Removing Barriers to Implementing
A Corporate Geographic Information System:
Case Study of the British Columbia Ministry of Forests

by

Christopher Robert Miller
B.A., University of Victoria, 1987

A Thesis Submitted in Partial Fulfilment of the
Requirements for the Degree of

MASTER OF ARTS
in the Department of Geography

We accept this thesis as conforming
to the required standard

[redacted]

Dr. C.P. Keller, Supervisor (Department of Geography)

[redacted]

Dr. M.C.R. Edgell, Departmental Member (Department of Geography)

[redacted]

Dr. R.A. Grant, Outside Member (School of Business)

[redacted]

Dr. J. McRae, External Examiner (School of Public Administration)

University of Victoria

Supervisor: Dr. C. Peter Keller

ABSTRACT

This study explores the challenge of implementing and using Geographic Information System (GIS) technology in corporate natural resource agencies using the British Columbia Ministry of Forests as a case study. The study commences with an examination of impacts and general issues relating to the introduction and implementation of any new technology in a organizational setting, focusing especially on the management of change. The advent of GIS as a new technology for managing spatial data and associated information for natural resource inventory, routine management and decision making is introduced. General impediments to corporate installation of GIS are identified.

The B.C. Ministry of Forests has been struggling for some time with corporate GIS implementation and use. The thesis summarizes the history of GIS in the Ministry including a discussion of the Ministry's mandate, in addition to providing a detailed account of the Ministry's implementation initiative. This study also reports on a survey conducted with employees in the Ministry of Forests in an attempt to identify attitudes and expectations towards GIS, as well as perceived impediments to GIS implementation. Survey results reveal that the Ministry has failed adequately to plan and to prepare for implementation of GIS technology, that the ad hoc introduction of GIS technology in the Ministry ignored organizational and human resource issues, and that there was initial failure to recognise the technological challenges and data management issues related to GIS implementation and use. This thesis concludes with a set a recommendations and conclusions that can be used to enhance the implementation of GIS technology in an organizational setting.

Examiners:

[redacted]

Dr. C.P. Keller, Supervisor (Department of Geography)

[redacted]

Dr. M.C.R. Edgell, Departmental Member (Department of Geography)

[redacted]

Dr. R.A. Grant, Outside Member (School of Business)

[redacted]

Dr. J. McRae, External Examiner (School of Public Administration)

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Page

Page

LIST OF FIGURES

ACKNOWLEDGEMENTS

I wish to offer sincere thanks to my thesis supervisor Dr. Peter Keller for his enduring patience, support and guidance.

I thank the members of my thesis committee, Dr. Mike Edgell and Dr. Rebecca Grant for their support and useful comments on my research.

To the late Dr. Derrick Sewell and Dr. Bill Ross, who gave the best they had to excel as both academics and teachers, thank you.

I am very grateful to my parents for their constant encouragement and financial support, without which my graduate studies could not have begun.

I heartily thank my brother Laird (a.k.a. ZTFV) for all the time and labour he put into proof-reading the many drafts.

To my wife Patti and daughters Emily and Claire who endured much as I studied long. To them I offer heart-felt thanks and appreciation for all the encouragement, understanding, advice, and long-suffering patience. Without your love and support I could not have my completed this task.

and to Him, who gave me the grace and ability to get the job done.

DEDICATION

This thesis is dedicated to the loving memory of my father Robert Lauren Miller, B.Sc., L.L.B., CRA, FRI, RI(B.C.) whose friendship and intellect, love and support is greatly missed.

CHAPTER ONE

INTRODUCTION

It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things.

The Prince, *Niccolo Machiavelli (1516)*

Initiating large-scale change is seldom a simple task. This is especially true when one attempts to implement a significant technological change within a large organizational setting. Although technological change has been an integral part of modern society, and will continue to be, it nevertheless causes substantial problems for those organizations involved with the task of implementing new technology.

A Geographic Information System (GIS) is a type of information management computer technology that has been increasingly used by resource management agencies over the last decade. This technology, while having many obvious and useful applications in the field of natural-resource management, has suffered greatly from the accompanying negative impacts and organizational change that can be associated with the implementation of any new technology.

In reading the literature and attending GIS conferences, one is led to believe that GIS is an extremely dynamic and useful technology; in fact, a technology that has become an accepted and established tool in resources management. What is not obvious from the literature is that most resource-management agencies often have difficulty using GIS, and that this new technology is proving to have numerous unforeseen impacts on organizational structure, mandates, and business functions (Somers, 1990; Sullivan and Miller, 1990; Keller, 1992). To date, little academic research has focused on the procedures and impact of implementing GIS in resource-management agencies. Various consulting reports have been written, summarizing general observations regarding GIS implementation failures. However, academically researched case studies have rarely, if at all, been documented.

