

## Surface Mine Change Detection & Monitoring

### USER COMMUNITY

Currently, in the State of Missouri there are approximately 1000 active mines of which more than 700 are open-pit mining operations. Due to lack of funding for the Missouri Department of Natural Resources' (DNR) Land Reclamation Program, the branch in charge of monitoring all mining activity in the state, no aerial photography has been acquired for years. This lack of funding has required on-site monitoring of all mines in the state, performed by a limited staff, on a yearly basis. But, as a result of minimal staffing, the re-visit period may extend well beyond 2 to 3 years.

An educational mini-workshop was held to familiarize the partners with the satellite technologies, its capabilities, and limitations. This allowed the users to see and therefore structure their needs based on the resolutions that we were proposing to work. These included the ETM and Hyperion platforms. From this and subsequent meetings several areas for potential application of the imagery data to possibly address their needs in monitoring the extent, health, condition, and possible age of the mining site were determined or eliminated. For example, the monitoring of the extent of a mine operation with these resolution groups was not accurate enough for utility unless the operation was grossly making infractions of its planned activity. On the other hand, when viewing the hyperspectral nature of Hyperion they were interested in knowing if the sensor could pick up acidity in the soil or some other marker that would allow mitigation or modification of a reclamation activity. Other areas of interest include vegetative state and status imagery (tied to permitting and regulations regarding reclamation of mined lands to a vegetated state), contextual impacts (streams, vegetation, lakes in the surrounding environment affected), and historic mining activity discovery from the Landsat archive (Is the site eligible for certain types of federal funding for reclamation?).

### PRODUCT DEVELOPMENT

Because of their limited knowledge of remote sensing capabilities, it was determined that an introduction to remote sensing capabilities was needed to establish a list of viable needs and wants before the project continued. During the second week in October, the team from the MO DNR traveled to Columbia for an introduction to remote sensing capabilities presentation. This presentation was aimed at giving examples of imagery used and what information their resolutions would allow us to obtain. In this meeting we explored the possible uses of Hyperion and Landsat with the group present to develop a better working knowledge of what would actually help them down the road. Upon completion of this meeting, we were able to compile a list of 8 prioritized reclamation sites to study in depth.

Based on these 8 sites, several parameters (e.g. biomass, vegetation type) were decided upon to study at each. Because each of these sites is at a different state of reclamation, certain parameters were deemed more prudent to study. While one site might be near the end of reclamation, a focus on biomass and vegetation replacement is necessary. Another site might be farther from reclamation, towards the end of mining operations, and a focus on soil chemistry would be more

appropriate. In table 1, each of the 8 sites is listed along with the parameters requested by MO DNR for our focus. For each of these 8 sites, historic satellite imagery has been gathered in-house to allow us a temporal look at how each site has changed through its development. Sensors utilized for this phase include Landsat MSS, TM, and ETM+.

After importing and building header files for all archival imagery, each of the 8 study sites were clipped to provide image coverage over only the necessary area. For each of these scenes, a preliminary unsupervised classification was performed using isodata classification in ENVI, and clustered down to 5 classes consisting of water, bare/urban, cropland, forest, and transitional cropland. The images below in Figure 2 illustrate the change over one of the study sites, Thomas Hill Energy Center, from 1980 to 1999.

Utilizing current remote sensing technologies, a monitoring protocol will be established to effectively prioritize site visits by a small number of individuals resulting in a more efficient monitoring of mined land reclamation projects. In support of NASA's mission to increase the use of the Earth Observation System (EOS) sensors, Hyperion hyperspectral data will be used in conjunction with Landsat ETM+ data. We will also explore the use of Hyperion to garner knowledge about mine mineralogy, topsoil chemistry, and vegetation establishment on reclaimed mines. We will also work towards a better understanding of the intended synergy between Landsat and Hyperion as they acquire imagery simultaneously. Work on change detection will also be discussed to highlight what similarities exist between both sensors in regards to visibility and classification accuracy.

### **Targeted Imagery products for Synergy IV Mined Land Assessment and Monitoring**

1. Imagery showing potential acidity in the soil (or some other marker) that would allow mitigation or modification of a reclamation activity. (Hyperion)
2. Imagery showing vegetative state and status imagery (tied to permitting and regulations regarding reclamation of mined lands to a vegetated state), (ETM)
3. Classified imagery showing contextual impacts (streams, vegetation, lakes in the surrounding environment affected), Some interest in examining the lead-mining areas in Missouri due to its toxicity and long term affects on humans. (Hyperion)
4. Historic imagery showing active mine sites prior to EPA mining regulations from the Landsat archive so as to determine if the site eligible for certain types of federal funding for reclamation. (MSS)

