaluate your intended work flow for your project. Do not jump into this technology to "try it." Efficient users have over a year of learning curve behind them.

Other test efforts are underway to compare object oriented segmentation with ecological modeling, line transect sampling, and classic aerial photography.

Segmentation software is relatively expensive and currently three vendors have this kind of object oriented tool available. The Definiens group is European and markets the eCognition software. The ENVI group has FX for feature extraction, with similar capabilities. The Feature Analyst function is available in the ERDAS Imagine Suite. All have the capability to export shape files in ESRI format. NPS experience spans all three software suites.

Software links:
Definiens: http://www.definiens.com/
ENVI: http://www.ittvis.com/
ERDAS: http://www.erdas.com/