Forest Service
Remote Sensing Tips
VEGETATION MANAGEMENT

Midlevel Riparian Vegetation Mapping Using Data-Mining Techniques: Support of Coalbed Methane Leasing Analysis

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Overview

A multistep process was developed for defining and mapping vegetation in riparian zones by integrating commonly available remote sensing and geographic information system (GIS) data. The application combines hydrological modeling, image segmentation, and data-mining techniques to generate baseline information about riparian communities. The resulting riparian vegetation map is useful for forest planning and can assist in evaluating and guiding the coalbed methane leasing process.

Riparian Vegetation

A riparian vegetation map is critically important to resource managers. With the development of coalbed methane resources as an emerging issue in the Powder River Basin of eastern Montana, the need for riparian inventories has become even more critical. The Ashland Ranger District of the Custer National Forest, located in the heart of the Powder River Basin, has been identified as the second-highest domestic-energy-development target in the Nation. This area may experience intensive exploration, development, and production of coalbed methane. Springs and associated riparian and aquatic areas are important features in the semiarid landscapes of eastern Montana, providing critical habitat to a variety of terrestrial and aquatic species (figure 1). Currently, there is insufficient baseline information about the amount, spatial extent or location, and quality of these systems.

Figure 1—Developed spring providing critical habitat for species living in eastern Montana's semiarid landscape.

The objective of this project was to develop a way to use remote sensing and GIS to provide current information about the location, spatial extent, and condition of narrow riparian zones in the landscape in a timely manner. The process used a combination of remote sensing and hydrologic modeling to delineate and map vegetation within a specified riparian zone. Products derived from this project will be used to 1) establish baseline information about these features; 2) support coalbed methane leasing analysis; and 3) support forest-level assessments, planning, and monitoring.

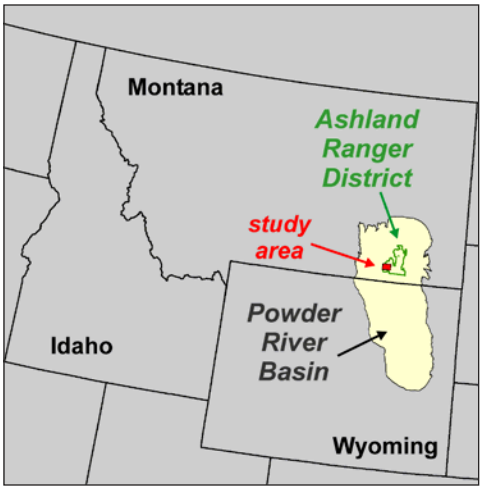

Figure 2—Study area located within the Ashland Ranger District, Custer National Forest, Montana. The Powder River Basin is under intense pressure to drill for coalbed methane.

Study Area

The study area is located in the southwestern portion of the Ashland Ranger District on the Tongue River watershed on the Montana side of the Powder River Basin (figure 2). An area corresponding to the Browns Mountain and Poker Jim Butte 7.5-minute topographic quadrangles was selected for testing.

Several data sets, listed in table 1, were compiled for the different phases of the project. All data used in this project, with the exception of training data, were readily available or easily derived from U.S. Department of Agriculture (USDA) Forest Service core data.

Riparian Mapping Process

The riparian mapping process outlined in this report was completed in phases. Phase One defined potential riparian areas across the landscape using digital elevation models (DEMs). Phase Two developed a high-resolution merged image from Landsat Enhanced Thematic Mapper (ETM) and used this image to create vegetation polygons. Phase Three used image segmentation to generate mapping units. Finally, Phases Four and Five collected field data and classified the polygons into vegetation categories. The inputs into these phases and their results are shown in table 1.