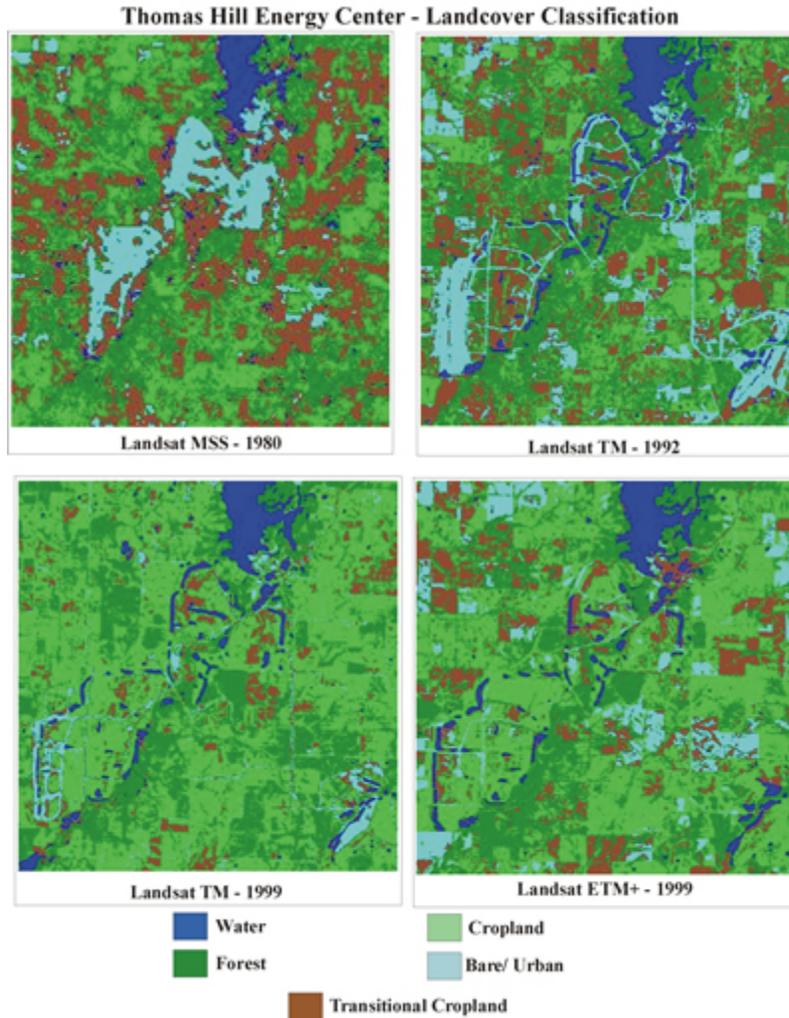


Figure 2: Preliminary classification of Thomas Hill Energy Center using isodata unsupervised classification.

### EXPERIENCE USER COMMUNITY

An introductory meeting was held with the Missouri Department of Natural Resources (MO DNR) to identify needs and wants for the initial phase of the project. In this meeting, the following key ideas were listed. These monitoring ideas were raw and based solely on their limited knowledge of remote sensing capabilities.

- o Key Dates to study would be:
  - o Early 1970's – EPA formation
  - o 1990 – Law Change in the State
  - o 2002 – Current activities
- o Monitoring Possibilities:
  - o Area of mine expansion
    - § To monitor licensed area vs. actual mine area
  - o Buffer Zones for Streams near Coal Mines
  - o Track Pit Advancement
    - § Topsoil replacement (270 days to complete)

- § Initial seeding dates for cover replacement
- o Road Construction
- o Roughness Monitoring
- § Graded vs. Non-Graded
- o Soil Chemistry
- § Acidity
- § Metals Content
- o Prove Abandoned Land

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Based on these 8 sites, several parameters (e.g. biomass, vegetation type) were decided upon to study at each. Because each of these sites is at a different state of reclamation, certain parameters were deemed more prudent to study. While one site might be near the end of reclamation, a focus on biomass and vegetation replacement is necessary. Another site might be farther from reclamation, towards the end of mining operations, and a focus on soil chemistry would be more appropriate. In table 1, each of the 8 sites is listed along with the parameters requested by MO DNR for our focus. For each of these 8 sites, historic satellite imagery has been gathered in-house to allow us a temporal look at how each site has changed through its development. Sensors utilized for this phase include Landsat MSS, TM, and ETM+.

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Permittee Name	Site Name	Selected Parameters
Associated Electric Cooperative	NEMO Mine	Biomass, Vegetation Type
Associated Electric Cooperative	Thomas Hill	Biomass, Vegetation Type
Hunt Midwest Mining Inc.	Randolph Quarry	Ground Cover, Biomass, Vegetation Type, Soil pH
Wood Coal Co.	Bates	Biomass, Vegetation Diversity
Alternate Fuels Inc.	Blue Mound	Soil pH
Continental Coal Inc.	Panther Creek	Active Monitoring
Midwest Coal L.L.C.	Tiger	Ground Cover, Biomass, Vegetation Type, Soil pH

***Mine Reclamation Study Sites***



Figure 1. From over 700 open-pit mining sites in Missouri, eight were selected as priority sites for this study.