GIS AS A PRIORITIZATION AND PLANNING TOOL IN ABANDONED MINE RECLAMATION[1]

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Abstract. The Utah Abandoned Mine Reclamation Program has developed a new GIS model for selecting reclamation project areas. The selection process utilizes three main factors that influence the potential hazards in mining areas. These include: known mining activity or mineral resource occurrence areas; population density in proximity to the mining areas; and proximity of access to the mining areas.

Mine closure priorities are ranked according to the degree to which the public is exposed to the dangers associated with abandoned mines. The first step in ranking mines for reclamation is establishing where they are likely to be based on potential mineral resource locations. Known mines and the density of those mines receive a higher ranking in the model than potential mining areas or mineral resources. The data sets used in the mining component include: Computerized Resource Inventory Base (CRIB); gilsonite veins; phosphate deposit areas; locatable mineral occurrences; and historic mining district.

The second ranking criteria used to prioritize abandoned mine closures are proximity to and density of population centers. Mines located near densely populated areas are assumed to receive greater visitation than mines located away from population centers. The population component of the model uses the census data from 2000.

The third major component of the ranking model is access to the mining areas based on the premise that the easier a mine is to get to, the more likely people are to visit it. Thus a mine's proximity to a high density of roads contributes to its hazard potential. A data set of road locations is used to determine the potential access to a mining area.

The mining activity, population, and access components are combined in the model to determine which abandoned mines pose the greatest potential risk to the public. The model is then used to generate a map of all areas above a hazard-rating threshold. The composite score for each of these areas then determines its rank. In this manner Utah's AMRP is able to use GIS to focus abandoned mine reclamation efforts in areas which pose the greatest threat to public safety.

Additional Key Words: Mining, AMRP, Utah

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Introduction

The Utah Abandoned Mine Reclamation Program (UAMRP) is the agency in Utah responsible for taking care of problems created by abandoned mines. Throughout the State of Utah there are an estimated 22,000-abandoned open mines posing hazards to the public. The UAMRP was created in 1982, since that time approximately 5000 abandoned mines have been closed, which include almost all of the abandoned coal mines; it is currently closing the non-coal mines.

For the UAMRP to achieve primacy under Surface Mining Control and Reclamation Act (SMCRA) an approved plan outlining its policies and procedures for implementing the Act was needed. One significant requirement of this plan was a section detailing how abandoned mine sites would be ranked and selected for reclamation. This section prioritized areas in Utah with the most hazardous abandoned mines.

This paper discusses the UAMRP's methodology to prioritize abandoned mines using a GIS model.

Model Creation

To achieve primacy under the SMCRA the UAMRP had to develop a plan discussing how abandoned mines would be addressed. The approach the UAMRP took in 1982 looked at the "badness" of a mine site (and its priority for reclamation) as a function of the number and type of problems at the site and the likelihood that people would encounter them. This in turn was a function of the population near the site and the accessibility of the mine to that population (as inferred from the distance, degree and type of road development). Mines would be assigned numerical values based on their site features, proximity to people, and accessibility, then ranked by their scores.

When the plan was written in 1982, the UAMRP fully expected the process to be automated. The approach anticipated a GIS, but the available GIS software at the time was rudimentary and cumbersome. GIS-type operations, such as scoring the population within a specified radius of a site, were done manually (by placing a template over a map and consulting census tables). Besides being crude and slow, the manual process necessitated breaking data types into coarse

categories or ranges. Nuances in the data were lost and the scoring became a “point in time” snapshot that was not easily updated as conditions changed.

The UAMRP ranking system depended on field inventory data for the scoring procedure. The system was originally conceived as working from a data pool with complete or nearly complete statewide field inventory data. In actual practice, the UAMRP could not complete a statewide inventory in a meaningful timeframe (the working estimate is that there are 22,000 abandoned mine openings in the state). The UAMRP proceeded with reclamation as it continued its field inventory effort. Construction projects were selected from the pool of available field data, but since the field inventory generally advanced only a year or two ahead of the construction, the choice of areas to inventory was becoming the *de facto* selection of construction projects.

By the late 1990’s, it became increasingly clear that the UAMRP project ranking and selection process needed refinement. The underlying philosophical assumptions of risk being a function of features, population, and accessibility were still considered sound, but there needed to be a more systematic application of the ranking and selection principles to the selection of field inventory areas. This required a suitable body of data from non-field sources to work with. Fortunately, advancements in GIS over the years had made such data available and had provided an automated system in which to analyze the data conveniently.

By the mid to late 1990’s, most of the coal work had been completed and more and more non-coal projects were being targeted. The basic nature of non-coal is that it is more appropriate to rank aggregations, - treat groups of mines in similar regions as a ranking unit rather the individual mine openings.

