

**LEVERAGING GEOGRAPHIC INFORMATION SYSTEMS
IN BRITISH COLUMBIA'S FOREST INDUSTRY**

by

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We accept this graduating essay as conforming to the required standard

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Abstract

This essay is written with the intent of being easily understood by forest managers and decision makers who may not necessarily possess knowledge of GIS. Forest managers have the ability to maximize the value they receive from their GIS investment by instituting a few simple yet effective measures. First, companies must develop a GIS vision and long-term plan which is consistent with the company's objectives. Critical components of the plan must include: central management of the enterprise GIS program; hiring qualified individuals; building capacity through increasing GIS knowledge; organizing GIS data in a company-wide data repository; and making the data more available to elementary GIS users. A successful GIS program is characterized by central management and it must be fully implemented across the entire company to be most effective. Managers must employ highly skilled individuals who possess both GIS education or training and forestry education or experience as well as ensure that ongoing GIS training is provided to all levels of GIS users. Roles and responsibilities within GIS positions should be clearly identified and employees should be responsible for performing duties commensurate with their individual skill level. Individuals should not be expected to perform tasks outside of their level of expertise. GIS data must be organized by feature type in a multi-user data repository and managed from a central location. Several pragmatic methods are suggested to make GIS data more available and usable to elementary GIS users. These methods include layer files, map templates and documentation. Companies must be able to use all of their data to its full potential to realize the best return on their GIS investment. By inputting a small amount of additional resources towards efficiently using their GIS personnel and programs, forest managers have the potential to yield higher levels of return throughout the company's business.

Keywords: geographic information system (GIS), forest industry, forest management, spatial data, GIS program, leverage GIS technology.

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Preface

*Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in the information?*
(Eliot 1934)

1.0 Introduction

Forest managers are tasked with attempting to balance many social, environmental and economic concerns when making critical business decisions. Managing a resource that is spatially distributed, biologically active (i.e. grows) and temporal presents challenges. In order to succeed, the future must be planned, current business managed through addressing competing objectives and historical records maintained. Geographic Information Systems (GIS) have become a standard tool to aid forest managers in this decision making process (Merry 2007). This paper defines GIS and discusses the common misconceptions prevalent in the forest industry which contribute to the underutilization of the technology. The reasons to use GIS in forest management will be explored and a strategy will be presented for organizing a GIS program¹ to enable forest managers to obtain the most value from their GIS investment.

1.1 What is GIS?

Often GIS is complicated to explain to those unfamiliar with the technology. As represented in Figure 1, the industry leader, Environmental Systems Research Institute, Inc. (commonly referred to as “Esri”) defines GIS as “a system which integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.” GIS allows forest

¹ A GIS program involves the deployment of all aspects of the GIS including organizational structure and people.

managers to organize, manipulate, and view data in order to reveal the various interactions and connections between data. It also assists by displaying data in numerous forms such as maps, charts, reports and globes. Collating data in this manner assists in timely and informed decision making and increases the ability to easily share information (Esri 2012f).

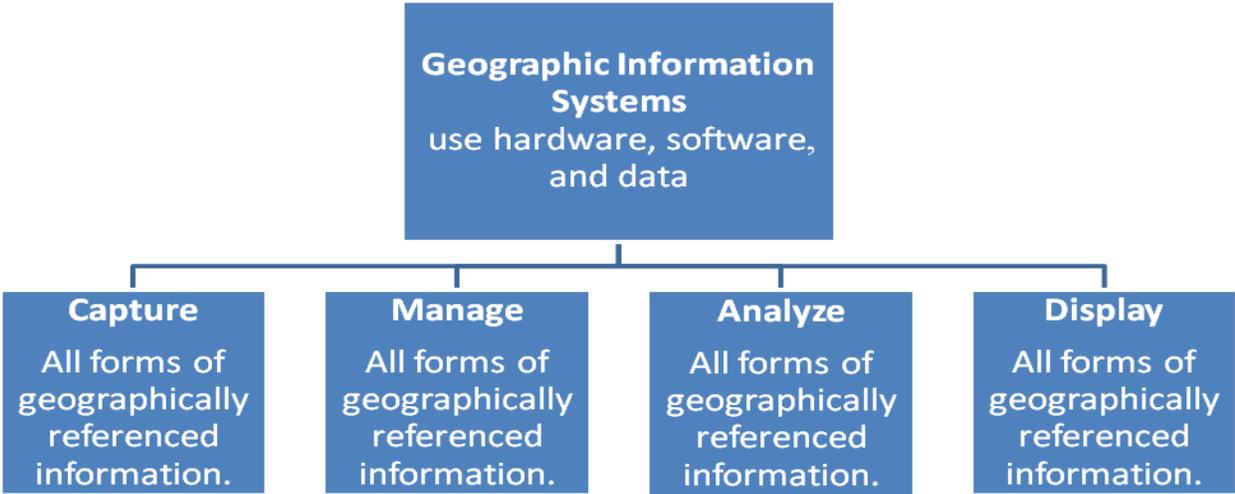


Figure 1. Visual representation of GIS definition

To fully explain a GIS, it must be noted that it has two fundamental and *related* components as shown in Figure 2 below. The figure to the left shows geographically referenced map layers and the figure to the right shows attribute or tabular data which is directly linked to the spatial data.

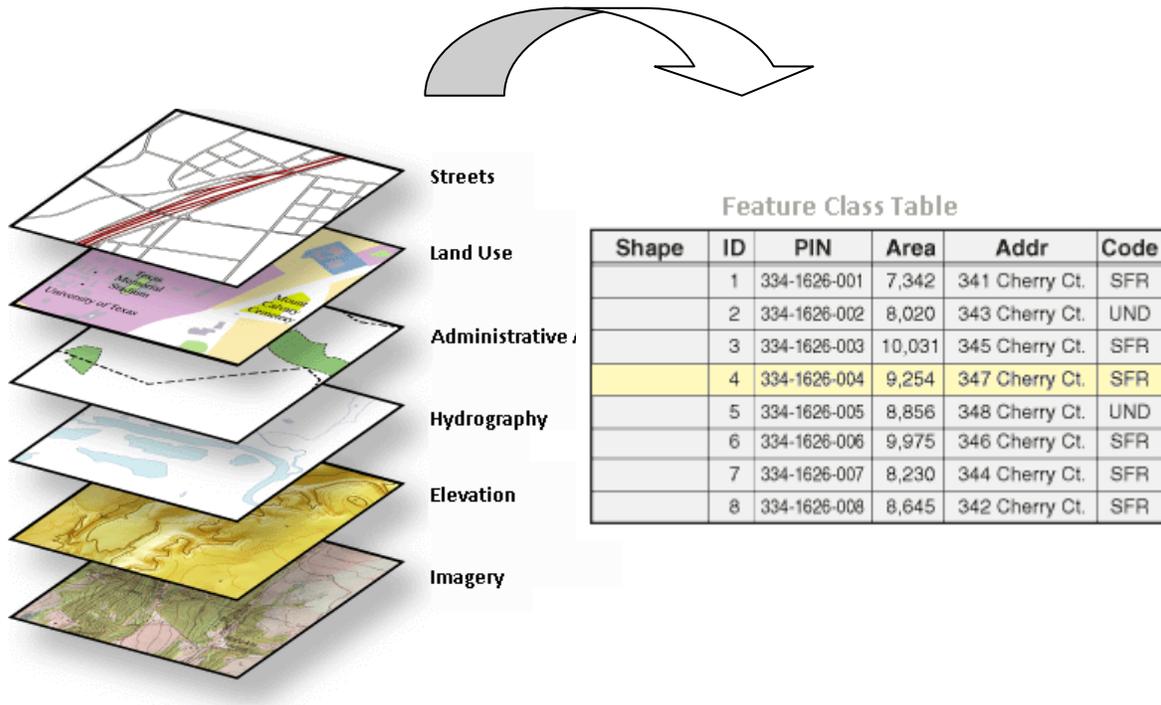


Figure 2. Spatial data represented as map “layers” and related attribute data. Source: (Esri 2012f)

