ABSTRACT

GEOGRAPHIC INFORMATION SYSTEMS AT THE OHIO DEPARTMENT OF NATURAL RESOURCES

By Kelli Lynn Vogt

This paper provides an analysis of the use of Geographic Information Systems in the government through the lens of a case-study/internship at the Ohio Department of Natural Resources. The internship was conducted in the Mineral Resources Management division of ODNR, and served to provide greater perspective and insight into the uses, advantages, and disadvantages of utilizing GIS in public policy making and management.
Geographic Information Systems at
the Ohio Department of Natural Resources

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By
Kelli Lynn Vogt
Miami University
Oxford, Ohio
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Advisor_____________________
David Prytherch

Reader_____________________
Robbyn Abbitt

Reader_____________________
Thomas Klak
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INTRODUCTION

Geographic Information Systems, or GIS, is a rapidly developing technology that is being utilized in both the public and private sector. This technology has the ability to incorporate many different forms of data, and can be used for analysis in many areas. Any data that have a spatial location can be used and analyzed in a GIS system. Agencies are using GIS in many areas such as resource conservation, city planning, and natural hazard prediction, just to name a few. This paper provides an analysis of the use of Geographic Information Systems in the government through the lens of a case-study/internship at the Ohio Department of Natural Resources. The internship took place in the Mineral Resources Management division in the Abandoned Mine Lands section which employs personnel in a variety of fields ranging from engineers to fiscal officers. The internship served to provide greater perspective and insight into the uses, advantages, and disadvantages of integrating GIS into public policy making and management. The main project of the internship, as my supervisor stated, was to create an “as close to all-inclusive as possible” database of completed abandoned mine reclamation project locations and accompanying data such as project type, name and number. This allowed for the examining the pros and cons of using GIS in smaller state government agencies, as well as its application to natural resource management with specific emphasis on mine land reclamation.

Ohio is a state fortunate to have endowments of many natural resources. From the time of the earliest colonists, many resources could be found both on the surface of the land as well underground. Previous to exploitation for lumber, plentiful forests could be found covering most of the state. To this day, mineral deposits can still be found under the surface all across Ohio. Deposits of coal, limestone, shale, oil, gas and other minerals are located in this former Northwest Territory region. These mineral deposits have long been mined and sold for use in many industries since the early 1800s.

During these early days, there was limited regulation on natural resource extraction throughout the entire United States, and Ohio was no exception. With no government oversight, early mining and timber companies could easily take as many minerals as they could access. Since there was no regulation on the methods used for obtaining natural resources, companies inevitably affected and upset the natural balance
of the environment. This was the case for many states and areas throughout the entire country. Erosion, acid mine drainage and plugged oil wells can be found across Ohio’s landscape. In order to address these problems, many states began to institute programs to control and regulate the use and extraction of natural resources. Many states established agencies to handle these new regulating activities. In Ohio, this responsibility fell in the hands of the Department of Natural Resources. For over fifty years, this department has been responsible for establishing standards and retaining control over the use and extraction of resources across the state.

Attempting to maintain records and accurate information on the use of natural resources, as well as regulating their use is no easy task. The Ohio Department of Natural Resources works to achieve this goal every day. With the advancement and development of new technology, many public and private agencies have begun using new equipment for storing and analyzing information. Also, the increasing use of computers and digital technology has caused many government agencies, the Department of Natural Resources included, to transition into the digital age. One such tool that has been growing in use in the governmental sphere is Geographic Information Systems, more commonly known as GIS. This tool has the ability to both house large amounts of data in an organized manner and also perform many varieties of analyses. Whether the agency needs to develop a plan for extracting coal that will keep environmental impacts at a minimum, or develop a plan for conserving and monitoring the use of other natural resources, GIS can assist. If the information can be linked to a spatial location to it can be analyzed using GIS. This tool can be very useful in many arenas, and the government is taking advantage of the many benefits GIS can offer. GIS can serve as a very powerful tool due to its ability to process and analyze many different forms of data.

With the number of GIS users increasing every day, different consulting companies and firms which solely provide these types of analyses are becoming more common. Various researchers and authors are studying these companies and their use of GIS. Additionally, many people are studying GIS usage in the public sector as well. Literature on the subject points to GIS having both advantages and disadvantages for use in the government. The government is taking advantage of this technology for many different uses. Especially on the federal level, government agencies have been utilizing
this technology for years. However, on a more local and at the state level, there are several key problems with GIS. The software is quite expensive, and hiring personnel who know how to use it can also become pricey. Many smaller government bodies are not able to afford to initiate a GIS program (Fleming, 2005). Even with the many benefits it can provide, the cost often prevails and prohibits. However, it is becoming more affordable, and smaller government agencies are now more able to take advantage of the benefits of GIS.

The impact that GIS could potentially have on governmental operations, can be studied through the lens of a government agency such as the Ohio Department of Natural Resources. Since ODNR is just beginning to initiate a large-scale GIS program, it provides an ideal setting to study the potential benefits and drawbacks GIS can have on a government agency. Generally speaking, ODNR has limited staff devoted to using the technology full-time. However, the individual divisions within the agency are at different levels of GIS usage. Some divisions, such as Mineral Resources Management (MRM), do not even have all their data stored in digital format, while others are already running advanced GIS operations such as Internet Map Services (IMS). Therefore, this state government agency served as an ideal example for seeing a GIS framework being built from the ground up. In addition, one can observe the advantages that are already being realized by those divisions using it more heavily. Therefore, through a case-study analysis, the effects and potential role of GIS in the governmental sphere can be understood. This case-study served to examine the pros and cons of using GIS in smaller state government agencies, as well as its application to natural resource management with specific emphasis on mine land reclamation. It could also be used as background information for ODNR, and specifically for MRM should they decide to continue their trek into the GIS world.

