The Application of GIS in Tallgrass Prairie Restoration and Management

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Introduction

Geographic Information Systems (GIS) is a quickly growing field which is constantly finding new areas of application. This paper investigates some of the ways in which GIS can be applied to the tallgrass prairie and savannah conservation project. This investigation incorporates sub-elements of GIS including global positioning systems, aerial photography, database management, modeling, and computer cartography. The main areas in which GIS can be applied to the tallgrass conservation project are in fieldwork/data collection, data management and retrieval, the identification of potential restoration areas, mapping for management and restoration purposes, and assisting in Landowner contacts. In addition to these main benefits of using GIS as a tool for conservation, GIS also makes possible the sharing and integration of tallgrass information from a variety of sources and locations across the continent.

What is GIS?

Although geographic information systems have been in use in North America for almost thirty years, it is still a topic that has not yet achieved a wide recognition and understanding in the minds of non-geomatics industry professionals. Therefore, a brief introduction to the topic of GIS may help to facilitate the explanation of how GIS can be applied to the tallgrass prairie conservation project.

There are many different definitions for the term GIS, each one constructed by someone of a different background, perspective, or discipline. Depending on the author, the focus of these definitions can stress the importance of mapping, database and software tools, or decision support applications (Chrisman 2002, pg 12). One of the most general definitions to be found was developed by a consensus of 30 GIS specialists with varying disciplinary origins and backgrounds:

> Geographic Information system – A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth (Deuker and Kjere 1989, pp. 7-8)

Although this definition may sound vague, it does encompass the majority of the uses and purposes that professionals have for GIS. It emphasizes that the technology is a system that is meant to organize data, computer procedures, and organizations to serve a common purpose. It also makes the point that there is a difference between the data that is put into the system and the data that results from the system. The most common understanding of GIS, which is more simplified than the Deuker and Kjere definition, is that GIS is a tool for effectively and efficiently working with spatial data for a certain purpose. GIS is a means to measure, represent, and operate on spatial information in order to produce more measurements and to discover new relationships by integrating data from different sources. These representations of spatial information can then be transformed in order to be integrated with other geographic information systems. It is important to emphasize here that GIS is a tool, meaning that it can be bent and shaped to whatever needs or purposes its users require. This includes the needs of conservation organizations such as Tallgrass Ontario.

Literature Review

There is a broad body of literature that exists on the use of GIS for the purposes of conservation. In fact GIS has been in use as a tool for conservation for so long that the majority of Conservation Authorities in the Tallgrass Ontario research area have existing

GIS capabilities. A good source of information on the use of GIS for conservation can be found at the ESRI virtual campus website: http://campus.esri.com/campus/library. This website contains links to over a hundred books and articles dealing with the subject of conservation GIS. One book entitled *Conservation Geography: Case Studies in GIS, Computer Mapping, and Activism* (Convis L, C. 2001) covers many of the basics of the use of GIS in conservation projects by providing examples of real conservation projects that have utilized the power of GIS to further their conservation programs. Each example given in Conservation Geography is mean to describe how GIS is being used to revolutionize the work of non-profit organizations and other groups that are committed to conservation. This encompasses issues of environmental justice, indigenous people's rights, and sustainable development as well as environmental preservation.

A good example of conservation GIS literature that pertains directly to the Tallgrass conservation project is an article entitled *Targeting sites for conservation: Using a patch-based ranking scheme to assess conservation potential* (Lee, J.T., Thompson, S., Woddy, S.J. 2001). In this article, Lee, Thompson, and Woddy present a method of targeting grassland habitat patches in the United Kingdom for conservation using a geographical information system. The method used by the authors involved a model which used a combination of two ranking systems, one biotic and one abiotic, to identify key areas of the existing grassland network that could form the basis of future grassland habitat expansion. This study is an excellent example of the habitat analysis potentials that GIS can provide for tallgrass conservation efforts in that it provides a well developed model for identifying tallgrass restoration areas that can be used to compare models created for tallgrass conservation and restoration in Canada.

Many books and articles on conservation GIS will briefly mention the use of GIS in the management of conservation GIS projects. However, it is difficult to find literature which extends beyond modeling for habitat identification and restoration to comment extensively on the topic of conservation GIS project management. Most academic conservation GIS literature stops with the description of the use of GIS for analysis rather than following through into the capabilities of GIS for conservation project management. This is not to say that GIS for analysis in conservation projects is not important, many ambitious conservation projects would be incapable of moving past the initial stages without the aid of GIS analysis functions. What is needed now though is comprehensive look at how GIS can be used in a conservation project from start to finish. The following sections will attempt to achieve this goal through the example of the proposed use of GIS for the Tallgrass Ontario conservation project.

