

MAINTAINING SPATIAL DATA IN AN ENTERPRISE LAND MANAGEMENT ENVIRONMENT

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Abstract: The Wisconsin State Board of Commissioners of Public Lands has contracted with GeoAnalytics, Inc. of Madison, Wisconsin, to develop a flexible, user-friendly application that can edit several different spatial layers while maintaining the link to their related business records in the enterprise database. The Board was looking for a low cost Geographic Information System (GIS) to help them manage forestry and permitting operations on unclaimed, original land grant parcels. They decided to modify an existing ArcView application, built by the Wisconsin Department of Natural Resources for managing State forest boundaries and attributes. They have specified that this tool be tied to their newly rebuilt enterprise management system based on an Oracle database and custom Visual Basic user applications.

Introduction

In May of 2000, the State of Wisconsin Board of Commissioners of Public Lands (BCPL) contracted with GeoAnalytics, Inc. of Madison, Wisconsin, to develop a flexible, user-friendly application, which they could use to maintain their spatial data layers. The Board was looking for a low cost Geographic Information System (GIS) to help them manage forestry and permitting operations on approximately 80,000 acres of land, mostly in Northern Wisconsin. The project requirements specified that the tool needed to easily edit several different layers while at the same time maintaining the link between layer features and related business data records.

BCPL is responsible for managing federal grants of land in the State that were originally set aside for the support of schools and other institutions. The agency undertakes timber production on many of the parcels and returns the income from this activity to a low interest loan fund for State municipalities. In recent years the Board has sought to modernize and streamline its business workflow. They have pursued several initiatives, including document imaging, the upgrade of their legacy loan system, and utilization of a number of land inventory technologies.

Information Management at BCPL has progressed along these tracks for several years. They are now beginning the process of bringing those threads together using modern client-server and Windows software running on high-powered NT-PC platforms. The integration of these different systems is aimed at decreasing redundancy, increasing the efficiency of data access and query, and providing the information needed to fulfill the Board's mission of stewardship, preservation, and sponsorship.

Lands Held in Trust

In 1848, BCPL was established to oversee the sale of 5.2 million acres of lands that were granted to the new State of Wisconsin for the support of public education. The proceeds of these sales were deposited into permanent funds and invested in trust for the benefit of various institutions. By 1900, the Board had sold 97 percent of the Trust Lands into private ownership. It was after this time that BCPL began to reinterpret their mandate to act as trustee for the lands remaining.

Due to depressed real estate markets, the Trust Lands were withheld from sale for forty years, until 1954. Also during this time, BCPL land management practices became more custodial in response to dwindling timber supplies, devastating floods, State conservation laws and the beginnings of the conservation movement in the United States.

With the housing boom during and after World War II, the Board made the transition from maintenance to sustained timber production. Having escaped the earlier era of timber exploitation, the Trust Lands had

retained characteristics of the State's old-growth pine and hemlock hardwoods. Where these lands have been recognized as ecologically unique, the Board has ensured their protection, in part by conveying them to state and federal agencies for wilderness, natural and wildlife areas.

One problem facing the current land management strategies is the scattered nature of Trust Lands. This distribution is based in part on the method of land survey practiced during the settlement of the State, known as the Public Land Survey System (PLSS). The system utilizes a grid of six-mile square townships, divided into 36 one-mile square sections. The 16th section in each township was set aside for the maintenance of public schools and became the foundation of the Trust Lands. Further fragmentation occurred as 16ths of sections, known as quarter-quarters (QQ) or fortys (40 acres nominal size) were sold to private owners (figure 1).