Evidence from said case-study will allow for drawing conclusions about not only the advantages and disadvantages of using GIS in a government setting, but also whether or not it can be applicable to abandoned mineland reclamation. These ideas are among the research questions presented in this report. To answer these questions, this report will begin by examining the existing literature on the subject. This literature will provide a base of ideas for the study by presenting pros and cons of GIS use in the government that
have already been studied. This paper, however, seeks not only to delve further into this topic, but also examine it though the lens of mineland reclamation. For this purpose, a discussion of Ohio’s coal industry, regulatory history, and brief background on ODNR will be presented as well. Finally, the specifics of the internship experience, as well as an analysis of the case-study and potential answers to the research questions will conclude the report.

**Research Questions**

The literature discusses the pros and cons of using GIS in the government. However, one must wonder if these ideas are accurate and how much they are evident in the government. Asking the question “what is the potential role of GIS in the government” does not take into consideration the current use of the technology. First, one must ask if the current government use pointed out in the literature is accurate and evident. Is GIS making government more efficient? Is it helping to retain data long-term and make it more easily accessible, and is the public able to realize and better understand what their government is doing? Or is the software sometimes too complicated and therefore becomes out of reach for most people to use? These are the key questions which will be analyzed through the lens of a case-study at ODNR. In addition, the area of natural resource management, and especially mine land reclamation is discussed in a very limited fashion in the existing literature. More specifically, the internship experience seeks to find if GIS can be relevant and useful in mine land reclamation, and if the potential benefits of using a GIS outweigh the software’s shortcomings. This information could be used when weighing the ideas of initiating a large-scale GIS program at ODNR, and other government agencies in the future.
LITERATURE REVIEW

In order to understand the motive for the case-study, one must take a look at the information available in the existing literature concerning GIS and its use in the government. Many authors have different views on the pros and cons of using such technology in the public sector. A context for the internship is set up in the existing literature on the subject.

Broadly speaking, GIS is a computer-based software that can link and display many attributes of spatial data. Siddiqui, Everett and Vieux define GIS as “a database management system designed to manage large volumes of spatially distributed data from a variety of sources” (1996, 515). Steinberg puts this into a broader context by stating “A GIS is perfect for integration physical, economic, and social data into one unified analysis” (2006, 37). The ability of GIS to integrate many different kinds of data into one common interface makes the possibilities for analyses nearly endless. Additionally, since GIS has the capability to bring together data from a variety of different sources and knowledge bases, it is being used in all levels of government and private sector organizations and is growing in number of users and uses every day. GIS has expanded into many fields including the environment, waste management, crime analysis and even site suitability for landfills or schools. If the information can be linked to a geographic point, then it can be analyzed using a GIS. In the environmental realm, GIS can become incredibly useful as well. Not only can it be used to plan for future excavation of natural resources, but it can also help predict and prevent possible disasters. Additionally, due to its ability to increase efficiency, potential for public visibility and non-degradability, GIS is a powerful tool for government agencies in the field of natural resource management and other environmental areas.

Advantages for GIS use in the government

This technology is becoming more commonly used in the public policy/governmental arena. Fleming points out that citizens do not want tax increases, but are demanding more and more services. So, how does the government provide more services with less money? The author would argue that GIS is the solution to this problem. Once installed, it can provide any number of services in a cost-efficient manner. For instance, plans for disaster relief or to determine which emergency facility is closest to a particular
location could be generated using a GIS, and these processes would only take a matter of minutes to complete given the appropriate data (Gunes and Kovel, 2000). In addition to the speed at which GIS can do such analyses, it also has the capability to repeat processes many times over. As Iverson (1997) point out, using GIS is often much quicker and can be done much more repetitively than field methods. Basically, the options are limitless, and allow the agency to produce results in a quick and timely manner. The ability to increase efficiency makes GIS very appealing to government agencies. Known for their notoriously slow decision making speed, governments can use GIS to generate information more quickly, and hence make decisions based in this data more quickly.

Using GIS can allow formerly difficult analyses to occur with the click of a button. GIS can make this process easier and more efficient by displaying all the information on one interface, and generating the data very quickly. One study by Daniel and Abkowitz showed the development of a tool in GIS software which would predict coastal erosion on Caribbean islands (2005). Once the data had been collected, the authors were able to generate useful results quickly. Given the Caribbean’s dependence on tourism and beaches as revenue generators, this could potentially save the economies of these nations by helping to prevent further erosion. The conservation of this natural resource could prove very beneficial in the future, and GIS makes it possible and cost-effective.