Tallgrass and GIS

This section will cover five main GIS components that will be useful in the Tallgrass Ontario conservation project. These components consist of GPS, Aerial Photography, Databases, Modeling, and Continuing Management. Although each one of these components might deserve an article of their own, the goal of illustrating how GIS is used in a conservation project from start to finish will necessitate some generalization.

GPS

The first main step towards the creation of a geographic information system for Tallgrass Ontario is creation of a tallgrass prairie fragment theme or coverage. The best way to accomplish this is to use **G**lobal **P**ositioning **S**ystems dataloggers to capture the boundaries of each tallgrass prairie fragment. This will involve tallgrass prairie researchers periodically taking dataloggers with them on fragment visits. GPS data loggers provide the best combination of accuracy and precision, ease of use, time consumption, and flexibility compared with other methods of mapping such as surveying equipment or aerial photo interpretation. Ideally, the capturing of fragment boundaries will occur approximately one year after a fragment has had a prescribed burn to allow the fragment to recover and for prairie plant species to move into areas that had not previously been burnt.

A normal GPS unit works by using satellite signals to determine the location of the unit at a single point in time. A GPS datalogger is able to record a set of positions and store them for use at a later time in a format that is understandable by different GIS software. By walking the boundaries of a prairie fragment with a GPS datalogger, researchers will be able to easily map the prairie fragments that they visit. Once all of the known prairie sites have been visited, the collection of prairie polygons can be assembled into one layer of information for the entire Tallgrass Ontario research area. This layer of prairie polygon information can then be used as a base with which to construct the rest of the geographic information system.

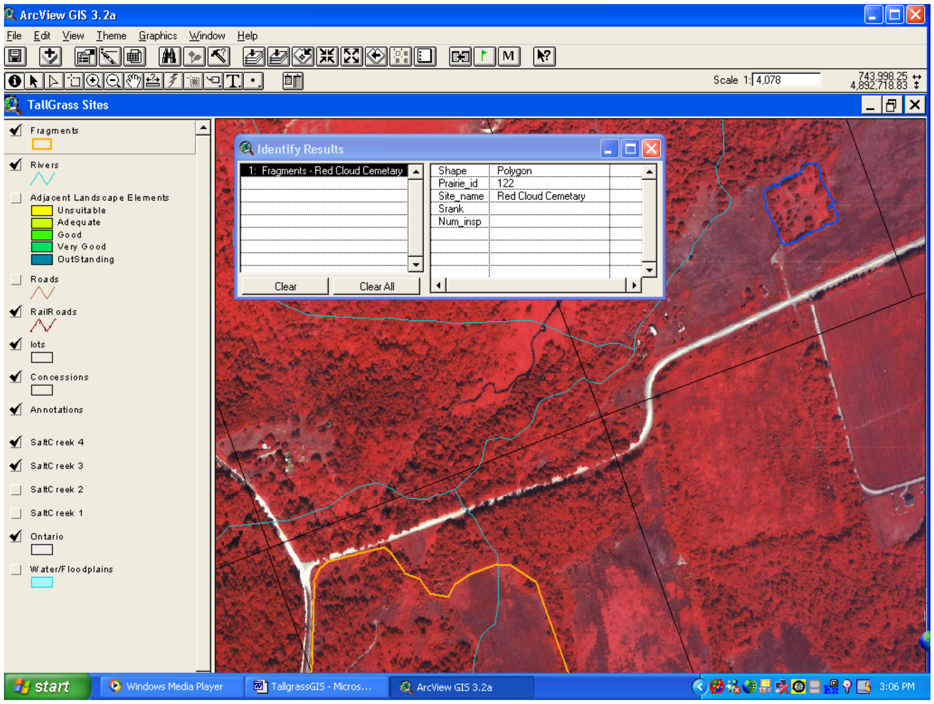
In addition, GPS units can be used as a tool for location verification in additional research and fieldwork efforts. The prairie fragment layer can be downloaded back onto GPS units which can then help prairie researchers to find the same prairie fragments that were identified for further research by the GIS. This will likely prove to be an invaluable tool for working with prairie sites that are in close proximity to one another.