1.2 GIS: more than map-making

Due to a general lack of comprehension of GIS, GIS experts in the forest industry are often mislabelled as “mapmakers” while their GIS skills go underutilized. As GIS is a complex system to explain, it is often simpler to describe it as a map-making exercise as most people grasp the concept of making maps. However, describing the intricacies of GIS and concisely conveying that GIS is far more complex than ‘mapping’ is challenging (Eredics 2010). As noted by O’Kelly (2000), there is a dichotomy between the sophisticated capabilities of GIS and the actual practical use of the technology. This is

evident in the incomplete realization of GIS which is perpetuated by unknowledgeable decision makers failing to realize the available benefits of using GIS to its full potential.

2.0 Discussion

To be competitive in the forest industry it is critical that companies are effective and efficient in their decision-making in all areas of their operations. To accomplish this they must receive maximum benefit from their technological investments. Using GIS systems and GIS personnel to their full capability is intrinsic to profitable decision making. To ignore the utility of GIS is to favour companies who are readily adopting the technology. Fully adopting GIS will lead to cost savings through improved user productivity, enhanced decision making, problem-solving and better recordkeeping.

However, since GIS benefits are not easily quantified (Korte 1997), oftentimes it is difficult to garner management support and subsequent funding for full development and implementation of a GIS program. To achieve support it becomes the responsibility of the GIS expert to determine the key drivers for the GIS program and use these drivers to monitor the value received from GIS. This information can then be used to communicate the benefits of GIS to the managers and decision-makers and obtain the funding necessary to support the development of an effective program.

An effective GIS program is properly organized, provides centrally managed workflows (data flows) and results in more efficient processes. To accomplish this, the program must be sufficiently staffed so information is available to forest managers to support timely and informed business decisions. By instituting these measures, costs are reduced and users are productive and efficient.

2.1 Why use GIS to support forest management?

Forestry professionals make complex decisions that require analysis of numerous spatial factors simultaneously. Attempting this without GIS is a time consuming laborious activity which creates redundancies throughout the process (O'Kelly 2000). Although GIS is credited with streamlining decision making, it has also been criticized for providing increased opportunities to make significant far-reaching mistakes (Nyerges, Chrisman 1989). This is why it is imperative to provide proper user training and support resources to the GIS program.

GIS can also be used to improve long-term planning and forecasting consistent with responsible forest management as well as simple tasks such as linking tabular and spatial data, cartography, heads up digitizing, data entry, editing of spatial and attribute data and querying tabular attributes. GIS provides complex spatial and network analysis, landscape-level analysis and modeling (total chance planning), 3D visual quality (viewshed) analysis and 3D fly-through visualization. Slope, aspect and shaded relief maps using digital elevation models (DEM) can also be produced using GIS.

An example of using GIS for decision making in forest management is using it to manage standing timber inventory (STI). STI provides data on available piece size and species distribution and helps the forest manager deliver logs which meet the current processing facility requirements. Log requirements can change quickly and employing GIS is one way to help forest managers react quickly and identify new areas for timber development that meet these new objectives.

GIS software programs allow forest managers to view field sites remotely (sitting in front of their computers) and communicate relevant information to field staff more efficiently. Using digital ortho photos or satellite imagery offers the advantage of knowing what types of conditions or terrain to expect in the field in advance of ground-truthing excursions.

Other components integral to forest management are the legal requirements associated with the various levels of administration. Forest managers must ensure that their decisions and subsequent actions are compliant with higher-level plans, provincial legislation and land use designations. For example, the Kootenay-Boundary Land Use Plan, government action regulations and designated wildlife habitat areas for species at risk. Using GIS is an efficient way to ensure that all relevant factors are considered and requirements are met when developing operational plans.

Many operational plans also include mapping requirements such as site plan maps, road layout and design maps and appraisal maps, as outlined in provincial legislation (Province of British Columbia 2012b). Developing these maps using map templates that are linked to data stored in a database is much more efficient than using traditional mapping methods such as paper-based maps or computer-assisted drafting (CAD) maps. GIS map templates allow users to easily recreate maps with the most current information stored in the database whereas traditional mapping methods often lead to duplication of efforts.

In addition, British Columbia's forest tenure holders are required by law to electronically report harvesting and silviculture activities online via the Electronic Submission Framework (ESF) as an Extensible Markup Language (XML) document which allows both attribute (XML) and spatial data as Geography Markup Language (GML) to be submitted together (Province of British Columbia 2012a). GIS is necessary to create the GML component of the ESF submission. Although it is technically possible to create the attribute (XML) portion of the submission using a text editor, it is much simpler and more efficient to use GIS tools that have been specifically built for this purpose.

2.2 Organizational structure of an effective GIS program

The following strategy will allow forest companies to leverage their GIS investment by focusing on the four components required for a successful GIS program. These components, as outlined by

Bettinger (1999) are people, databases, technology and organizational commitment. The pieces that will be further explored include:

- developing a GIS vision;
- aligning the organization's structure to effectively support a GIS program;
- focus on capacity building within the GIS program by building an effective GIS team and integrating ongoing GIS training;
- organizing the GIS data;
- and making the GIS data more available and useable to end users.

In addition to these components, it is critical to integrate continuous improvement into the GIS program in order to adapt to changing needs and fix areas that no longer function efficiently.

First, a workable GIS vision focused on the company's objectives must be developed (Korte 1997). The vision must be well articulated and measurable to be successful. An example vision might be, "To enable forest managers to make better and more efficient decisions." Due to the inherent changing nature of GIS technology, the vision should be regularly examined and reevaluated to determine if the strategic goals are still relevant (Sharir 2012).

Once a GIS vision is in place it is important to develop a long-term plan for the GIS to help communicate its' purpose and provide direction that can be understood by the users (Korte 1997). The goals must be clearly defined, easily understood and measurable (Sharir 2012). The plan should include key events, schedules and individual assignment of responsibilities to specific individuals. There must be concrete deadlines for achieving the goals and clear expectations of employee-specific accountabilities.

