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WATERSHED, SOIL AND AIR MANAGEMENT

Visualizing Past and Present Mining Activities Using Geospatial Technologies

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Overview

Across the Nation, there are approximately 1,500 hazardous-substance sites affecting every region in the U.S. Department of Agriculture (USDA) Forest Service. Hazardous substances from abandoned mine lands degrade the health of watersheds and pose a potentially serious threat of acid mine drainage. Also concern about visual effects of past and present mining activities increases as more people move into former mining areas in and around national forests (figure 1).

The Clean Water Action Plan and the Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management envision a new, collaborative effort by Federal, State, tribal, and local governments in alliance with the public and private sectors. The objective is to restore and sustain the health of watersheds in the Nation. Remote sensing is a beneficial tool to assess mining activities across all jurisdictions. Digital imagery for watershed overviews can assist decisionmakers in setting priorities for watershed cleanup. This report highlights the effectiveness of digital imagery in visually assessing the results of mining activities. A companion report highlights the useful role of remote sensing in assessing resource damage at hazardous waste sites. The Remote Sensing Steering Committee (RSSC) of the USDA Forest Service funded this project.

Figure 1—An oblique aerial photograph provides an overview of mining activities in the Independence Range in Nevada's Humboldt-Toiyabe National Forest.

Visualizing the Situation

Visually integrating geospatial data, including remotely sensed information, and exploring potential spatial relationships among different data sources helps problemsolvers investigate hazardous sites. Investigators can assess recent and abandoned mining activities with remote sensing technology in several ways:

- Identifying, mapping, and displaying three-dimensional (3-D) views of mining activities. Current or historical aerial photographs and digital imagery, from satellites, for example, contribute valuable overviews of an area.
- Analyzing hazardous-substance sites through interpretation of imagery. Interpretation techniques vary from simple photo delineation to advanced analysis of hyperspectral imagery used to map surface minerals or acid mine drainage (figure 2).

Figure 2—Dead trees in the Carbonero mine area in Colorado's Uncompahgre National Forest. Note the urban development in the background.

This report focuses on remote sensing as a visualization tool to provide an overall understanding of environmental problems caused by mining activities. The examples come from three national forests.

Digital Imagery

The longtime, standard remote sensing tool is an aerial photograph. Advantages over other sources of imagery include fine spatial detail, stereo viewing capability, and cost effectiveness. Aerial oblique views, as depicted in figure 1, offer a unique perspective for assessing large areas.

Recently, digital scanners and soft-copy image-analysis software have become affordable for individual forests. This technology enables individuals to scan (digitize) aerial photographs and create a maplike orthophoto. Figure 3 shows an orthophoto mosaic of the Howard Fork drainage basin in southwest Colorado, one of the more severely degraded sites within the Grand Mesa, Uncompahgre, and Gunnison (GMUG) National Forests. Here, silver, gold, lead, zinc, and other metals were mined starting in the late 1870s. This overview was developed using 1:12,000-scale, resource aerial photographs. The original 9-by-9-inch prints were scanned at 500 dots per inch (dpi) and orthorectified using 10-meter digital elevation models (DEMs) and 1-meter digital orthophoto quads (DOQs). Geospatial data for this process are standard and available to most national forests. Such DOQs can be used in a geographic information system (GIS) along with additional information layers, such as property boundaries, hydrology, and mine locations, to describe a basin or watershed.

Three-Dimensional Views

Digital imagery can be further manipulated with data-visualization software. Simple tools can create 3-D views that enhance geospatial data. Data visualization is essentially a qualitative form of spatial analysis. By visualizing a landscape, we can better understand, interpret and verify complex systems to support informed decisions.

Figure 4 shows the same DOQ created for the Howard Fork basin draped over a DEM. The customized inset view shows mine locations in cyan and ownership boundaries in black. Satellite imagery can produce overviews larger than a basin or watershed. This type of satellite imagery, for example from Landsat Enhanced Thematic Mapper (ETM), is readily available for all lands in the United States. ArcGIS and ERDAS Imagine software, now available to most national forests, provide tools for building such 3-D overviews. Building one's own 3-D perspective rather than acquiring oblique photography can customize both the perspective and the scale.

Virtual Reality—3-D Virtual Flights

Creating a 3-D virtual flight takes data visualization one step further. Virtual flights, also called fly-throughs or flybys, can be developed using basic geospatial data such as a satellite image and a DEM. To generate a virtual flight, thousands of distinct images are combined into an animation file (Almer and Stelzl 2002). Animation file formats may have "mpg" or "avi" extensions. These files can then be viewed using several public-domain media viewers, such as Windows Media Player or Real Player.