What are needed, therefore, are case studies that identify the issues to be considered by natural-resource agencies before embarking on GIS implementation. Such studies should use research findings to make recommendations and to form guidelines that resource-management organizations can follow. Lack of guidance has resulted in a large number of poorly planned, ad hoc efforts to implement large-scale natural resource GIS, which often end up as costly failures (Keller, 1992).

1.1 Overall Research Objectives

The research presented here attempts to examine general organizational impediments to GIS implementation, and specifically to study the consequences of implementing GIS in a large resource-management agency as a case study. The research will attempt to identify and discuss issues that ought to be considered prior to system implementation, to document typical problems that may be encountered in an ad hoc implementation strategy, and to offer guidance for future implementation initiatives. In particular, the objectives of the research are:

1. to review the management science literature to identify general organizational impediments that pertain to implementation of new technology;
2. to place the review conducted above in the context of implementing GIS technology in a large organization;
3. to document and examine the history of a large resource-management organization's attempts to implement GIS as a case study;
4. to analyze the results of a GIS user survey undertaken as part of the case study to identify human resource issues and perceived bottlenecks to successful implementation; and
5. to propose guidelines and recommendations to assist future GIS implementation strategies for large resource-management agencies.

This thesis will use the British Columbia Ministry of Forests as a case study. The Ministry of Forests has been selected for the following reasons. Forestry was one of the first resource-management disciplines to use GIS technology, and it has become one of the most dominant users of this technology over time (Keller, 1992). The British Columbia Ministry of Forests represents a timely case study given its historical experience with GIS. The Ministry embarked on an initiative to implement computer-assisted mapping in 1978. Consecutive implementation strategies have not gone smoothly. The current long-term goal of the Ministry is to provide all Regional and District Forest Offices with GIS technology to enhance forest-management processes, but the Ministry is struggling to achieve this objective. Finally, the author is presently employed by this Ministry and, therefore, has obtained insight, knowledge, and access to information otherwise not available.

1.2 Chapter Contents

The remainder of this thesis is organized as follows. Chapter Two contains a brief review of literature on the impact of technological change on organizations. Chapter Three describes GIS functionality and its application in resource management, in particular, the use of GIS in forestry. The role of the Ministry of Forests, its mandates and business functions are discussed in Chapter Four. Also found in Chapter Four is a detailed chronology of the Ministry's attempt to implement GIS. Chapter Five provides a critical analysis of the Ministry of Forests GIS implementation initiatives. An examination of the various issues and problems that have been part of this GIS implementation is found there. The chapter concludes with a discussion of the need for a GIS user survey to provide useful information on how better to manage the human resource and change-management issues associated with GIS implementation. Chapter Six describes the methodology used in the GIS user survey that is part of this research. The analysis and interpretation of the survey results are found in Chapter Seven, along with supporting tables that summarize the survey data. A series of recommendations on how to improve the implementation process, a thesis summary and final conclusions make up Chapter Eight.

CHAPTER TWO

THE IMPACT OF TECHNOLOGICAL CHANGE AND INNOVATION ON ORGANIZATIONS

2.0 Introduction

A great deal of literature exists on the subject of technological change and innovation within organizations (Lawrence, 1954; Kolb and Frohman, 1970; Zaltman, Duncan and Holbeck, 1973; Moch and Morse, 1977; Kotter and Schlesinger, 1979; Woodward, 1980; Trist, 1983; Tichy, 1983; Hage, 1987; Kent, 1989; Noori, 1990; Sankar, 1991; Oskamp and Spacapan, 1991).

Compared to studies that focus on the individual and innovation, the study of innovation in an organizational setting presents unique challenges. Organizations are complex human aggregates with various centres of decision making; and they are endowed with traditions, values, policies, and procedures that can impede or enhance the innovation process (Pennings, 1987).

Much of the literature that deals with technological change within organizations has focused on how efficiencies can be gained, or how manufacturing processes can be enhanced (Lawrence, 1954; Hall, 1982; Kent, 1989; Gattiker, 1990; Oskamp and Spacapan, 1991). Most of this work examines the effect of technological change and its potential to enable organizations to enhance their ability to achieve organizational and economic goals. The literature is full of case studies that analyze the impact of technology on manufacturing, service, and administrative organizations. However, there exist very few studies on the impact of technological change on resource-management agencies. One of the aims of this thesis is to help fill this gap in the literature.

This chapter provides a general review of the literature on the impact of technological change on organizations. The information discussed here will be compared with that found in the case study to assist in understanding the type and extent of organizational change the Ministry of Forests is going through as it implements GIS technology.