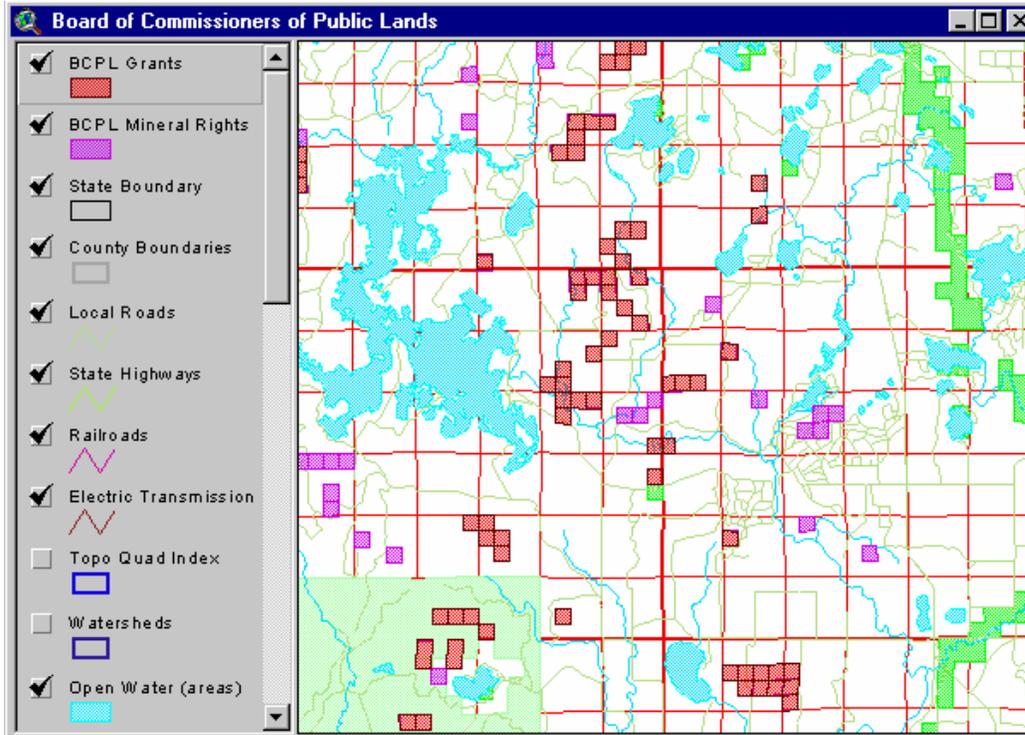


Figure 1

The quarter-quarter has become the basis of land management at BCPL. Income from land activities go to different funds depending on the type of the original land grant associated with each QQ. The QQ then is the smallest unit to which all land management practices must be attributable. This includes property transactions, forestry, conservation and permitting. It is also the tie by which the relationship between spatial layers and business records can most often be made.

Getting a Handle on Geography

Spatial information has been with us for hundreds of years in the form of maps that we used to navigate the seas and to delineate boundaries. In the same way that computers helped us to organize text based information into databases and spreadsheets, they are now helping us to organize our spatial information into layers and views. Layers are groups of geometric features representing similar objects, such as soils or forest types. Each feature in a layer can be assigned a unique number, or ID. The ID can be used to associate spatial features with related tabular records. Combine this data structure with a user interface and you have a Geographic Information System.

By using classes of attributes to symbolize their linked spatial features, we can produce thematic maps to discover new patterns in the data. In this way, GIS provides another tool for visualizing data and extracting information. Specifically, in land and forest management systems, there are many types of information that have a significant locational component. When these various layers are overlaid, as with soils and forest stands, a new pattern of information emerges that can lead to beneficial changes in management practices.

Since about 1995, BCPL has been investigating the use of GIS as a new means of preserving and managing the lands it holds in trust for the citizens of Wisconsin. Early efforts were directed towards data development and map generation. The Board created their first recent map of Trust Lands by matching their tabular list of QQ parcels with the Landnet layer built by the Wisconsin Department of Natural Resources (WDNR). The Landnet is a representation of the PLSS down to the QQ, and was developed in turn from a Section level layer published by the U.S. Geological Survey.

Later efforts carried out by the Board to describe their spatial assets have included the purchase of Global Positioning Satellite (GPS) receivers and interpreting software, the acquisition of multiple, complimentary spatial data layers, and the development of several land management computer applications built with Environmental Systems Research Institute's (ESRI) ArcView GIS. ArcView is a customizable, user-friendly Windows program that provides a powerful query and analysis interface for spatial data.

These first spatial tools were used by BCPL to manage the wealth of spatial data they had accumulated and to produce useful products as part of business workflow. The ArcView custom applications that were built included a spatial data browser, a rudimentary land editing tool, an image cataloging and display dialog and a timber sale and permitting database with reporting capabilities. The latter application was unusual in that it recorded timber sales based on timber that had been submerged in Lake Superior for over a hundred years (figure 2).