Therefore, GIS has the capability to increase efficiency and effectiveness while at the same time saving taxpayers’ money by increasing productivity. Brudney and Brown point out that in government operations where GIS was in use, productivity increased anywhere from fifty to one hundred percent (1998). This significant increase is a result of quick and easy access to large amounts of spatial data on any number of topics. Additionally, the authors point out that GIS grants the ability to look at the larger, city or countywide picture, while still seeing the locations of very small details such as fire hydrants or street signs. Also, given the ability of GIS’s user analysis to help predict natural disasters, or erosion, it can assist government officials in making decisions that will maximize the positive impacts on society while negatively affecting as few people as possible. The flexibility of GIS enables a broad range of potential uses and allows for governments to increase productivity and in turn, effectiveness.
An area that is growing in use of GIS technology is that of governance and public policy (Fleming, 2005). Rather than simply using GIS to display a variety of data on one interface, governments are beginning to actually use the technology to aid in their decision-making. GIS is becoming more widely used to assist in several of these areas. Its ability to incorporate a great amount of data into one visual display allows for lawmakers to more easily understand the problem. Additionally, with the analysis capabilities of the software, users can predict the possible effects of a certain action (Fleming, 2005). By predicting the potential outcomes, lawmakers can jump ahead a few steps in the policy making process. They no longer have to wait to see the effects of their new policies. Rather, they can be visualized in the GIS and shown before any decisions are made. (Fleming, 2005) This aids government officials in evaluating their options and then selecting the most appropriate policy to achieve their desired results. This helps to eliminate potential problems and can ensure that a government’s policy is not going to be a waste of tax money.

In a similar way, GIS can also be useful with the extraction of natural resources. As Carter reported in 2005, Coal mining companies have recently begun using GPS and GIS technology to map their coal extraction techniques which can greatly decrease spending and conserve energy. Additionally, to please both the public and abide by government regulations, coal companies are using GIS software to plan the future locations of mines while taking into consideration the surrounding infrastructure and potential environmental consequences. (Carter, 2005) All this can be done on one software interface, making GIS an easy route for mining companies to select appropriate sites for future mining.

Much like the coal companies wanting to keep the public on their side by examining potential impacts from mining, Anderson points out that GIS can provide a user-friendly format which even people who know nothing about the subject matter can understand. GIS provides this service. This can therefore rouse community participation and make the public more aware of government actions. GIS has the ability to bring information to the public eye which is easy to understand and can be seen in a visual format. GIS does not just create maps, rather it can make a single display out of multiple pictures (2005). It can incorporate several charts or graphs and show the data spatially on
one common interface. This makes it very public-friendly. While the community members may not actually know how to use the technology themselves, they can still attend meetings, see policy effects in a user-friendly format, and provide input based on these displays. Elwood points out one example where citizens could make a drawing of where they would like to see parks installed in the city. This drawing could then be scanned, georeferenced and digitized for use in a GIS. (2006) Therefore, GIS can be a powerful tool for incorporating the public in the decision making process.

GIS can also be very user-friendly. Once created, it can be uploaded onto an Internet Map Server (IMS) for public internet use. The general population can then have the ability to access much of the data that the government is using. For instance, a map layer could be created to show where abandoned mines are located. It could then be uploaded onto an IMS where a potential home builder could access the information and know if their desired location is in danger of underground mine damage in the future. As an additional advantage, the public would have the ability to see what their hard-earned tax dollars are producing. Not only would GIS help the government and other public agencies perform geographic analyses quickly and efficiently, but the public would be able to reap the benefits as well.

One other benefit of GIS is its non-degradability. Once created, geographic data is stored in a digital format that can carry over from generation to generation. This can help to retain institutional knowledge within an agency. For instance, many in the baby boom generation are currently reaching the age of retirement, and many of these individuals have been at their current place of employment for twenty-five to thirty years. Therefore, they possess great amounts of knowledge that can hardly be passed to a replacement during an orientation and training period. GIS can help in this regard as well. By capturing locational data and knowledge on the work that the previous employee completed during his/her service, future generations of workers will have this information at their fingertips. As Ventura points out in his work regarding local governments use of GIS, the ability to pass the information between employees and new hires is essential to retaining completing work to its fullest (1995).
Disadvantages for GIS use in the government

There are some disadvantages to using GIS in a government setting. Possible concerns include the idea that GIS decreases the democratic right of the people or that the technology is taking power away from the masses and into the hands of a few because only a limited number of people know how to use the technology. This is true to some extent. First, costs for GIS software and powerful computers to operate it are decreasing, however the costs of producing high-quality data are increasing (Fleming, 2005). Companies who produce data can charge high prices, and the cost of hiring staff to generate data on site can be expensive as well. Therefore, many cities or small local governments could afford the computers and necessary software but creating the data suitable to their individual needs may be out of reach. The costs of using GIS once the data have been collected and created are minimal; however, the initial building phase involves a significant investment from the agency.

There have also been scenarios where an organization has invested the money for the hardware and software needed for GIS operations, but then have limited staff that know how to use it (Nedovic and Godschalk, 1996). If there is only one staff member in an office who can perform GIS analyses, this person is probably overworked and does not have time to complete requests from everyone. Additionally, as Ventura points out, GIS is continuously changing and updating software. Therefore, staff need to have ongoing training to keep up with these changes. Many smaller governments do not have the funding to maintain this type of training. (1995) These factors can lead to GIS being used less and even when utilized, it is not being used to its maximum level of effectiveness.

In addition to the need to continuously train staff, Ventura points out other potential institutional and technical problems for GIS in the government. First he points out that GIS software often does not contain all the tools necessary to perform desired functions. Therefore, users may have to tap into other software, and hence need to possess knowledge on their uses as well. (1995) Additionally, small government organizations often lack funding to buy these other software packages. Other costs can arise when searching for data. Often the cost for data can be quite high. Seiber points out that this becomes a common problem for many agencies. They can buy the software,
but the affordability of “relevant and high-resolution data remains high”. (2006) This can usually lead to agencies building or creating their own datasets. But, manual labor for this process is not inexpensive either. Many of these problems come into focus during the case-study, as the internship experience highlighted some of these issues first-hand.