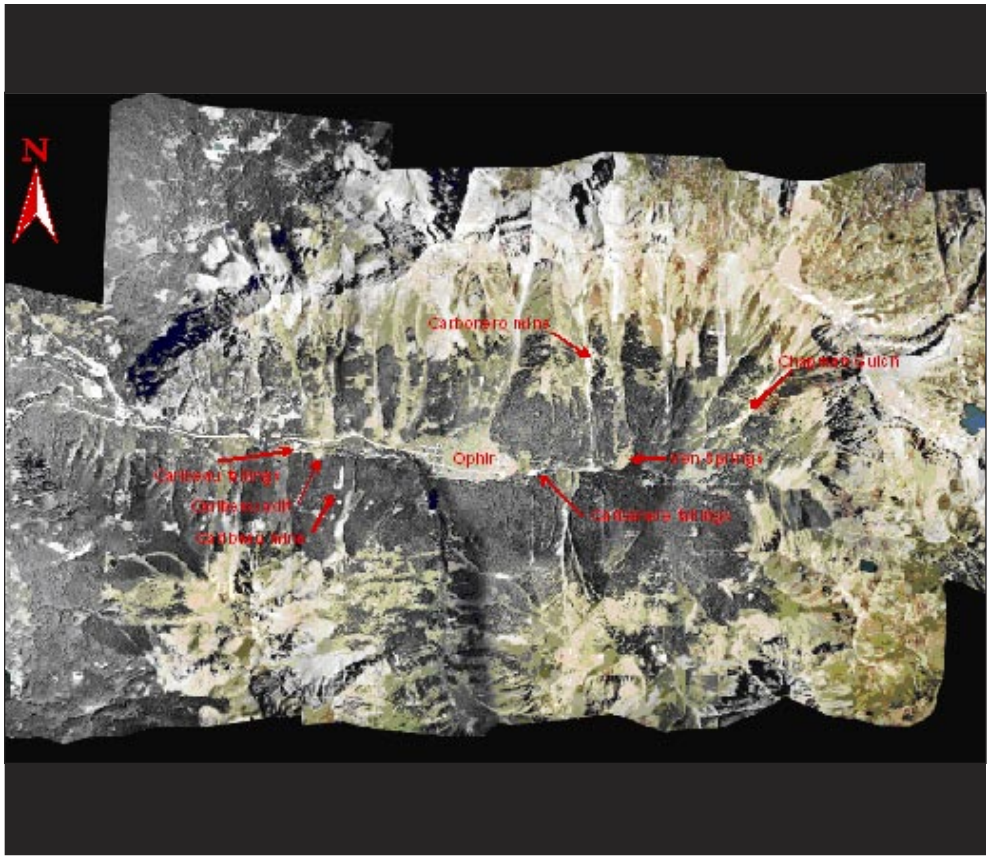

Figure 3—Aerial photographs can be scanned and orthorectified to be compatible in a GIS and allow accurate distance and area measurements. This digital mosaic of aerial photographs was developed for the Howard Fork drainage basin.