Conceptual Model

The modeling and ranking process looks at three main factors that influence the potential hazard in mining areas. These factors include known mining activity or mineral resource occurrence areas, the population density in proximity to the mining areas and the proximity of access to the mining areas.

Mine closure priorities should be ranked in a way that reflects the amount of danger to which the public is exposed. The first step in ranking mines for reclamation is to know where they are or likely to be based on potential mineral resource locations. Known mines and corresponding

density of those mines received a higher score in the model than potential mining areas or mineral resources. The datasets used in the mining component: Computerized Resource Inventory Base (CRIB), gilsonite veins, phosphate deposits areas, locatable mineral occurrences, historic mining districts and un-patented mining claims.

The second ranking criteria used to prioritize abandoned mine closures were the mine's proximity to population center's and the density of the population. It was assumed that mines located near densely populated areas received more visitations than mines located far from population centers. The population component of the model uses the census data from 2000.

The third major component of the ranking model is access to the mining areas. The easier a mine is to get to, the more likely people are to visit it. Thus, a mine's proximity to a high density of roads significantly contributes to it's hazard potential. A roads dataset was then used to determine the potential access to a mining area.

The mining activity, population, and access components were combined to determine which abandoned mines pose the greatest potential risk to the public. The model is then used to generate a map of all areas above a certain hazard-rating threshold. The composite score for each of these areas determines its rank. Thus using GIS, the Utah AMRP is able to focus abandoned mine reclamation efforts in those areas which pose the greatest threat to public safety.

The Conceptual Formulation Of The GIS Model

Questions to be answered by the by this paper:

1. How the model developed?
2. What was thought to be in the model?
3. What was ended up with in terms of available data?

Formulating a conceptual GIS model to rank and prioritize abandoned mine sites for reclamation by creating a list of all the spatial datasets envisioned that would give an indication as to where abandoned mines exist and which of those mines pose the greatest threat to public safety. The following are examples of what are available:

Where mines exist:

- CRIB/UMOS

- Mining claim locations
- Mining district location
- USGS map adit and shaft symbols
- Geologic map (favorable host rock/veins/alteration zones)

Factors increasing public safety hazard of mine site:

- Accessibility (Roads, ATV trails, Hiking trails, etc.)
- Proximity to population centers
- Proximity to recreation areas (State Parks, National Parks, National Monuments and National Recreation Areas, etc)
- Hunting/Sportsman visitation
- Proximity to Tourist destinations
- Use by OHV recreationalists

The next step was to determine what, if any statewide digital data sets existed. In Utah there is a state agency Automated Geographic Reference Center (AGRC) that is dedicated to sorting and maintaining a vast array of statewide data sets. These data sets were our most valuable resource. By contacting numerous other state and federal agencies, we were able to collect some highly useful data sets as well as to get a feel for what datasets may be coming available over the next few years. The principal limiting factor in determining which data was useful was whether the data set was available statewide. For example, the USFS has digitized all adit and shaft symbols for USGS 7.5 minuet quad maps containing Forest Service Lands. If the dataset were statewide this data would likely be some of the most useful data concerning the locations of abandoned mines. However because the data does not exist statewide, we were unable to incorporate it into the GIS ranking model.

Once it was determined what datasets were available, we looked at the data's attributes and began to determine which attribute would provide information for our model. For example, the roads datasets contain attribute information detailing the road surface type as well as number of traffic lanes. These attributes present a clear picture of the functional mobility of the dataset beyond just whether a road is or not present.

Technical Implementation Of The GIS Model

The geographic datasets were processed using Environmental System Research Institute's (ESRI) Arc/Info software including the Grid extension. The processing of each dataset was programmed in ESRI's Arc Macro Language (AML). By using AML's to process the datasets, each data set was distinguished by differing attribute values.

Three main groups of data were used for the model; the "access" component, which used two roads coverage's, the "people" component consisting of the 2000 census data, and the "mine" component consisting of a variety of mining and mineral datasets. All datasets were converted to grids with a quarter mile grid cell size. Weighted values were assigned to the various attribute components and in the case of the roads and census data, densities were calculated using focalsum calculations. The grids were then merged to form a final composite coverage. Within the final datasets, areas were ranked to define critical areas for AML mitigation.

Adaptability Of The GIS Ranking Process

GIS is helping the Utah AMRP to concentrate our efforts and resources in those areas where they can do the most good. The datasets produced can be used to represent the portion of the state in which abandoned mine reclamation has been completed. The model also indicated the portion of the state that requires additional ground-truthing to refine the dataset. GIS will help us maximize our limited funding by streamlining the process of prioritizing and planning our future work in these areas.