Aerial Photography

Once the prairie fragments polygon data has been collected with the GPS dataloggers, air photographs can be obtained for each of the locations where polygon data was collected for tallgrass prairie fragments. In some cases, air photographs may have already been obtained as part of the original research/fieldwork plan. Also, for locations where researchers were unable to visit and collect gps data for fragment polygons, air photo interpretation can be used as an intermediate method. While not nearly as accurate as GPS, air photo interpretation is the next best option for creating tallgrass prairie fragment polygons. In addition, the presence of air photos in the GIS provides an excellent resource for adding context to the tallgrass prairie fragment polygons. By placing air photos under tallgrass prairie fragment polygons, users of the GIS will be able to place the fragments in the proper context of the surrounding landscape and can gain valuable insight into the situation of each tallgrass prairie fragment (figure 1).

As mentioned earlier, air photos may have already been purchased for the purposes of conducting initial data collection fieldwork and research. Once air photos have been properly georeferenced, they can be used to aid additional data collection, fieldwork, and research, either by making printouts of the tallgrass prairie fragments to be visited, or by using newer versions of GPS dataloggers, such as ARCpad dataloggers, which allow users to download both data layers and georeferenced air photos back to the GPS unit. This would mean that researchers could follow a combination of the air photo and the fragment polygons to ensure that additional research is being completed on the appropriate tallgrass fragments. Air photos also play an important role in the development of prairie restoration models as will be discussed in the modeling section.

Figure 1: Example of a tallgrass prairie remnant collected through GPS overlaying a georeferenced aerial photograph



<u>Relational Database</u>

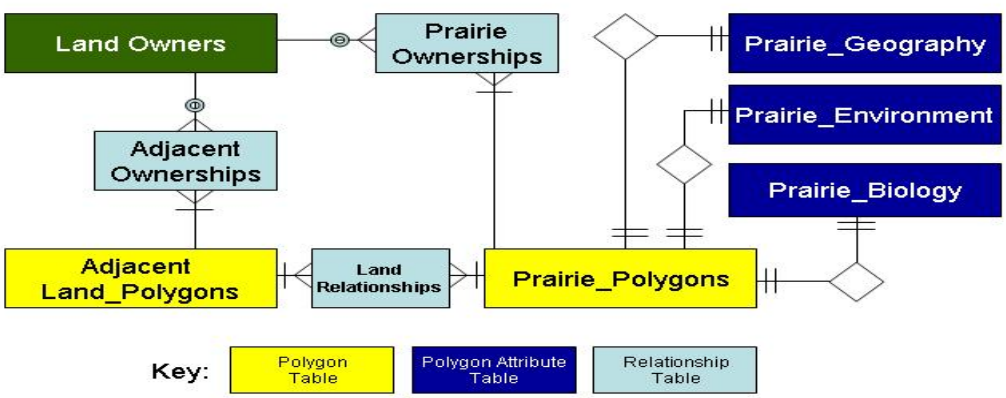
Although each of the six GIS components is important for applying GIS to the Tallgrass Ontario conservation project, the database component may be the most important of all. Without the database, the other components would be lacking in meaning and content, or would be much more difficult and cumbersome to work with. The main reason why the database component is so important to the Tallgrass Ontario conservation project is that it enables an efficient and manageable format for organizing information that is easily accessed and maintained. Having an efficient and manageable system of accessing and maintaining information is essential to the success of the project considering that Tallgrass Ontario must work with close to 200 different tallgrass prairie fragments, each with its own sizeable set of data for 70 different data fields.

The Tallgrass Ontario database will revolve one main table which will contain essential information for the tallgrass prairie fragment polygons discussed earlier. Each tallgrass prairie fragment polygon will have its own unique identifier which will be used to link the polygons with the corresponding records in the main tallgrass prairie table. This main table will then be used to link with thematic tables for information on different subjects concerning each fragment, such as geography or biology. These subject tables will contain important information as well, but it will be information that is not accessed as frequently as the information in the main tallgrass prairie table. This division is meant to make viewing the tables easier for users that are interested in different types of information on each fragment.

Additional tables that will be linked with the main tallgrass prairie table are an adjacent landscape element table and an ownership table. These two tables will be linked with one another as well as being linked with the main tallgrass prairie table. The nature of the relationships between the adjacent landscape element table, the tallgrass prairie table, and the land ownership table will require the use of relationship tables, also called associative tables, in order to properly relate the three tables (figure 2). This database structure will allow Tallgrass Ontario to effectively access and maintain information about each prairie polygon, adjacent landscape element, and Landowner. The ability to link prairie and adjacent landscape element polygons to their respective landowners will prove invaluable to Tallgrass Ontario in that site visits for future research will be able to efficiently contact landowners of sites to be visited.