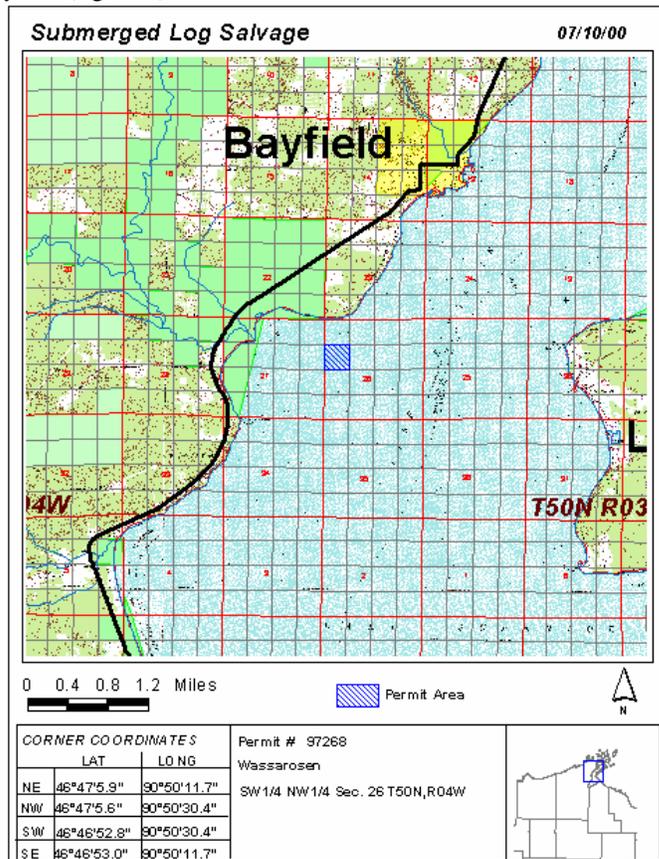


Figure 2

Beyond a Standalone GIS

Historically, GIS developed as a standalone system where spatial data could be managed and maps could be generated based on internally stored attributes associated with spatial features. As with the entire computer industry, the trend in recent years has been to integrate proprietary and application specific data with data from other business processes and from different disciplines. This not only leads to new insights into the exact nature of data, but also streamlines an organization's workflow from one operation to another.

In conjunction with the State of Wisconsin standardizing on an "open" Windows NT operating environment, BCPL made plans to convert its legacy systems. Applications written in this new realm have the innate ability to intercommunicate. This, in addition to Windows user-friendly qualities, would allow the Board to reduce data entry requirements, provide real-time reporting in response to inquiries, and bring data easily from one program to another in an automated way.

As part of BCPL's system modernization plans, their initial, spatial land management tools would be expanded to include a sophisticated spatial editor tied directly to the new enterprise database. Land management attributes would now be stored with other business data for the first time, and in some cases, it will be the first time this data has ever been digital. In addition to deriving the same automation benefits described above, this new system will allow BCPL to accomplish the following goals:

- ◆ Maintain an accurate tabular and graphical inventory of lands and timber.
- ◆ Assist in the prevention of trespass on state and private lands
- ◆ Plan interactions with other state land management agencies to promote the consolidation of public lands and an ecosystem approach to land management
- ◆ Permit the sharing of electronic data among public agencies, including counties, state departments and Federal bureaus
- ◆ Assist in the determination of accurate survey lines
- ◆ Accurately locate critical habitat areas
- ◆ Avoid cutting of timber in sensitive environmental/archeological areas
- ◆ Plan for increased timber yield harvesting

Retrofitting RAVE

The WDNR recognized some of these same benefits from digital access to spatial information, and so several years ago, began development of what would become the Reconnaissance ArcView Editor (RAVE), a forest stand management application. RAVE is an ArcView custom extension that allows the user to easily edit forest timber-type areal features (polygons) while at the same time updating tabular records. The text-based information tied to the features contains data about species composition and planned and completed timber management activities.

As BCPL was preparing for enterprise integration, they evaluated several approaches they might take to adding the spatial component to the system. Examples of possible tools they looked at are the professional GIS capabilities of the higher priced ESRI program, Arc/Info, the extremely customizable tool kit provided by ESRI's MapObjects component modules, and the existing RAVE application for ArcView.

Being a small agency, one of BCPL's main priorities for the system was that it be cost-effective. They would rather find a functional alternative to higher priced products such as Arc/Info. MapObjects, while being by design an interoperable player in the Windows environment, is strictly what you make it, having no default, multi-functional user interface. When comparing the cost of development time for a from-scratch approach like MapObjects to modifying the existing RAVE application, BCPL decided to implement the second solution.