GIS in Natural Resource Management and Mining

There is a plethora of literature available on the uses, advantages and disadvantages of GIS. However, one area of natural resource management that is not very well written upon in GIS literature is that of abandoned mine lands. There are discussions of using GIS to plan various natural resource consumption processes (Hinton, 1996; Knox and Weathersfield, 1999; Iverson et. Al 1997), as well as for tracking land use change related to consumption of natural resources such as coal (Prakash and Gupta, 1998). The variety of topics covered in the literature makes a case for using GIS in the government, specifically in the natural resource domain, and also displays that the technology is already in use. From shore-line erosion to enhancing coal mining techniques and including hazards management, GIS is definitely being utilized in many areas of natural resources management. However, there is limited literature available on its use specifically relating to mine land reclamation.

The following case-study analysis hopes to fill some of this gap in existing literature as well as analyze the advantages and disadvantages of using GIS in a government setting. By having a first-hand look at building a GIS related to mineland reclamation, this report hopes to begin filling the existing void in the literature, as well as provide insight on the general use of GIS in the government. The report can also serve to help to perform a cost-benefit type analysis based on the advantages and disadvantages pointed out in the literature.
OHIO’S COAL INDUSTRY

In order to appropriately understand the case-study, one must first have a general understanding of the background of the participating agency as well as a brief history of natural resource production in the state of Ohio. Oil and gas can be found all over the state. Additionally, there are coal resources in the southeast portion of the state. This coal has been mined by various groups since the 1800s. (Peacefull, 1996) There are approximately 28 counties which contain coal in the state, and therefore also 28 counties where reclamation projects generally take place (Figure 1).

Figure 1: Counties in Ohio containing coal resources. (Map by Author)

According to Leonard Peacefull, coal has been mined in Ohio for over 100 years, and remains one of our most important mineral resources. Many of the steel plants throughout the state have long relied on this coal production for manufacturing. With the discovery of more environmentally friendly energy resources, Ohio’s coal production has
declined. The heavy industrial steel mills have declined in power, thus requiring less coal resources. (Peacefull, 1996) However, even with the lowered demand within the state, coal continues to be extracted and used across Ohio.

The coal from these areas has been mined in a variety of ways. Different extraction methods have been used depending on the depth and location of the resource. Strip and underground mining are the major ways in which coal was and is mined in Ohio. Both methods can lead to environmental problems if the land is not restored following cessation of mining activity. Surface mining is done by removing the topsoil and overburden to access the coal. This creates several problems. Peacefull highlights some of the potential issues arising from surface mining. First, he says, that erosion can become a significant problem from the removal of the upper layers of the earth. The erosion then leads to the formation of drainage patterns which were not previously in existence. These new waterways lift the waste left from the previous mining, and carry the drainage to other areas. This pollutes local distant water bodies. Finally, the barren land which remains after surface mining is unaesthetic and continues as a scar on the landscape. (Peacefull, 1996) If these problems are not corrected through reclamation, they can lead to serious environmental issues.

**Regulatory History**

For the first 150 years, this industry was completely unregulated by any governing body. In 1947, the first laws came into effect to regulate strip mining practices throughout the state. They required that companies gain a license to mine coal and pay a 100-dollar bond for each acre of land affected by coal mining. The second monetary requirement was an effort to make certain that reclamation of the land took place after mining ceased. However, this law was still very lenient and not at all near the standards of reclamation which are currently in place today. It was not until 1972 that a major piece of legislation regulating reclamation laws was passed in Ohio. At the time, this law was the most inclusive legislation of its kind from across the nation. (Ohio Department of Natural Resources, 1999)

Since there was limited regulation of mining activity previous to 1970, companies and/or individuals would come to an area, mine the coal and then leave without restoring the land to its original quality. With the passage of the new legislation regulating the
mining of coal, these practices changed. Lawmakers focused on creating laws regarding reclamation of lands after mining is complete. These laws provided for the restoration of land after coal mining was completed. However, the laws were not retroactive, and therefore did not hold companies responsible for areas they had mined before the bill was enacted. The private mining agencies were not liable for any problems or issues which arose with the land they had mined before and they were not required to perform reclamation operations in those areas. With all the coal mining that took place in southeastern Ohio previous to the reclamation, there are obviously areas which were not reclaimed and have developed into problem areas for landowners in this region.

In the 1970s, when the first extensive reclamation law was passed in Ohio, it went a long way towards forcing coal companies to restore land when mining is completed. However, the problem lies in the mining that took place previous to 1970. Many of the companies in operation before this date may no longer be in existence. Therefore, they cannot be held responsible for damage done to mined lands. The responsibility for restoring these areas then falls under the jurisdiction of the state government. Problems such as subsidences or remaining entries from underground mining, highwalls and acid mine drainage are health and safety risks which cannot be ignored. The jurisdiction for correcting these problems lies in the hands of the Ohio Department of Natural Resources.