Without such goals, there are no measures of success or failure. Setting smaller, achievable goals throughout the process provides a means to celebrate incremental successes which eventually contribute to accomplishing the long-term goal. This plan will act as the basis for staffing requirements, hardware /software purchases and budget requests. The initial plan must be designed with full implementation of an integrated GIS program as the end goal, keeping in mind that there will be built in development milestones identified in the project timeline. Successful implementation may require coordinated department by department or division by division implementation in order to methodically maintain the integrity of the data and of the plan.

A GIS program must be fully integrated into the company's business operations for it to reach its full potential (Korte 1997). This shared enterprise system must be implemented and adopted across the entire company, not just one department or one localized division. Enterprise GIS is when access to GIS data, maps and applications is broadly available throughout an organization and delivered from a central location. Organizational problems are created when each division manages its GIS independently and no universal GIS program is in place within the company. Sharing processes across independent divisions is impossible and results in inefficiencies and duplication of efforts (Bettinger 1999) from the company point of view. Peuquet & Bacastow (1991) suggest that implementing an enterprise system may force a change in the hierarchical decision making structure of an organization, leading to a shifting of power and influence from one area to another.

2.3 Build a strong GIS team

Bettinger (1999) notes that clear organizational commitment to a GIS program is critical to its success. An organization can show commitment by focusing on building capacity within the program by increasing employee expertise in GIS. The system will fail to deliver promised results if given too little funding or too few support personnel, i.e. GIS-proficient employees. The European Committee for

Standardization's official *Guide to Good Practice in Knowledge Management* says, "knowledge is the combination of data and information, to which is added expert opinion, skills and experience, to result in a valuable asset which can be used to aid decision making" (European Committee for Standardization 2004). To get the most value from GIS you must have a strong GIS team. Sharir (2012) echoes this sentiment when he stated, "the difference between excellence and mediocrity is people."

To increase expertise one must recognize that it is time specific and relates to possessing an in depth understanding of specialized knowledge or the mastery of a specialized skill set. If the knowledge or skill is no longer specialized or current, the 'expert' is no longer useful. For example, as Obermeyer (2008) pointed out, the medical community once considered leeches acceptable treatment for some ailments. Now lasers are used in place of leeches and with changing technology come changing skill requirements. GIS technology changes rapidly and managers must recognize and plan for this.

Developing and maintaining expertise in GIS requires a combination of both continuing education and experiential learning in the area where the GIS will be applied, for example, forest management. Since the field of GIS is so diverse, the GIS skills required in the forest industry are often very different from the applied GIS skills required of users in other industries, such as utilities, health care or planning.

Difficulties arise when trying to build a strong GIS team because it is challenging to hire GIS-proficient employees who also have sufficient forestry knowledge and experience to effectively do the job. Difficulty securing people with the necessary skills could be due to a lack of qualified forest industry GIS personnel. When hiring for a forest industry GIS position, forestry education and experience is desired, but not necessarily the most important requirement. A solid foundation of GIS skills is critical and difficult to learn on the job whereas the forestry knowledge necessary to perform GIS tasks can be more easily learned in a working environment. In situations where GIS is trying to be taught on the job

the GIS person providing the on the job training is spending valuable work time training rather than doing productive GIS work.

Obermeyer (2008) points out “that implementing a GIS ...require(s) enhancing GIS expertise within the organization.” In order to enhance GIS expertise, a company can either hire a new GIS-proficient employee or (re)train an existing member of the organization. To facilitate a decision that makes the most sense it is critical to first clearly define the roles and responsibilities of each GIS position within a forestry organization. David Hodgkinson, retired business owner, states that managers must hire the right candidate to fit the position and associated job description, rather than tailoring the job description to fit the people as so often happens. The individuals skill set should match the job responsibilities (Personal conversation, March 2, 2012). GIS skills vary from elementary to advanced, that is from basic data entry, digitizing and data format conversion to complex spatial analysis, such as terrain modelling, viewshed analysis and project management. Expecting an elementary GIS user to perform the same duties as an advanced GIS user is unrealistic and an inefficient method of utilizing GIS as well as poor use of a company’s GIS investment.

Research shows that GIS job descriptions can be divided into six special categories based on job responsibility. These include managers, coordinators, specialists, programmers, analysts and technicians (Huxold 2000). A visual representation of how these roles might be organized is shown in Figure 3.

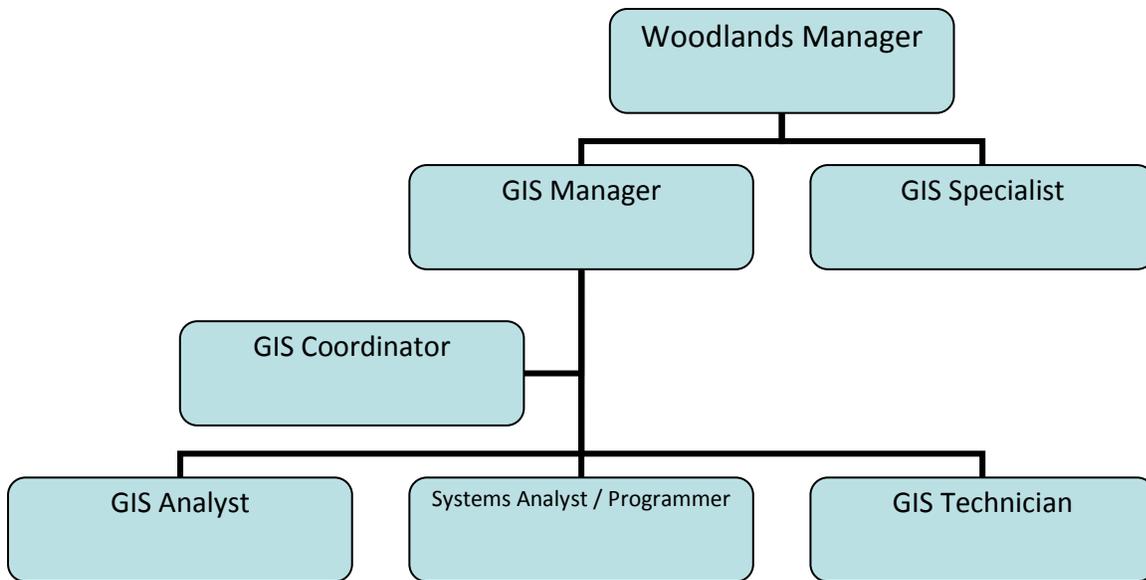


Figure 3. Example of a potential BC forest company GIS organizational chart

Woodlands Manager

In forestry organizations, the Woodlands Manager is responsible for managing and being accountable for all aspects of the woodlands division. These key decision-makers must be convinced of the benefits of complete GIS implementation because they are responsible for budget and funding decisions.

GIS Manager

The GIS Manager most likely reports to the Woodlands Manager. He or she plays a critical role in determining the success of a GIS program as they champion the development of the program, keep the vision as the focal point for both the GIS team and the Woodlands Manager, offer support and leadership throughout the process and also help redirect energy when changes in the implementation need to occur (Korte 1997). The GIS Manager supervises most GIS positions, ensures the GIS technology is being used properly and efficiently, provides necessary resources, sets project objectives and determines project budgets. An understanding of or background in both GIS and forestry is necessary to be successful in this position.