2.1 Types of Innovation

To better understand the impact that technological change can have on an organization, it is important to define the various types of innovation that can take place. Innovations can be simply defined as departures from existing practices or technologies. Often the term is used to describe actual inventions themselves, or is interpreted as a disposition toward new ways of doing things.

Innovation or technological change can occur in a variety of forms. As Hage (1980) and de Neufville and Croissant (1991) point out, innovations can vary in their degree of radicalness. A radical innovation is a significant departure from previous practices. Innovations can occur within or outside an organization. Technological change can also take the form of an idea or process that is completely new, or it can refer to something new only to a particular organization.

Innovation or technological change can take at least three forms (Zaltman, Duncan and Holbeck, 1973). (1) A forced innovation can take place within an organization or be imposed by government legislation, competition or outside environmental forces. (2) A programmed innovation is that which is planned through product or service research and development. (3) A non-programmed innovation usually occurs when there are extra resources available in the organization that can be used for innovative purposes or projects. This type of innovation is non-programmed or not planned for, in that the organization cannot anticipate when such resources will be available (Zaltman, Duncan and Holbeck, 1973).

2.2 Organizational Characteristics and Innovation

The characteristics of an organization has been said to play a vital role in the success rate of innovation. Hage and Aiken (1970) and Moch and Morse (1977) agree that the following organizational characteristics are related to high levels of innovation:

1. High level of complexity in the professional training of organizational members.
2. High level of decentralization of power.
3. Low formalization.
4. Low level of stratification in the differential distribution of rewards (if high stratification is present, those with high rewards are likely to resist change).
5. A low emphasis on volume (as opposed to quality) of production.
6. A low emphasis on efficiency in the cost of production or service.
7. A high level of job satisfaction on the part of organizational members.

There is some argument over the relative importance that organizational characteristics play with regards to innovation. Some state that the perspectives of organizational members and the role of elites are more important than organizational characteristics (Hage and Dewar, 1973). Corwin (1973) summarizes this point of view by stating that elite values in fact play a larger role in organizational change if the innovation itself is viewed more as a political event within the organization. The economic conditions and the internal politics of an organization can greatly affect the innovation process. Elite values can be understood in an organizational context as the values of those persons who hold positions of influence and power, in most organizations this would be the executive management. Many times organizational performance and change can be determined by the relationship between what organizational elites value and what the organization actually accomplishes (Hage and Dewar, 1973). Corwin (1973) states that most organizations are characterized by power struggles. The outcome of these struggles, along with organizational characteristics, determines whether or not a particular change or technological implementation will take place.

The role of elite values has greatly influenced the implementation of GIS in the Ministry of Forests and will continue to do so. GIS is still a new technology to the Ministry and as a result the success of the current implementation plan is very dependent on the activities and values of elites or what some call "GIS champions." Until a larger audience of Ministry GIS users becomes more aware of both the benefits and costs of GIS, it is likely that the Ministry's rate of success in implementing GIS technology will be determined greatly by the role of elite values.

2.3 Organizational Culture and Technological Change

Understanding organizational culture is another important factor in bringing about successful technology implementation (Laudon and Laudon, 1988; Gattiker, 1990; Noori, 1990; Sankar, 1991). Organizational culture is defined simply as a set of key beliefs, values, perceptions and attitudes that are shared by members of an organization (Smircich, 1983). Examples of some of the factors that make up organizational culture are the philosophy that guides an organization's policies towards its employees and customers, the rules of the game for moving up in the organization, dominant organizational values such as product quality, and the working climate for employees as they interact with other staff.

The role that culture plays in an organization is vital, as it provides members with a sense of identity and belonging, as well as assisting in creating a commitment to corporate beliefs, values and goals. Both Gattiker (1990) and Sankar (1991) state that such culture enhances the stability of an organization as it provides members with a framework or structure that can help make sense of organizational events and activities. In this sense culture can be used as a powerful force to identify and strengthen organizational priorities and goals.

The importance of the role of organizational culture is emphasized by Wilkens (1983), who states that the means by which new technology is implemented must be consistent with the value system of that culture in relation to issues such as the quality of work life, job rotation policies, change-management techniques, decision-making and planning processes, and employee career advancement and training policies.

Sankar (1991) states that the impact of new technologies on organizational culture is both obvious and certain, and that in order for new technologies to be successfully adopted, the organizational culture must change accordingly. Noori (1990) and Sankar (1991) agree that the strategic management of organizational culture is vital due to its dynamic interaction with basic institutional components and processes such as communications, decision making, innovation, organizational structure, functions, mandates and goals.