**Regulatory Agency**

The Department of Natural Resources falls under the umbrella of state tax funded agencies in Ohio. There are several divisions housed in under their network. The Division of Mineral Resources Management is one of these divisions. Others include the Division of Water, Watercraft, Natural Areas and Preserves, Forestry, Wildlife, Geological Survey, Real Estate and Land Management, Recycling and Litter Prevention, Soil and Water, and Engineering. (www.ohiodnr.com/aboutus.htm/#) All these make up one agency which is headquartered in Columbus, Ohio. As mentioned earlier, my internship was housed in the Division of Mineral Resources Management (DMRM). The goal of DMRM is to “provide for the responsible development of Ohio’s energy and mineral resources in a safe and environmentally sounds manner.” (http://www.ohiodnr.com/mineral/about.htm) This division is made up of several sections which all function under the same heading. These include Permitting, Hydrology and
Bonding, Field Inspection and Enforcement, Technical Support Services, Abandoned Mine Lands, Engineering and Design Services, and Mine Safety. This division itself has had many transformations and merges over the years. It began as the Division of Mines which was created in the 1800s when coal mining in Ohio began. Originally it was housed under the Department of Industrial Relations. In 1949, the Division of Reclamation was created under the Department of Agriculture to preside over new projects being completed in regard to legislation changes. The two merged in 1995, became housed under the Department of Natural Resources and became the Division of Mines and Reclamation. In 2000 the division merged with the Oil and Gas Division to become the Mineral Resources Management that it is known as today. According to their website, the priorities of DMRM include regulating coal and industrial mineral mining, protecting and conserving lands and waters by preventing negative mining impacts and requiring restoration, supporting efforts to extinguish threats to the public or environment caused by oil, gas and mine emergencies, and educating and informing Ohio’s citizens about the division’s role in responsible development of mineral and energy conservation of the environment.

Managing the natural resources of a well-endowed state such as Ohio takes great coordination. Abandoned underground mines can be found all over the eastern part of Ohio. The locations are numerous and often the extent of mining is unknown. This makes it difficult to keep track of the data on mining and abandoned mines. Additionally, mineland reclamation work is often dispersed over a wide area, and found in remote locations. Therefore, the mining inspectors as well as reclamation project officers are traveling across the state with limited access to technology or internet, and limited communication with ODNR’s home office. Therefore, this industry could greatly benefit from a system which can help to organize and house data, as well as strengthen connections between branches and home offices. GIS can provide such a technology.
THE INTERNSHIP

The internship was in the Abandoned Mine Lands section. This placement was obtained in response to a posting on the Ohio Department of Natural Resources website. After e-mailing the contact person listed under the posting, I received further information. I went for an interview and learned what the position would entail, and a job description was obtained and approved by the chair of the Miami University geography department as a feasible internship option for completing my degree. I worked at ODNR for forty hours a week throughout the months of May, June, July and August. Then I continued my work into the fall semester, working approximately twenty hours a week while attending class in Oxford, Ohio. My supervisor was an environmental specialist in the AML section of DMRM. However, her supervisory role was mainly limited to answering my questions and providing greater background information on the division, mining and reclamation tactics. Once she had initially explained the project and provided information on source data, I generally operated under my own supervision.

The supervisor of the project stated that the main project of the internship was to create an “as close to all-inclusive as possible” database of completed abandoned mine reclamation project locations and accompanying data. The Abandoned Mine Lands section serves to “eliminate health and safety hazards and clean up land and water damaged from mining that occurred prior to today’s stricter reclamation laws; including reclamation of underground mine openings, highwalls, dangerous mine subsidences, and clean up of hazardous and/or polluted water impoundments, acid mine burning coal refuge, and others”. (http://www.ohiodnr.com/mineral/about.htm)

All of these problems are the result of previous coal mining in a particular area. The Abandoned Mine Lands section has two different programs under which they operate. These are the State and Federal AML Program. Both are funded by coal mining severance taxes. For each ton of coal mined in Ohio, tax is levied upon the mining company and the money is then used to complete reclamation projects throughout the state.

ODNR was primarily looking for assistance with archiving data which was not housed into one location. Many government institutions suffer with the problem of converting old information retained in paper format into a digital framework.
Oftentimes, data on one subject may be located in several locations or in different formats. Bureaucratic institutions can change the procedures and/or paperwork requirements over time. Therefore, the types of data retained on file can be varied and change through the years. This was precisely the case with ODNR. Over the years, the Abandoned Mine Lands reclamation division has completed nearly 1100 projects which are recorded in a Microsoft Excel spreadsheet. However, through the years, the program requirements for record keeping on each project had changed, and the data was held in a variety of different formats. The task of the internship was to find information and location data on each project. In order to track down all of the 1100 projects listed in the original spreadsheet, several sources needed to be utilized. These were primarily the Annual Work Plans published yearly by the Division of Mineral Resources Management, the Abandoned Mine Lands Inventory System record books, and sets of United States Geological Survey 7.5 minute quadrangle maps detailing project locations across the state. The Annual Work Plan information was housed in a series of three-ring binders which had been collecting dust in the archives for years. My first task was to begin wading through that information.

**Data Availability**

Diverse data sources, like those at ODNR, can be effectively managed through the use of GIS. ODNR mineland reclamation generates large volumes of data in different formats, and my project was to incorporate them in a GIS. The Annual Work Plans described above have been created each year by the division, beginning in the 1980s and following to the present. Each year’s work plan details the potential projects being proposed for that particular year. The book serves as an informative packet, and is used to fulfill funding requirements. Each potential project is laid out and mapped to show its location and extent. Then a data sheet is filled out detailing the work that is to be done, and what reclamation techniques are to be employed. However, all the projects in these books are not necessarily completed. The Annual Work Plans are merely plans for potential work to be completed. Each project in these binders has not necessarily been constructed. MRM serves to correct mining problems that are of immediate threat to Ohio citizens first. Then, remaining funds are devoted to other projects of lesser danger.
Therefore, some of the proposed projects remain in the proposed stage for many years. The AML section may or may not end up constructing all the projects.