GIS Coordinator

The GIS Coordinator usually reports to the GIS Manager. The GIS Coordinator's role is similar to the GIS Manager, but without management or budget responsibilities. They coordinate the GIS program across all departments and divisions within the company. The GIS Coordinator must have extensive working knowledge of the database and software, often having the responsibility of designing the GIS database, developing the analytical procedures required to support the GIS applications, providing technical support to end users, developing data standards and performing quality control checks. The GIS Coordinator is responsible for organizing project personnel and other day-to-day supervision of GIS projects, meeting planning and so on.

GIS Specialist

A GIS Specialist may report directly to the Woodlands Manager or the GIS Manager and is the individual with extensive specialized GIS training, for example, a registered professional forester (RPF) with extensive expertise in GIS. Most duties of the GIS Specialist are internal to specific projects rather than coordinating across departments or divisions.

GIS Analyst

The GIS Analyst is a GIS expert who has completed a natural resources degree and a one-year GIS advanced diploma program (ADP). The GIS Analyst performs complex spatial analysis, enters data into the database and creates reports, maps or other pieces of supporting documentation based on that information. The GIS Analyst designs map templates to be run by elementary GIS users. They may also coordinate updates and changes to the database structure and perform quality control checks to ensure the accuracy of the data. In addition to these roles, the GIS Analyst may provide technical support for other users. A forestry background and/or knowledge is an important qualification for a GIS Analyst.

GIS Technician

The GIS technician is an entry-level position suitable for a recent graduate of a GIS advanced diploma program. Responsibilities involve routine data entry, data management and generation of maps from templates. The position does not require the candidate to have a background in forestry, although it would be preferred.

System Analyst/GIS Programmer

The System Analyst and GIS Programmer are highly technical positions. The Systems Analyst oversees the technical workings of the GIS system including designing, creating, modifying and managing the GIS applications. There is a trend in the forest industry to use a service provider who employs highly specialized individuals with a background in information technology to fill this role. People in these roles require constant training to maintain the high standard of knowledge required to keep up with the rapidly changing technology. Hiring a service provider means the company does not have to employ and continually retrain these highly specialized individuals.

GIS Programmers are critical to an organization because most GIS software cannot initially be used to its full potential, as most require customization to meet the specific needs of customers.

Programmers are able to design automation tools that allow elementary GIS users to run complicated or repetitive GIS tasks.

2.4 GIS education and training options

Users of GIS must have formal training (Watts, Tolland 2005) in order to utilize GIS successfully and to its full potential. Rapid advancements in GIS technology mean that it is difficult for all levels of users to maintain their GIS skills. As such, employers must provide their employees with professional development opportunities to stay apprised of these rapid advancements. Training enables all GIS users to better understand the capabilities and constraints of the GIS system and allows for the creation of

more productive and efficient workflows for the assigned tasks (Boden 2012). Appropriate training enables users to examine data more thoroughly, increases their ability to problem solve and allows for brainstorming of multiple alternatives while making timely and informed decisions (Bettinger 1999). As users begin to understand the capabilities and constraints of the system, they are more likely to grasp how the information can be used and creates an environment where users feel greater responsibility for the quality of the data they provide to the system (Bettinger 1999). Good quality data is essential to a successful GIS.

In many situations, untrained GIS users get more knowledgeable co-workers to complete GIS work for them which perpetuates the lack of understanding and the inefficient use of the system. By continuing to accept a poor understanding of GIS by certain employees, the company will not be realizing the full potential of the system. Companies can overcome this shortcoming by investing in GIS training thereby realizing returns in areas such as employee performance, employee retention, cost savings and increased profits (Boden 2012).

Academic GIS Education

GIS training options include both academic education and various forms of non-academic training. Most recent graduates of a university-level forestry program are required to take a course in GIS (Merry 2007). However, as Dr. Mike Meitner, Associate Professor in the Faculty of Forestry at the University of British Columbia (UBC) notes, the Faculty of Forestry at UBC does not have such a requirement (Personal conversation, March 26, 2012). Such unfortunate circumstance coupled with the fact that many people who work in forestry did not graduate recently and therefore have never received formal GIS education or training perpetuates the continued underutilization of the technology. Individuals who demonstrate good GIS skills honed through academic education and training are highly desired in the forest industry.

A manager who is presented with the choice of hiring a candidate with strong or weak GIS skills, all else being equal, is more likely to choose the candidate with strong GIS skills.

Presently, both the British Columbia Institute of Technology (BCIT) (British Columbia Institute of Technology 2012) in Burnaby and Selkirk College (Selkirk College 2012) in Castlegar offer full-time advanced diploma (ADP) and baccalaureate degree programs in GIS. BCIT offers part-time online courses that can be taken with or without enrolling in the ADP. The ADP is intended for students who already possess a degree or diploma. The GIS curriculum teaches GIS theory and principles, provides software training and pairs it with discussions on remote sensing, mapping and other management issues. A listing of other academic GIS programs in British Columbia can be found in Appendix I.

Instructor-led and Self-paced Training

Esri offers a variety of instructor-led training options both online, and in person at their training centres or at your place of business (Esri 2012c). Self-paced training options include web courses, training seminars, instructional podcasts and workbooks. Online web training, including many free courses, is available from Esri at www.esri.com (Esri 2012c). In addition to training courses, Esri has extensive, version-specific online help, for example, ArcGIS 10 Desktop Help (Esri 2012a). The Esri support web page and user forums are also invaluable for problem-solving (Esri 2012b).

GIS Professional Certification

Professional certification procedures are well established in forestry, medicine, law, planning and surveying. More recently, the GIS profession has adopted professional certification. Two methods are now available for an individual to achieve professional certification in GIS. One of the certifications available requires an individual to have a specific level of education and professional experience, to share with the GIS community and requires the adoption of a professional code-of-ethics (Obermeyer 1993). The other certification is simply an evaluation of a person's technical abilities in a certain area of

GIS. Working towards certification is one way for a GIS employee to keep their GIS skills current and remain a valuable asset to the company.

GIS Certification Institute

The GIS Certification Institute is an independent, non-profit organization providing the GIS community with a complete certification program (Grams 2006). A GIS Professional (GISP) is a certified individual who has met the minimum standards for ethical conduct and professional practice as established by the GIS Certification Institute (GISCI). There are currently 46 GISPs in British Columbia (GIS Certification Institute 2011) who earn on average \$10,000 more than non-GISPs according to the Urban and Regional Information Systems Association's (URISA) 2011 salary survey (URISA 2012).

Esri Technical Certification Program

The Esri Technical Certification Program recognizes competent individuals who are proficient in best practices for using Esri software, developing GIS applications or administering an enterprise GIS. Exams are available for different areas of expertise at Associate and Professional levels. The program is open to Esri users worldwide (Esri 2012e).