It is likely that this database will be constructed using a relational database management software program, such as Microsoft Access for example, rather than being directly contained in a GIS project file. This is perhaps the best option because by containing this information in a separate database the data can be accessed and modified without forcing users to go through the often cumbersome and awkward database management aspects of most GIS software. A separate database will also allow Tallgrass Ontario to maintain referential integrity and will protect the database against data corruption and data loss. Additional data that is added to the database, such as new fields or records, can be automatically added to the tables in the GIS by means of platform customization.

Figure 2: Entity Relationship Diagram for proposed Tallgrass Ontario relational database



Modeling

Modeling with GIS is a complex and finely tuned procedure which is used to attempt to represent the complexity of reality in a simplified manner to assist in making spatial decisions. An excellent resource on the intricacies of modeling entitled *GIS Modeling in Raster* (DeMers 2002) explains many of the fundamental basics of modeling using GIS. As mentioned in the Literature Review, many conservation projects rely on

GIS for rare habitat identification and for proposing restoration areas. The main method for identifying these locations is through modeling to assess the impact of many different factors on many different locations. Although Tallgrass Ontario will require the use of GIS for many purposes, modeling for the identification of rare tallgrass habitat and for identifying potential restoration areas will be one of the most important since many of the steps in the conservation project will depend on spatial analyses done using modeling.

The model to be used by Tallgrass Ontario will rely mainly on information collected for the tallgrass prairie polygons and for the adjacent landscape element polygons. Adjacent landscape element polygons will be created using a combination of georeferenced air photos and the tallgrass prairie fragment polygons. This will require a significant amount of air photo interpretation to determine the land use classifications of each adjacent landscape element. A combination of biotic and abiotic factors will be used to generate an equation that will enable Tallgrass Ontario to give each landscape element that is adjacent to a tallgrass prairie polygon a restoration ranking value. This restoration ranking value will be used to determine which landscape elements have the most tallgrass prairie restoration potential. An excellent benefit of using GIS to construct this model is that it may be easily repeated once it has been completed, meaning that any changes that are recorded in the database will be incorporated into a new set of restoration rankings every time the model is run.

Continuing Management

Once the restoration model has been constructed and implemented, Tallgrass Ontario will need to start incorporating the GIS into its conservation management practices and strategies. Much of the use that Tallgrass Ontario will have for the GIS in its management practices and strategies will revolve around time sensitive factors like keeping track of dates that prairie polygons require prescribed burns, new GPS fragment boundaries, fresh seeding, etc. These time sensitive factors can be maintained manually by data entry and editing in the prairie database, but this can be done more easily through customization of the GIS to update the database automatically.

An additional benefit that the GIS will provide is to facilitate cartographic production for a variety of purposes, particularly in the production of management guidelines. Each set of tallgrass prairie polygons that are closely situated will require a separate set of management guidelines. The capabilities of GIS for map production will greatly enhance the ability of Tallgrass Ontario to create and modify management maps for any set of tallgrass prairie fragments. Without the assistance of GIS for the production of these maps, any modifications to the management guidelines would require maps to be reconstructed from scratch where GIS would allow the necessary changes to be made with only a few modifications.

Conclusion

The potential application of GIS to the Tallgrass Ontario prairie conservation project has several facets. Through the use of GPS technology, aerial photographs, relational databases, and spatial modeling, Tallgrass Ontario will have all of the tools required to implement and maintain a fully functional geographic information system. Although the successful operation of this GIS will require proper maintenance and training, the benefits of the GIS in the restoration area identification, landowner contacts, and continuous management will prove invaluable to strengthening and focusing the conservation efforts of Tallgrass Ontario.

Bibliography

Chrisman, N. 2002 *Exploring Geographic Information Systems, 2nd Edition*. (Toronto: John Wiley and Sons Ltd.)

Convis, C. L. 2001 *Conservation Geography: Case Studies in GIS, Computer Mapping, and Activism*

DeMers, M.N. 2002 *GIS Modeling in Raster* (New York: John Wiley and Sons)

Deuker, K.J., and Kjerne, D. 1989 *Multipurpose cadastre: Terms and definitions*. (Falls Church, VA: ASPRS and ACSM.)

Lee, J.T., Thompson, S., Woddy, S.J. 2001 *Targeting sites for conservation: Using a patch-based ranking scheme to assess conservation potential* in Journal of Environmental Management, 61, 367-380.