However, once a project is funded, the division will send out notification that they will be accepting construction bids for the work to be done. They collect offers from various parties, and then select the best suited for the job. Generally, construction companies who do environmental work are the primary bidders. Once a construction agency has been selected, the work on the project can begin. Typically projects can take anywhere from one week to several years to complete, depending on the extent of the work to be done and the area the project covers. For filling in an open mine shaft or subsidence, the time frame is much shorter than that of a large scale project involving the correction of acid mine drainage.

Once a project is initially proposed, it is also entered into the Abandoned Mine Lands Inventory System of the United States Department of the Interior. This system attempts to track ongoing, completed, and proposed projects going on throughout the entire country. Ohio’s work is no exception. ODNR workers in the Mineral Resources are responsible for entering the data into the system and keeping is up-to-date. These inventory reports are also stored in paper copies in the DMRM office. They served as yet another data source for my project. The inventory tracks what and where projects have been proposed or completed, along with many pages of bureaucratic or fiscal information on each project. This information was very useful when attempting to determine if a project had been completed. Trying to find completion dates or records that the project had been built was a difficult task. Many times, I had to rely on personnel knowledge for this information. The AMLIS provided the fairly accurate information on completion dates for the projects. Since the project was meant to capture all completed reclamation projects, this data proved to be valuable.

The final primary source used to gather location information on each project was a set of 7.5 minute quadrangles. The division keeps a copy of every Ohio quadrangle in the coal mining region on file. These have drawings of the extent and areas of most projects. The maps, however, were generally used as a last resort, as they have not been updated as regularly as the other sources. Therefore, some of the information contained on these topographic maps was slightly inaccurate, and therefore not the primary choice
when searching for information. If there was no other source available for obtaining the spatial data, these maps became the only choice.

**GIS Methods**

Data management is an essential part of acceptable GIS work. Given the diversity and volume of the data sources, organization is key to making the system useful to the agency and the public. The process began with data capture. In a GIS software program, this involves digitally clicking a mouse to place a point or points as a geographic reference for that location. For this project, the data capture attempted to store locational information on each project. By using the variety of sources available, locations were captured for nearly 1000 of the project locations in question. Once a paper map of the location was obtained, the process of combining all the projects into one digital database began. The supervisors of the project decided to use the personal geodatabase format provided by ESRI’s ArcMap products. The personal geodatabase is highly portable and can be transferred between people easily. It also ensures that all data in the database have the same projection and spatial reference information. These features make the personal geodatabase the easiest form of digital spatial data collection for wide distribution. The goal of the project was to make the information readily available to the employees and field staff at ODNR. Therefore, the geodatabase served this need the closest, and was chosen for use in this particular project. This type of file structure would accomplish several goals. First, it would enable the data to be distributed on a large scale. Additionally, it maintains a simple file structure. In the personal geodatabase, all the files are added as feature classes, and further broken into feature datasets. These files are all retained under the single geodatabase. Rather than having many files which would all need to be loaded to view the data, the entire geodatabase could be displayed showing all the necessary attributes. This helps make the data useable for more people and therefore helps to eliminate some barriers to using the software. Additionally, it can make the whole process more efficient by having all the data available in a well-organized and easy-to-access file.

For each of these projects, both a pinpointed geographic location and attributes were needed for each. These attributes ranged from project name and number to the coal seam which was mined and the completion date of the reclamation project. Additionally,
the project supervisor wanted to include attributes regarding the type of work done, as well as the county, township and quadrangle of each project location. All this data was housed in the attribute table for each type of project. A screenshot of the attribute table can be seen in figure 2 below.

After working with the information for several days, the decision was made to change the initial setup of the geodatabase from housing solely point data to including polygon and lines as well. Previously, we had been using points to capture the locations of projects which encompassed very large land areas. Also, for showing where things such as a highwall backfill had taken place, which typically is a long and narrow area, lines seemed more appropriate. Additionally, polygons would be more appropriate for showing large areas which had been regarded or lines more useful for elongated projects. All the previously mentioned attributes were present in each of the feature classes. Figure 6 on the following page provides examples of the three different types of features.

Additionally, the projects were further divided into separate feature datasets based on which section within the Abandoned Mine Lands group had handled each. There are three main programs within the Abandoned Mine Lands section. Each program takes care of a different set of problems in previously mined areas. First, the Acid Mine Drainage program works to combat problems resulting from improperly drained coal mining areas. Second, the emergency program attempts to resolve issues which are of immediate threat to people’s safety such as a landslide on the major highway, or a subsidence in the middle of a road. Finally, the non-emergency program covers the other mining-related problems which fall into the less urgent category. All three of these programs work together and make up the Abandoned Mine Lands group in the Mineral Resources division of ODNR.
For the purposes of the project, subtypes were created within each feature class to accommodate these different programs. The majority of the projects were in the non-emergency sections, and therefore this became the default option. The emergency projects were captured upon completion with Global Positioning System points, and could be easily imported into the geodatabase, easing the labor of capturing the projects in that program. However, the non-emergency and AML projects were without this convenience. Therefore, capturing these areas and/or points was my task. Generally, this involved looking at a paper copy of a map showing the project location and finding the same location on screen to plot its location. Usually, the projects were hand drawn on a copy of a topographic map. Therefore, I used the digital topographic maps as the primary means for finding a location. This was the tedious and taxing part of the job. Attempting to zoom and locate the appropriate spot for each project proved to be difficult and required extreme patience. The full extent of the geodatabase can be seen on the map in figure 3 below. Also, a zoomed in view of the southeast portion of Ohio, where a large number of projects exist can be seen in figure 4 in greater detail on the following page.