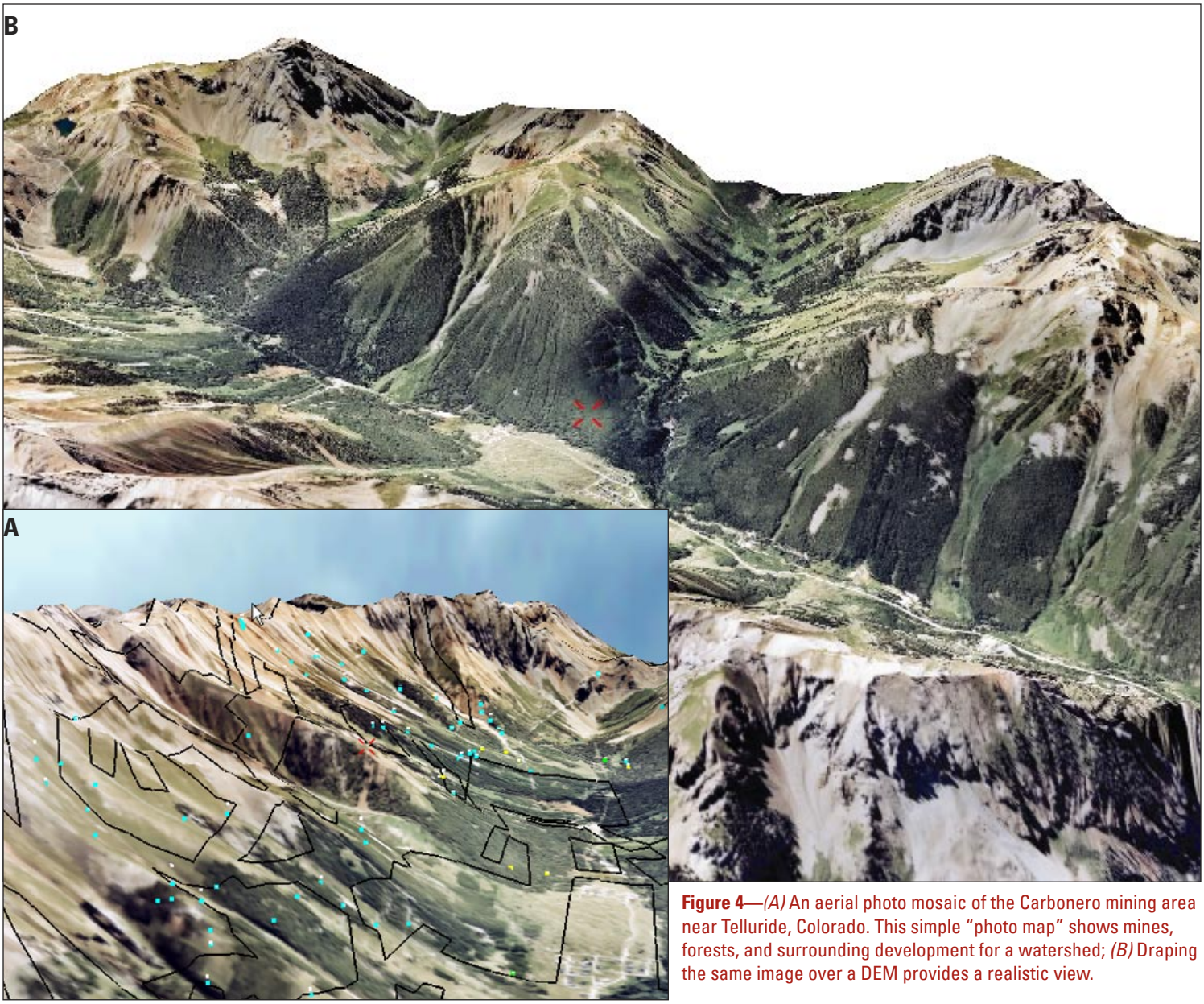

Figure 4—*(A)* An aerial photo mosaic of the Carbonero mining area near Telluride, Colorado. This simple "photo map" shows mines, forests, and surrounding development for a watershed; *(B)* Draping the same image over a DEM provides a realistic view.

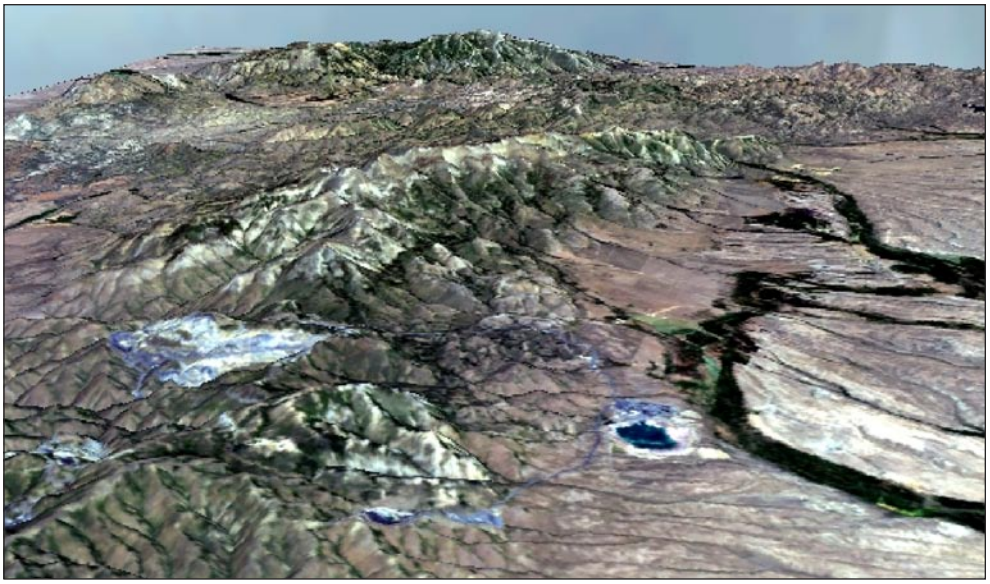

Figure 5—This 3-D fly-through of the Independence Range in Nevada was developed using satellite imagery and DEMs.

Figure 5 displays a single perspective from a virtual-flight sequence overlooking a portion of the Humboldt-Toiyabe National Forest. Landsat ETM imagery was used to create a virtual flight of mining activity in the Independence Range. The mine location is identical to the one in the the oblique photograph in figure 1. While the satellite image contains less detail, it covers a much larger area. Virtual flights can be made with Imagine's Virtual GIS module, an extension to the basic software.