Software User Conferences

Participation in software user conferences is a good way to stay in touch with the most recent advancement in GIS and can be the most enriching activity GIS professionals can engage in (Grams 2006). In addition to user presentations that share best practices and opportunities for companies to get specific technical questions answered by software staff, the Esri user conferences include technical sessions at very reasonable prices compared to other face-to-face training options. Special interest group meetings allow GIS users from all regions and industries to connect. Nearly every commercial sector, government organization, and non-profit field attends the Esri user conferences. These user-to-user communication opportunities are essential for sharing real-life GIS experiences, best

practices and imparting professional wisdom amongst colleagues. In addition to learning opportunities, software developers often use them to solicit feedback from users which is critical for the future development and upgrading of their GIS products.

2.5 Spatial data organization, standards and documentation

Once you have a solid GIS team in place and they are adequately trained through the various methods outlined above, it is critical to begin systematically organizing the GIS data. The data will need to be centrally located and categorized based on the type of information.

Enterprise GIS

An effective GIS program facilitates accurate, efficient and coordinated storage of both current and historic information. Companies are no longer relying upon paper-based files which are cumbersome and out of date. For most major forest companies, both historic and current data should be stored in an enterprise, company-wide, multi-user data repository such as an Esri's ArcSDE geodatabase² format (Magai, Wookey 2006). Enterprise geodatabases have many benefits compared to other spatial data formats³. They are scalable and high performance (Magai, Wookey 2006), in a central location, include sophisticated rules and relationships, facilitate effective retrieval of large amounts of data and allow data security to be controlled more easily compared to file-based systems. The purpose of an enterprise system is to improve business efficiency and effectiveness. If this is not occurring then the system is not properly organized and or managed. To manage the enterprise GIS, centralized GIS staff who are highly skilled and have significant GIS education, training and expertise should be in place.

² A database or file structure used primarily to store, query, and manipulate spatial data.(Esri 2012f)

³ Note that CAD data, which was historically used for forestry applications, is out-of-date by approximately 10 years; it makes a pretty picture, but that is about it.

When a company employs a shared enterprise system amongst its departments or divisions, it is most effective if managed from a central location. Enforcing the organizational structure of the data requires time and effort as data has a tendency to become disorganized when users are left to manage it themselves. The database structure must be centrally coordinated and users prevented from being able to make ad-hoc changes in order to meet short-term objectives. Without central control over the data, data becomes easily disorganized and “lost” with the money spent to collect the data wasted. As librarians commonly say, “An improperly shelved book is a lost book; it may as well not be in your collection.” This is also true for GIS data. The time and money spent on collecting data is representative of the largest portion of the GIS investment, therefore, it is critical to organize it properly (Korte 1997).

When there are no centralized repositories for information, such as in an enterprise GIS, differences in data type, format, measurement unit, spatial representation, projections and location result. This produces incompatibility and data usability issues. GIS data also regularly appears encrypted, for example, it is common for a table of attribute values to contain coded values. This makes deciphering the meaning of such codes difficult for everyone except for the most experienced GIS users and those that are intimately familiar with the project data. When centralized data is not used, there is a tendency within companies to have multiple versions of the same dataset existing in many formats and locations. Organizing all spatial data into an enterprise system and enforcing the organizational structure of the data can resolve this data issue.

Forestry spatial data categories

Below is a listing of various types of forestry spatial data (Janzen 2001):

- Administrative data (forest tenure areas, management areas, ownership boundaries)
- Political locations (federal, provincial and municipal boundaries, towns, cities, municipal districts)
- Access management features (roads, trails, railway, ferry routes)
- Land classification and vegetation inventories
- Water features (stream, river, lake, water sources, community and domestic watersheds)
- Digital aerial photos and satellite imagery
- DEM, contour, elevation, slope, aspect
- Research plot locations
- Cultural and archaeological inventories
- Wildlife habitat and features
- Recreational areas (parks, reserves, trails)
- Range features (fences, water troughs, cattle guards, salt licks, etc.)
- LIDAR (light detection and ranging)

This data is most effectively organized by feature type or categories as shown in Figure 4 below.

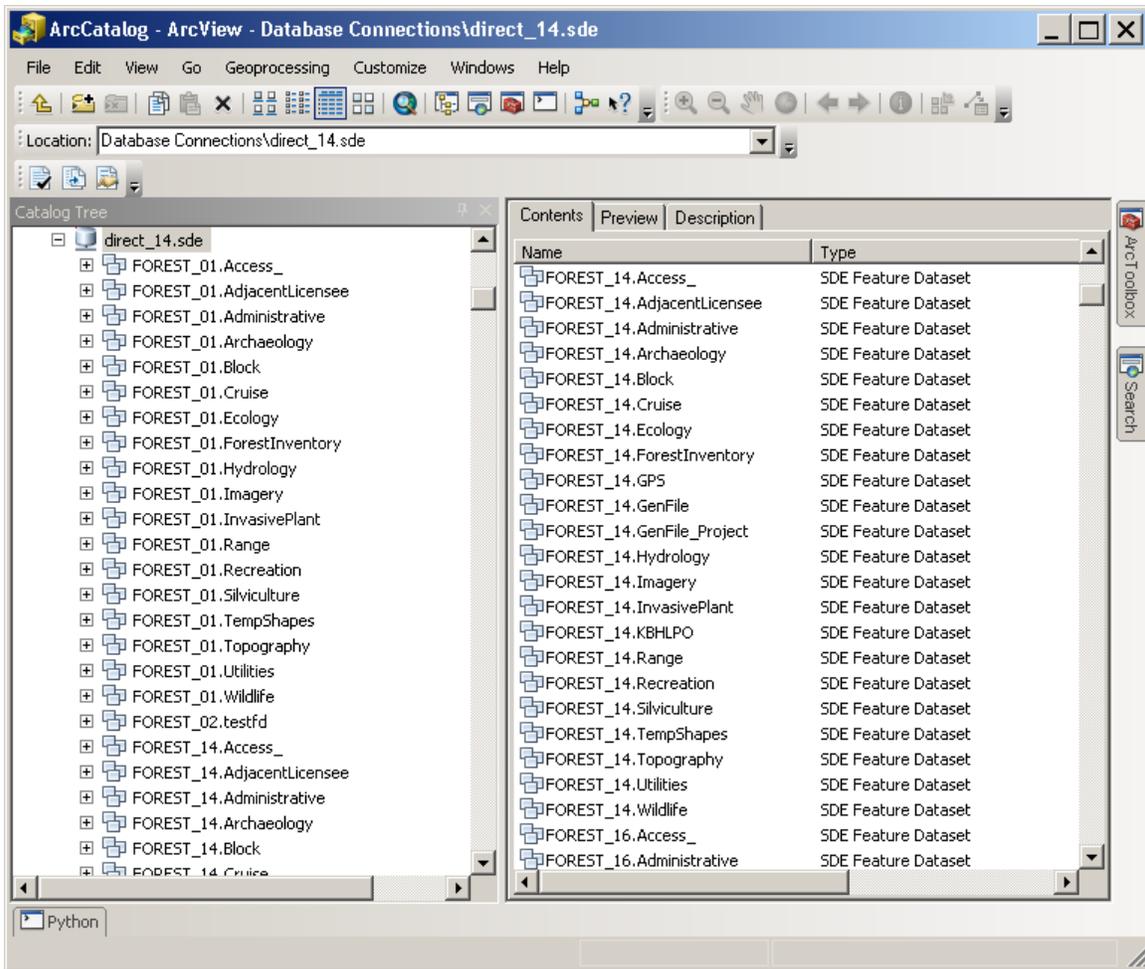


Figure 4. Example of a BC forest company GIS database structure

Organizing data into logical groupings and making it available for all levels of GIS users is important if users are expected to make sense of the expansive amounts of data available to them (O’Kelly, 2000). When a system is more intuitive, it results in greater user buy-in (O’Kelly 2000). The example presented in Figure 5 shows spatial data relating to timber cruising. The timber cruising data is organized into a group called a feature dataset.⁴ This group includes individual layers or feature classes⁵ such as