Figure 3: All GIS-recorded projects in Ohio. (Map by author)
Figure 4: View of the types of data used on a county scale. (Map by author)
FIELD CHECKING

The majority of the work at ODNR involved the capture and digital conversion of these projects. However, once the majority of the GIS work was completed, a field check on the quality of the data collected thus far began. The process helped to ensure the accuracy of the data gathered. In order for the database to be useful, it needed to contain data that were accurate and precise, as well as complete. Meeting with the field project officers provided an opportunity to check the data I had completed, and fill in gaps in the information. Additionally, it helped to bridge the gap between the central and field offices. Many times, the field officers were the most proficient and had the greatest amount of information on the projects. The GIS dataset will bring this information to a central location where both the main and field offices can access it.

The field checking process involved traveling around Ohio meeting with the project officers at each of the MRM field offices that do work in the coal mining region of Ohio. These are the men (and woman) who are responsible for the oversight and design of each reclamation project. Most of these people have been in their positions since the initiation of reclamation laws in Ohio, and hence have seen and worked first-hand on most of the projects being digitally collected. Their insight proved invaluable, as books and maps can only cover so much, and any changes which took place after the initial design of the projects were not recorded on paper. Using the knowledge of these people allowed for a more accurate depiction of the locations and extent of these projects. They were able to correct many errors encountered in the work, and hence provided information which could not have located elsewhere.

Additionally, the meetings with these project officers were essential for data retention. As previously mentioned, most of these people have been in their positions for many years, and have built a strong base for institutional knowledge which would be lost should they retire. Since the program has been in operation for nearly 30 years, many of these individuals are indeed reaching an age where they are eligible for retirement. For example, I met with one project officer who was set to retire in a month. He had been one of the project officers in the Salem, Ohio office for nearly 20 years. This individual was responsible for leading, designing and monitoring hundreds of reclamation projects in his area, and he was the only one who knew the details on these projects and their
specific locations. Had I not been able to meet with him, and tap into his memory, all his knowledge would have been lost for the division, and no one else would know the information he did. This was the case with many employees. The knowledge and information they possess could easily have been lost, if not for the new GIS database.

While books and maps provide a base towards knowing where projects were located and what work was done on each, they are not nearly as extensive or in-depth as a person’s knowledge who actually worked on the project first-hand. The internship involved not only converting data from paper sources into digital format, but also focused on preserving the institutional knowledge which would have otherwise been lost in time.

Before the development of the GIS, if someone had, thirty years from now, wanted to know where a mine entry was closed off, they may have had no way of accessing accurate information. The GIS system will provide not only quicker access to such information, but also more precise data. Additionally, this data will now be preserved permanently in digital format. The entire system serves as an example of what government agencies, small and large, can work with to archive, store and access data.

During this field checking period, I also had the opportunity to witness some reclamation projects that were under construction. This helped to provide even greater insight into what goes in to one of these projects. As can be seen from the photos on the following page, there are multiple approaches the AML program takes to correct mine damage. Seeing these projects spawned other ideas for GIS uses in mineland reclamation, especially in the projects involving acid mine drainage. Project officers could use GIS to calculate water flows and patterns and perhaps better see areas that would be affected by acidic water from a mine. They could then better correct the problems by seeing the whole picture. By overlaying other waterways such as streams or rivers, they could see where contamination issues could potentially arise and therefore do their work more efficiently and for the greater benefit of the public. This highlights the need for GIS personnel to not remain isolated from field workers and others who will be predominately using the data. By working together, the GIS and field staff can accomplish the greatest results. This serves to take those actually constructing the projects, and turn their knowledge and expertise in a non-degradable database.
Additionally, the field staff would best know of potential uses for the GIS, and could provide the greatest insight on future uses.

Figure 5: Acidic water impoundment under treatment in Jackson County, Ohio. (Photo by author)

Figure 6: Rock-lined channel for directing and correcting Acid Mine Drainage, Vinton county, Ohio. (photo by author)
RESULTS

The case-study at ODNR provided an excellent view of the creation of a GIS database for use in the government. Their GIS program is really just beginning to take root, and being in the early stages of a project such as this gave a good perspective on the pros and cons of using the technology. The goals of the internship were to determine some of the advantages and disadvantages to using a GIS system in the government, and draw conclusions about its use in mineland reclamation. While the literature points out many pros and cons for GIS in a government setting, relatively little has been written regarding its use in abandoned mine land reclamation is limited. This case-study is intended to begin filling this existing gap and further question GIS use through first-hand experience. By participating in an internship experience at the Ohio Department of Natural Resources, the following conclusions were drawn.

The Advantages

The GIS database built at ODNR does indeed support the idea of non-degradability. This was basically the point of the internship; taking data that had the potential of being destroyed and transferring it into a more secure format. By taking the information stored in a variety of paper-type sources, and inputting the data into digital format via GIS, it can now be retained and preserved for many years to come. Additionally, the data is now housed in one compact place, and is well-organized. It can be pulled up upon request and instantly access all the information previously housed in multiple locations. Therefore, the internship experience at ODNR absolutely supported the idea of GIS helping to retain data and making it much more easily accessible.