Conversion Requirements and Strategies

The RAVE tool already contains several of the capabilities BCPL has chosen to implement. The polygon editing interface builds on ArcView's out-of-the-box editing routines to provide a compact, time saving dialog that also maintains the link between features and forest attributes (figure 3). The application also contains an efficient tabular editing interface based on forms built with ArcView's Dialog Designer extension.

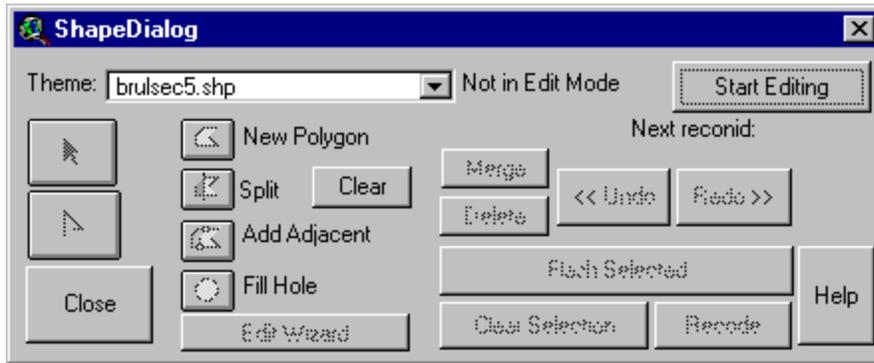


Figure 3

What RAVE does not contain is a direct connection to an enterprise database. Attributes edited in RAVE are eventually output to text files that are then manually loaded into the WDNR Oracle database. BCPL would like to replace this flow with a more efficient, interactive update of the database server, which in the Board's case is also Oracle. In addition, the tabular editing dialogs in RAVE are too restrictive for BCPL needs.

Once again, in the interest of economy, BCPL would like their spatial editor to be capable of editing a number of layers with different tabular dependencies. Even if this was not the case, the specific content and structure of WDNR's forest stand information differs enough from BCPL, that just minor changes to RAVE's hard-coded references will not be sufficient. The sum of these discrepancies between the existing and proposed applications forces the design to carefully manage an economy of style. While intent on preserving as much of the previously engineered code as possible, new approaches must be pursued to provide the necessary functionality within budget.

Solutions and Tradeoffs

In order for BCPL's Geographic Editing Module (GEM) to serve a variety of layers, the variables of tabular dependencies must be minimized. Following the pattern of earlier subsystems within the enterprise information system, BCPL would prefer that text attributes be maintained through a consistent set of Visual Basic derived forms (figure 4). This eliminates the need to handle multiple table relationships in GEM, allowing it to focus on assuring that spatial features remain tied through a single key value to the rest of the system's related attributes.

Figure 4

The Oracle system developers must cooperate with this approach by denormalizing some structures and by creating alternate structures, such as database views. Views are virtual tables based on SQL queries that combine records from multiple tables into a single, ArcView accessible logical entity. Once these database simplifications are in place, a layer configuration table can be built that defines a consistent set of parameters for each layer to be handled by the editor. GEM can read from this table the name of the spatial data file, the primary Oracle table, and the primary and foreign keys that join the two. Tabular fields can be assessed on the fly and generic attribute editing forms can be built accordingly.

Transforming RAVE's two step, manual method of updating the enterprise database into an interactive process for GEM could follow one of two paths. One way would be to set up a tabular link from ArcView to Oracle that lasts the duration of a GEM edit session. The tools in ArcView for managing and manipulating this type of table, however, are completely different from those that work with ArcView's native database format, dBase. By choosing the alternative route of downloading the required Oracle table to dBase format, RAVE code snippets can be reused.

Another advantage of severing the Oracle connection after making a copy is that the connection does not have to be maintained. At the end of a GEM session, records that have been flagged as being new or modified can be individually inserted or updated through a series of SQL expressions. The probability is low at BCPL that multiple editors might attempt to access the same data. This allows GEM to handle table locks in a manual way by setting a field in the layer configuration table to either checked out or in.

In the end GEM will be less specific than RAVE, but more flexible. As BCPL moves along the path of continued modernization and automation, more sophisticated spatial tools can be incorporated. For the time being, however, GEM allows the Board to take a significant step towards integration and efficiency.

References

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