⁴ “In ArcGIS, a collection of feature classes stored together that share the same spatial reference; that is, they share a coordinate system, and their features fall within a common geographic area. Feature classes with different geometry types may be stored in a feature dataset.” (Esri 2012d)

baselines used to establish the cruise grid, cruise grids, cruise plots, point of commencement (POC), tie points, timber types and strip lines. Spatial relationships (topological relationships) exist amongst these features such as strip lines must be connected to POCs, cruise plots must fall within block boundaries and cruise grids must intersect with baselines, etc.

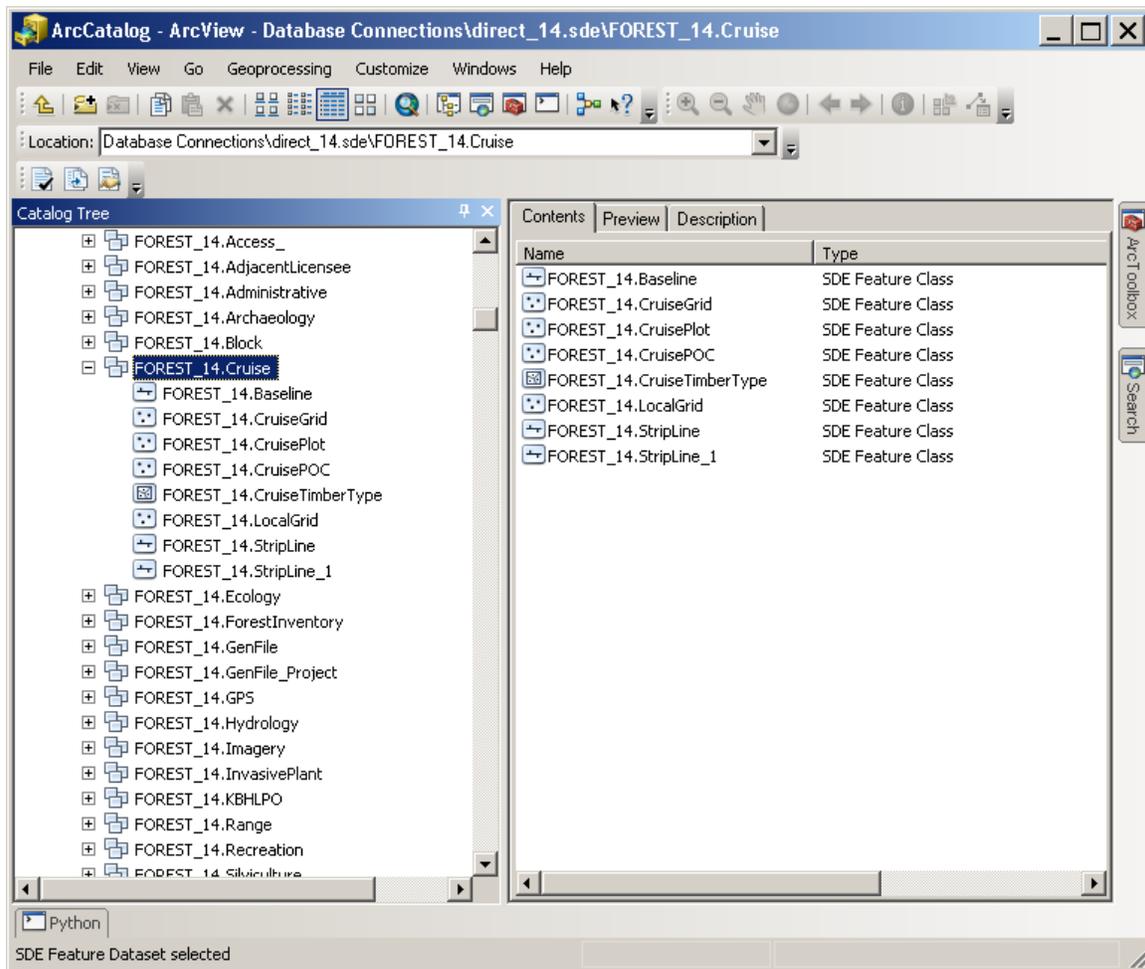


Figure 5. Timber cruising: an example of a forestry spatial data category

⁵ "In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes. For example, highways, primary roads, and secondary roads can be grouped into a line feature class named "roads." In a geodatabase, feature classes can also store annotation and dimensions." (Esri 2012d)

Layer files

In order for a GIS program to succeed, the data must be easily available and usable. One simple method of making GIS data more available and usable is by creating and managing a set of layer files from the source data for each dataset. Source data is raw data that is not symbolized and when displayed has little meaning to most users. Layer files instead store the path to a source dataset and other layer properties including symbology, allowing the layer to be viewed by the user as meaningful information (Esri, 2011). A user simply adds a layer file to a map without having to understand the complexities of designing and symbolizing the layer. Providing pre-designed map layers to end users makes browsing and using data easier.

As shown in Figure 6, layer files should be organized in folders on the company network in similar categories to the data described above so that users can learn the system of organization once. Figure 7 shows layer files that have been created for cruise type data.