This point was further confirmed during the field work of the case-study. All of the project officers with whom meetings were held agreed that the GIS database would make the data more user-friendly. Even when they were working in remote locations, they would be able to have the data housed locally on their computers and be able to access it quickly. They also pointed out the extra benefit of including information that was previously only available from individuals and their personal knowledge. This helps to retain institutional knowledge that may have otherwise been lost to retirements or others leaving the department. Additionally, they saw the potential for using GIS to plan
future projects. Whether it be for analyzing water flows or better pinpointing locations of mine shafts, all appreciated the potential benefits GIS has to offer.

While not all of the project officers were necessarily well versed in using GIS, they appreciated the benefits it could provide and admired its storage and recall capabilities. Additionally, the information technology specialists in the Division of Mineral Resource Management had set up a special GIS program for their employees. This was an easy to use version using the ArcView 3.3 software which provided simple drop-down menus where staff could pull in a variety of map layers. By adding the reclamation projects layer to the menu, even people who do not actually know how to operate a GIS program could still add them and access the information. While initially, the program was designed by someone well-versed in programming, the end result was spread over a wide-audience and worked well for the purposes of the division. Overall, it was generally agreed that the new GIS system would help to lessen the time spent searching for information, and that it was set at a level that could be understood and used by many individuals.

Additionally, the use of internet map services or IMS sites can bring GIS within the reach of all citizens with access to a computer. During the case-study, work was completed to help update the data underlying an IMS site on abandoned mine lands. After scanning and georeferencing the images of mine maps, they were digitized and added the data to the current IMS which provides the public with information on the location of formerly mined areas, and where there could be potential future problems. This IMS is open and available to anyone with access to the internet, and can help people pinpoint the location of abandoned underground mines. Using this information, they could determine if there is a chance for problems on their property as a result of underground mines. The application is simple to use and easy to understand. There is even an address locator which will pinpoint the exact location of one’s house. This is just another example of how GIS is not solely for use by highly trained individuals. Additionally, rather than taking power out of the hands of the people, it can actually empower individuals by allowing them access to more information. When spatial data is placed in an IMS format or depicted on a colorful map, people who previously had no knowledge about the subject can easily understand it thanks to GIS.
The Disadvantages

Among the negatives are the difficulty and frustrations that go along with building a GIS dataset. I can personally attest to the struggles one goes through when building a GIS dataset from the ground up. Even for someone who is used to using the software and has spent several years learning the techniques, GIS can be difficult. There are always technical problems and issues which arise making the technology more challenging. For example, I had several problems with when I renamed attribute fields in one software program, and then lost all data recognition of these fields in another. This was just one of many difficulties encountered while building the dataset. Due to this, the literature is correct in pointing out that GIS is not necessarily user-friendly for the many people. It takes years to develop and learn all the skills needed to properly pilot and create a working GIS system. However, it can be argued that it is only necessary to have one or two “experts” who can create systems that others can easily operate. The ArcView application mentioned earlier that DMRM uses is a perfect example. Nearly everyone in the division then had to power to access the information and even create and print maps.

Additionally, the data will need to be continually updated. First, the 100 or so projects that were not captured in the initial database building still need to be identified. Also, as the Abandoned Mine Lands Program continues to complete reclamation work these new projects will also need to be added to help maintain the database. While this is not a difficult task, it is one that would require some GIS skills, and would need to be undertaken by someone possessing such. This becomes a common issue with GIS databases. Oftentimes, an agency will hire someone to build the beginning of a data structure, but once that person leaves or moves on, no one continues working to keep the data up to date. This is especially true when using data that are current and still be being added to. It is common for data to be not up to date and therefore are not nearly as useful to users.

Recommendations

The work completed in the internship is merely a beginning of what could potentially be done. I recommend that the Division of Mineral Resources Management, and ODNR as a whole continue using and expanding their GIS program.
specifically, the following are suggestions in greater depth regarding how DMRM can increase the effectiveness and uses of the GIS dataset I worked on:

1) To make the GIS most useful, a specific staff member must be responsible for continuously updating the GIS dataset for newly completed reclamation projects;

2) Hire several full-time GIS professionals to continue expanding the amount and type of available data;

3) Offer an on-site training course for field and central office staff members to increase GIS fluency and staff’s ability to use the data in an effective manner;

4) Use training to increase GIS usage;

5) Continue reminding staff that the data is available for use, and use software training to encourage greater utilization of available resources;

6) Calculate number of projects completed per year in order to track increases or decreases;

7) Overlay population data with reclamation project data to determine the number of citizens helped from the program;

8) Use population data to further analyze locations of projects in reference to the number of people living in those areas.

Conclusions

The Ohio Department of Natural Resources will continue to serve the citizens of the state for many years to come. This agency can continue to take advantage of the new advances in GIS technology, which may aid in their service provision task. But initiating a large scale GIS program takes time and money. Many government agencies have neither. However, ODNR is moving in the direction towards advancing their GIS programs. They are continually making improvements and taking advantage of the powerful software. Additionally, there is a place for GIS in mineland reclamation. Using GIS, reclamation officers can have a wide variety of information right at their fingertips, and be able to access the data instantly. This can help to provide better services to those in need of assistance due to problems from abandoned mines. Moreover, future steps could include using more GIS tools to perhaps create construction plans or analyze water flows to maximize reclamation effectiveness. There is a place for GIS in the government, and also in mineland reclamation.
Sources