This project used a combination of remote sensing and geospatial information, including DEMs, digital orthophoto quads (DOQs), and Landsat ETM. A Landsat ETM satellite image and a DOQ were merged into a high-resolution image to identify riparian vegetation. GIS modeling then derived a stream network (figure 3, left) and floodplain basin (figure 3, right) based on the DEMs. The merged image became the basis for the vegetation map units, while the hydrologic modeling process determined the potential riparian zones. The potential riparian vegetation units were identified by intersecting the map units derived from remote sensing with the results of the floodplain model (figure 4). The riparian units were then grouped into unique vegetation types based on a classification of representative field-data points. A subset of the classified map appears in figure 5.

An accuracy assessment of the model compared the classification code of those units from which the training point was withheld to the way the site was classified in the original database. Thirty-two of the 44 training sites were classified correctly, corresponding to an overall accuracy of 73 percent. This accuracy assessment improved to 77 percent when the segments representing upland vegetation (dry grass, xeric shrubs, and barren ground) were grouped into a single class, and cottonwood and mixed hardwoods were merged into their own separate category without subdividing them based on their species.

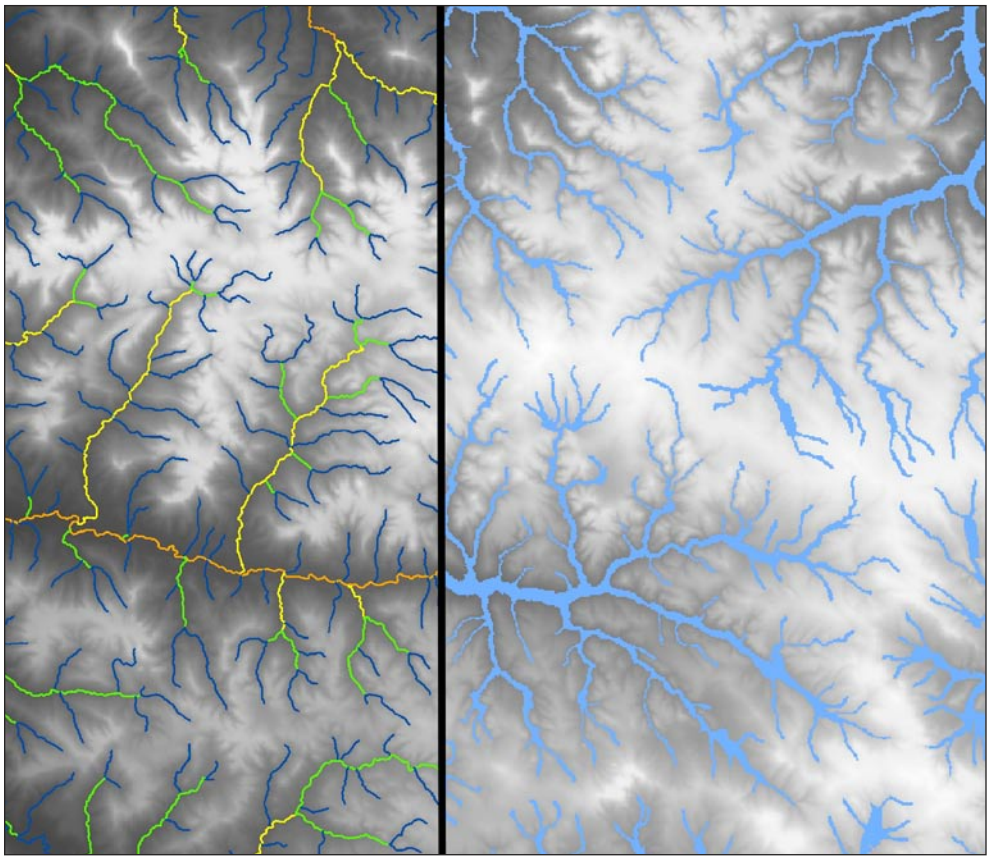

Figure 3—Stream segments derived from DEMs *(left)* with floodplain delineation shown in blue *(right)*. Both were inputs for determining the potential riparian zone.

Table 1—Breakdown of phases in the riparian modeling and classification process.