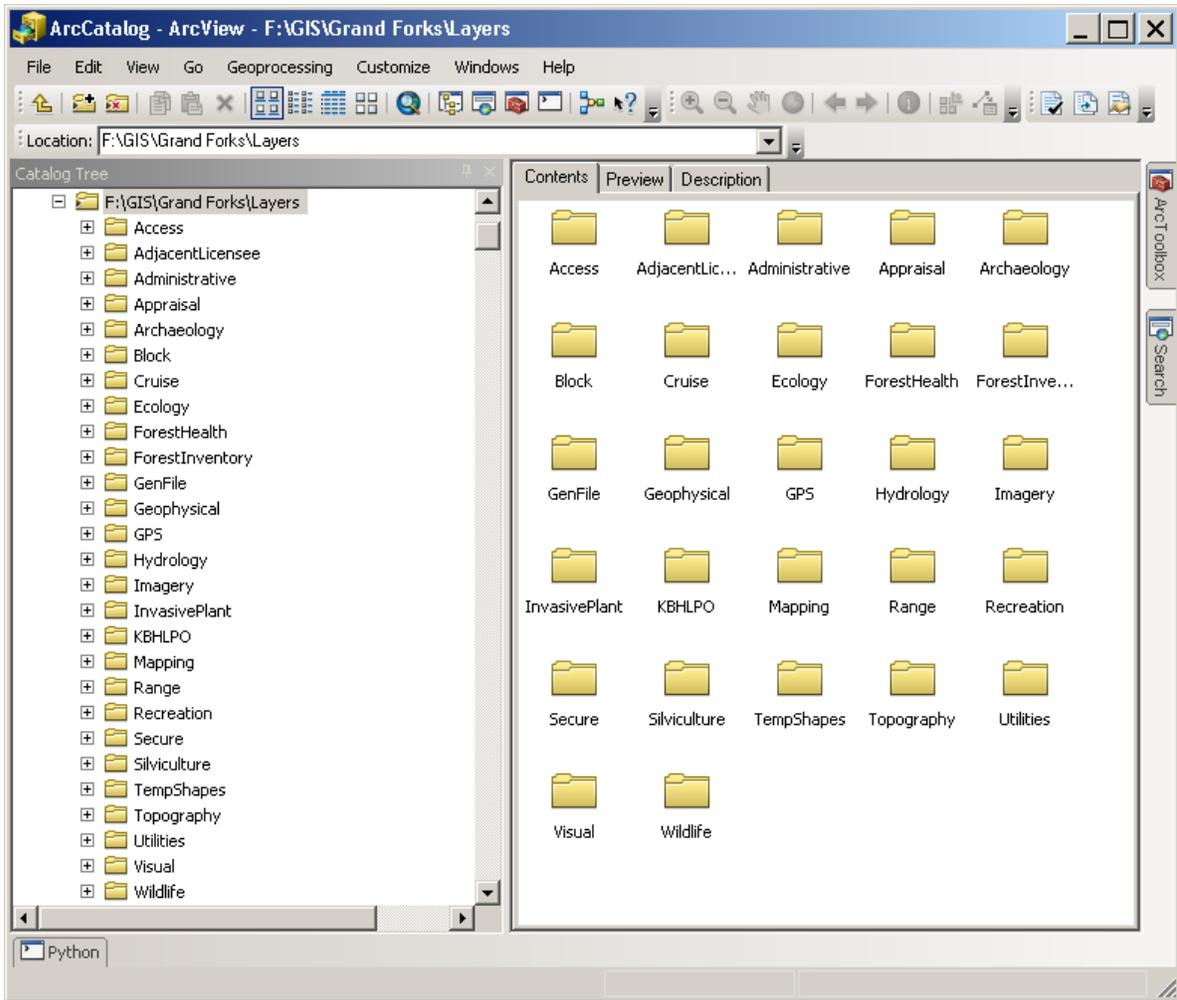


Figure 6. Suggested layer file directory structure

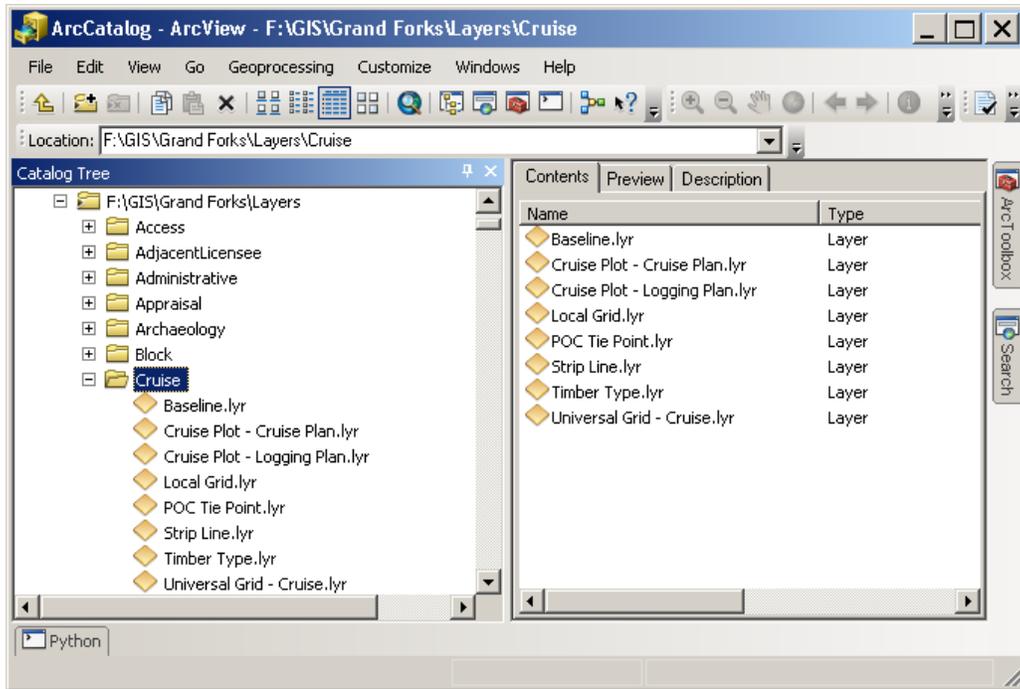


Figure 7. Example of timber cruising layer files

An even more pragmatic approach to managing layers would be to have a layer file manager application integrated with the forest information management system that enables the data manager to change a 'master' layer file once and have all maps with the corresponding layer be immediately updated throughout the entire system.

Map templates

Layer files are easily added to map templates and elementary GIS users can be turned into mapmakers by using these templates. Map templates are created and managed by the GIS expert and assist by eliminating the map creation bottleneck and frees up GIS experts to use their expertise for performing complex GIS analyses or programming custom tools rather than making maps.

Documentation

Organizational standards concerning quality control need to be developed in conjunction with organizing data. Distributing spatial data standards that match the enterprise database structure will enable companies to receive data in a format that is consistent with their database structure. This facilitates automatic data loading procedures which increase efficiency and contribute to cost savings. These standards must be adhered to by all database users internally and externally if the integrity of the database is to be maintained. Such standards also enable data quality checks.

Insufficient documentation and description of data is common. Such documentation is referred to as metadata. The GIS Manager or GIS Coordinator is responsible for maintaining appropriate metadata so that all users can understand what the data means, not just the individuals who are familiar with the data. The metadata dilemma is that skilled GIS personnel are often working under such tight time constraints that developing and maintaining metadata is often ranked as a lower priority because there is simply not enough time. There is recognition that metadata should be created, but often other priorities take precedence.

In order to facilitate and support general use of the GIS system, user guides and “how-to” documents should be developed to help elementary GIS users perform routine tasks. By providing such documents less time will be spent by the GIS expert on user support and more time can be dedicated to productive and specialized GIS work.

3.0 Summary/Conclusions

GIS is a critical component of economical forest management and forest companies cannot function effectively without it. Forest managers currently have within their control the ability to compound the outcomes of their efforts in GIS without significantly increasing their long-term costs. An appropriately

staffed GIS team enables GIS experts to perform complex GIS tasks while field operations staff can successfully build their own maps from templates. In turn, large scale operational decisions are made with information provided by the GIS which provides economic benefits to the company.