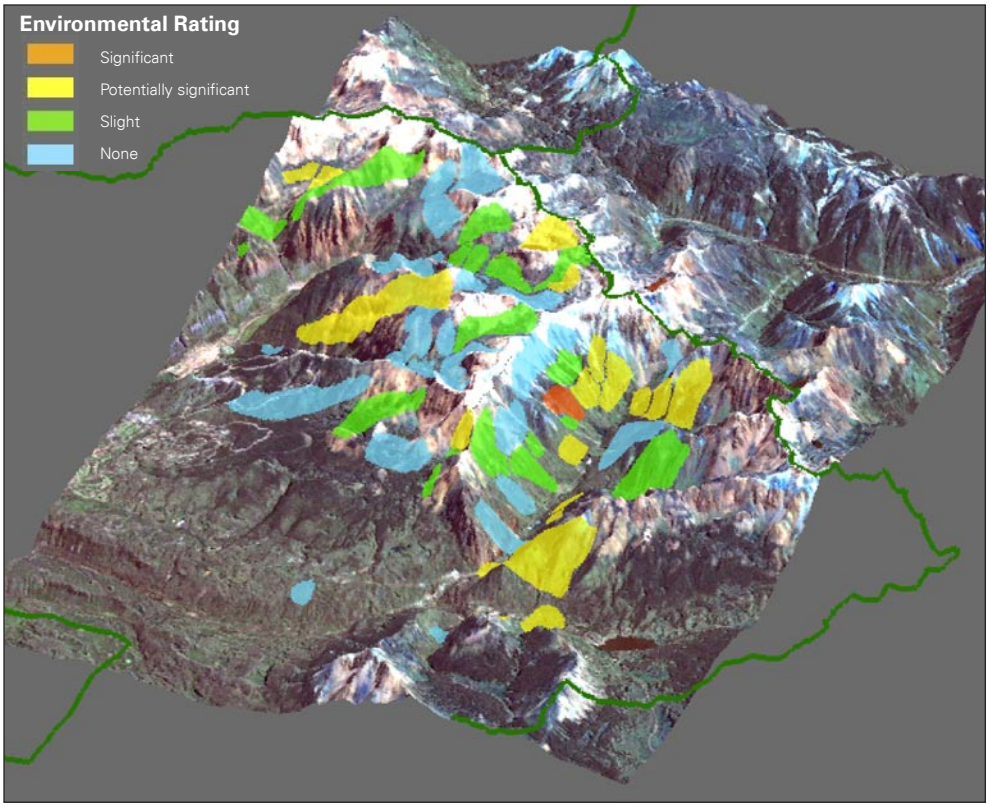

Figure 6—A view of the Howard Fork drainage basin and surrounding Telluride, Colorado. Environmental-rating polygons draped over a 3-D image provide context for viewing quantitative information.

The Watershed Approach

The watershed approach is critical to setting priorities and taking action to clean up hazardous substances from mining activity. Combining quantitative studies, such as abandoned mine-land inventories, with data visualization improves our understanding of complex systems and enhances our ability to interpret and discuss critical issues (figure 6). Displaying and sharing information improves coordination and fosters cooperation among stakeholders. Using data-visualization tools is increasingly popular as viewing capability becomes more and more universal. Software for developing such analysis techniques is now within reach for most national forests.

References and Suggested Reading

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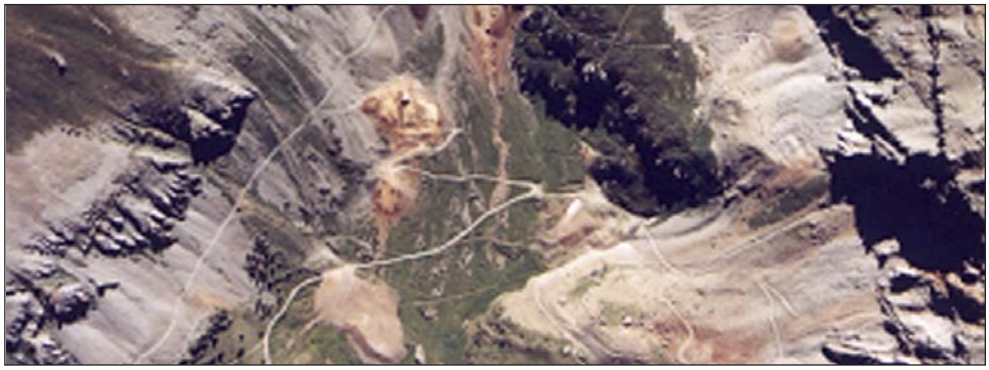

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