Phase	*Description*	*Data input*	*Output*	*Software used*
1	Hydrological analysis and modeling	10-m DEM	Drainage order and floodplain Distance to stream Slope, aspect, wetness Curvature	ESRI ArcGIS, RSAC AMLs, ESRI ArcGrid
2	Image segmentation and remote sensing data manipulation	1-m DOQ 30-m 2000 ETM+ 30-m 1997 TM	Merged 3-m DOQ/ETM Image segments Derived image indices DOQ texture image	Leica Erdas Imagine Defines eCognition RSAC TEUI toolkit
3	Data stratification	Potential floodplain Image segments	Potential riparian segments	ESRI ArcGIS
4	Training data compilation	Aerial photography Field data Riparian segments	Vegetation-coded database	ESRI ArcGIS MS-Access
5	Data mining/vegetation classification	Products from Phases 1–4	Classified vegetation map of riparian area Accuracy assessment	Leica Erdas Imagine ESRI ArcGIS Rulequest See-5

Note: Inputs include DEMs, DOQs, Landsat ETM satellite imagery, and field data points.

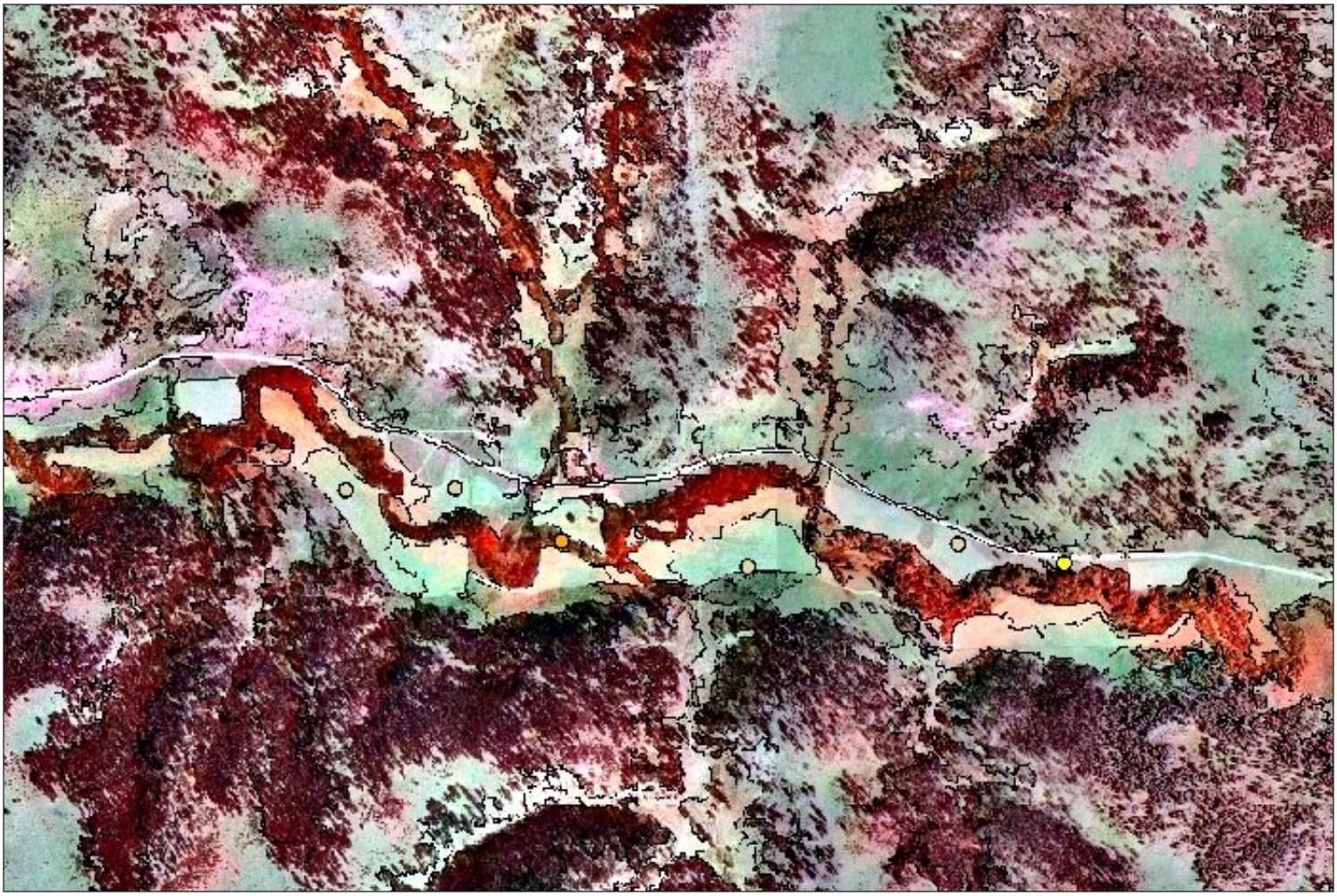

Figure 4—High-resolution, merged DOQ-ETM image shown with image segments. Point locations identify a sample of field data points used in the classification and accuracy-assessment processes.

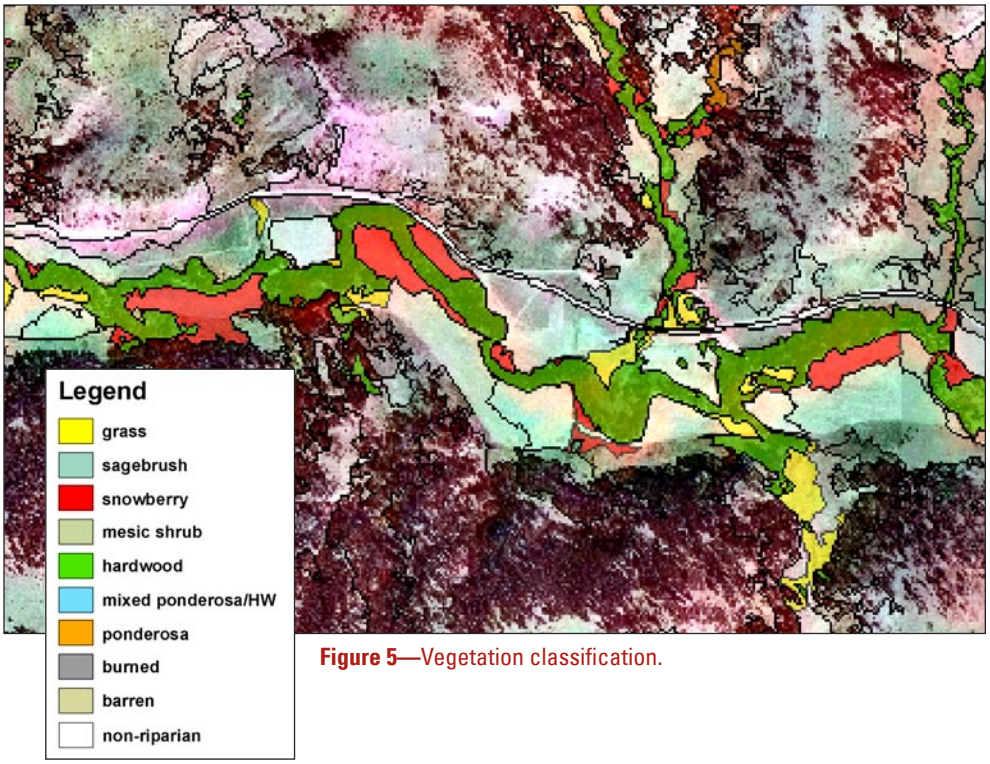

Figure 5—Vegetation classification.

Conclusions

This project demonstrated how hydrological modeling, image processing, and data-mining techniques can be combined in a geospatial environment to map riparian vegetation successfully. The results indicate that this process can establish baseline information about the location of water-dependent communities. The small-scale features that were of special interest in this project, however, need data of higher spatial resolution than were available.

References and Suggested Reading

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