In order to garner support for developing a GIS program, it would be beneficial for forest companies to carry out a cost-benefit analysis of fully implementing an enterprise GIS. To do this would mean measuring both the tangible and intangible benefits of doing the GIS work against the cost and potential consequences of not fully implementing the program. A method for performing this cost-benefit analysis is outlined in "Managing geographic information systems" written by Nancy Obermeyer (2008).

To make a GIS program function effectively there must be commitment from company managers to see the development, implementation and maintenance of the program through to completion. There must be support to build capacity within the GIS program by hiring a strong qualified GIS team and committing to increase GIS knowledge by providing ongoing training for all GIS users. This goes hand in hand with maintaining organized GIS data that is easily available to end users. Once these supporting pieces are in place, the key to an effective GIS program is the central management of the system; otherwise, the available benefits of GIS cannot be realized. All major forest companies are using GIS, however only forest companies that make the best most effective use of the technology will see the benefits in their bottom line.

References

Bettinger, P. 1999, "Distributing GIS capabilities to forestry field offices: Benefits and Challenges", *Journal of Forestry*, vol. 97, no. 6, pp. 22.

Boden, S. 2012, *Expenses or Essential Investment? Looking at the value of GIS Training*, Winter edn, Esri, Redlands, CA.

British Columbia Council on Admissions and Transfer 2012, 2012-last update, *Education Planner* [Homepage of British Columbia Council on Admissions and Transfer], [Online]. Available: <http://www.educationplanner.ca/> [2012, 3/19/2012].

British Columbia Institute of Technology 2012, , *BCIT : : British Columbia Institute of Technology* . Available: <http://www.bcit.ca/> [2012, 3/18/2012].

Eliot, T.S. 1934, *The Rock*, London.

Eredics, P.J. 2010, *Mapping forestry*, 1st edn, ESRI Press, Redlands, CA.

Esri 2012a, , *Desktop Help 10.0 - Welcome to the ArcGIS Help Library* . Available: <http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html> [2012, 3/18/2012].

Esri 2012b, , *Esri Support* . Available: <http://support.esri.com/en/> [2012, 3/18/2012].

Esri 2012c, , *Esri Training* . Available: <http://training.esri.com/gateway/index.cfm> [2012, 3/18/2012].

Esri 2012d, , *GIS Dictionary* [Homepage of Esri], [Online]. Available: <http://support.esri.com/en/knowledgebase/Gisdictionary/browse> [2012, 3/31/2012].

Esri 2012e, , *GISP and Esri Technical Certification Programs Are Complementary | ArcNews Online* . Available: <http://www.esri.com/news/arcnews/spring11articles/gisp-and-technical-certification-programs-are-complementary.html> [2012, 3/18/2012].

Esri 2012f, , *What Is GIS? | Geographic Information Systems* . Available: <http://www.esri.com/what-is-gis/index.html> [2012, 3/18/2012].

European Committee for Standardization 2004, *European guide to good practice in knowledge management - Part 1: Knowledge Management Framework*, European Committee for Standardization, Brussels.

GIS Certification Institute 2011, , *Certified GIS Professional (GISP) Search*. Available: <http://www.gisci.org/secure/members/directory/results.asp> [2012, 3/18/2012].

- Grams, S. 2006, *The History of the GISCI Certification Program*, GIS Certification Institute.
- Huxold, W. 2000, *Model Job Descriptions for GIS Professionals: The definitive reference guide of GIS positions for public and private sector agencies*, The Urban and Regional Information Systems Association, USA.
- Janzen, J. 2001, 12-10-2001-last update, *Data Categories for Spatial and Attribute Data* [Homepage of Ministry of Forests], [Online]. Available: <http://www.for.gov.bc.ca/his/datadmin/CorpDataCategoriesDAMA02.pdf> [2011, 11/18].
- Korte, G.B. 1997, *The GIS Book*, 4th , Updated & Expanded edn, OnWord Press, Santa Fe, NM USA.
- Magai, R. & Wookey, L. 2006, "A Conceptual GeoSpatial Data Warehouse Model for Forest Information Management", *Emerging Trends and Challenges in IT Management*, , pp. 753-757.
- Merry, K.L. 2007, "An Assessment of Geographic Information System Skills Used by Field-Level Natural Resource Managers", *Journal of Forestry*, vol. 105, no. 7, pp. 364.
- Nyerges, T.L. & Chrisman, N.R. 1989, "A Framework for Model Curricula Development in Cartography and Geographic Information Systems", *Professional Geographer*, vol. 41, no. 3, pp. 283-293.
- Obermeyer, N.J. 1993, "Certification and accreditation in GIS: Prospects and pitfalls", *Computers, Environment and Urban Systems*, vol. 17, no. 1, pp. 91-102.
- O'Kelly, M.E. 2000, "GIS and educational and instructional challenges", *Journal of Geographical Systems*, vol. 2, no. 1, pp. 23-29.
- Province of British Columbia 2012a, 2012-03-14-last update, *Forest and Range Practices Act* . Available: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_02069_01 [2012, 3/18/2012].
- Province of British Columbia 2012b, , *Legislation & Regulations - Ministry of Forests, Lands and Natural Resource Operations*. Available: <http://www.for.gov.bc.ca/tasb/legsregs/> [2012, 3/18/2012].
- Selkirk College 2012, , *Geographic Information Systems at Selkirk College* . Available: <http://selkirk.ca/programs/rr/academicprograms/gis/> [2012, 3/18/2012].
- Sharir, E. 2012, *Seminar in Achieving Excellence*, Grand Forks, BC.
- URISA 2012, , *URISA 2010-2011 Salary Survey*. Available: <http://www.urisa.org/2011SalarySurvey> [2012, 3/18/2012].
- Watts, S.B. & Tolland, L. 2005, *Forestry handbook for British Columbia*, 5th edn, Forestry Undergraduate Society, University of British Columbia, Vancouver, BC.

Appendix I Academic GIS Programs in BC

Source: (British Columbia Council on Admissions and Transfer 2012)

GIS-Specific academic programs:

- British Columbia Institute of Technology (BCIT) - GIS Bachelor of Technology degree (B.Tech) or Advanced Diploma Program (ADP)
- Okanagan College - Geographical Information System Certificate
- Selkirk College - Bachelor in Geographic Information Systems (BGIS) or Advanced Diploma in Geographic Information Systems (ADGIS)
- Simon Fraser University - Certificate in Spatial Information Systems
- Vancouver Island University - Advanced Diploma in GIS Applications

GIS is also taught as part of other academic disciplinary programs:

- Northwest Community College - Applied Coastal Ecology Program
- Selkirk College - Integrated Environmental Planning Technology Diploma
- Simon Fraser University - Bachelor of Science (Major or Honours in Geographic Information Science) Degree
- University of Northern British Columbia - Bachelor of Science (Integrated) Degree
- Vancouver Island University - Forest Resources Technology Diploma or Bachelor of Arts (Major in Geography) Degree