Some of these components and processes that make up organizational culture can influence the level of success of implementing such a dynamic technology as GIS. The organizational culture of the Ministry of Forests is in part affected by both the size of the Ministry and its inherent decentralized structure where District offices are in many ways autonomous from the direction of Branch offices headquartered in Victoria.

Sankar (1991) states that three strategies can be used to manage organizational culture in the face of implementing new technology. These three are: (1) ignore the culture, (2) manage around the culture, and (3) change the culture to match the plans to implement the new technology. This is where one can see the pivotal role of management and the implementation project champion(s), as the process of modifying organizational culture is predominately a role of management. "Many academics and practitioners believe culture can be positively influenced by consistent, thoughtful managerial action" (Sankar, 1991, p. 83).

2.4 Managing Organizational Change

The pivotal factor in ensuring the success of any implementation of information management technology is the way in which the resulting organizational change is managed. Since organizations cannot completely control the environment in which they exist, they must periodically bring about organizational changes to react to new circumstances such as increased competition, technological innovations, changing governmental legislation, or shifting public demands (Greiner and Barnes, 1970; Bedeian, 1989). Organizational change can be classed into two basic categories (Bedeian, 1989):

1. changes in the way in which an organization adapts to its external environment; or
2. changes in the behavioral patterns of an organization's members.

In most cases, it is the latter, more complex category that proves to be the most important with regard to organizational change. Bedeian (1989) points out that an organization in an ever-changing environment cannot even function, much less improve, if its members are unwilling to change their working relationships and job functions when change is required. If an organization desires to move in a new direction, new behavioral patterns and relationships must be developed that are consistent with this new direction; otherwise such change will be neither effective nor lasting (Greiner and Barnes, 1970).

The implementation of an information-management system such as a GIS can have a substantial behavioral and organizational impact. Such a technology can change the way in which people and groups interact and work, since it transforms the way information is collected, accessed and used to meet organizational objectives.

> The impact of the computer is compared to the effects of the industrial revolution in changing hierarchies, realigning political power struggles, radicalizing labor, and disrupting social and psychological patterns (Sankar, 1990, p. 161).

These changes in information management often lead to new distributions of power and authority within an organization. This is an example of one of the most common organizational changes that the introduction of new technology can bring about.

> Implementation of a new information system is often more difficult than anticipated because of organizational change requirements. Since information systems change important organizational dimensions, including the structure, culture, power relationships, and work activities, there is often considerable resistance to new systems (Laudon and Laudon, 1988, p. 113).

Given the above, it becomes apparent that it is necessary to examine the ways in which organizational change can be managed when analyzing the impacts of corporate GIS implementation and use in a large organization, such as the Ministry of Forests. GIS, after all, represents a technology that will permit an organization to develop new information products and modify information flows, thereby allowing people to rethink the way business is being conducted.

GIS technology will also allow organizations to take on new mandates previously not manageable, implying additional organizational change (Somers, 1990). Laudon and Laudon (1988), Noori (1990), and Sankar (1991) all concur that to succeed in implementing any computerized information-management technology, management must analyze the changes that such technology brings about in an organization, for the very simple but important reason that such analysis can help provide management with necessary information and guidelines to assist them in the change-management process.

One of the purposes of this thesis, therefore, is to use the Ministry of Forests as a case study to examine the changes in an organization brought about by an attempt to implement GIS. Studying these organizational changes should lead to a better understanding of the impacts of GIS implementation and use on the Ministry of Forests, and in turn provide insight as to how the implementation process itself can be improved.

2.5 Managing Resistance to Technological Change

The importance of managing organizational resistance to technological change is evidenced by the prominence that this topic is given within the overall literature (Lawrence, 1954; Kotter and Schlesinger, 1979; Tichy, 1983; Laudon and Laudon, 1988; Noori, 1990; Oskamp and Spacapan, 1990). As mentioned earlier, the introduction of new technology can affect the people within an organization. In consideration of this, technological change must be managed skilfully in order to facilitate a smooth implementation.

Managing the resistance to technological change in an organizational setting is a very complex task. Figure 1 provides a good overview of the numerous inter-related processes and factors involved. Here one can see the relationships among the sources that bring about the pressure to change (i.e., internal and external environmental factors).

This pressure to change can in turn establish the need for the implementation of new technology. Frequently the introduction of new technology can bring about employee resistance which can originate from personal or organizational sources. Such resistance can be reduced by either removing the sources of the resistance, and/or increasing need and desire to change. By examining Figure 1, one can see that there is a great range of methods and processes to reduce technological resistance; from education and communication, to negotiation and finally, explicit or implicit coercion. In most cases the thoughtful application of one or more of these processes results in the successful implementation of the technology in question (Noori, 1990).

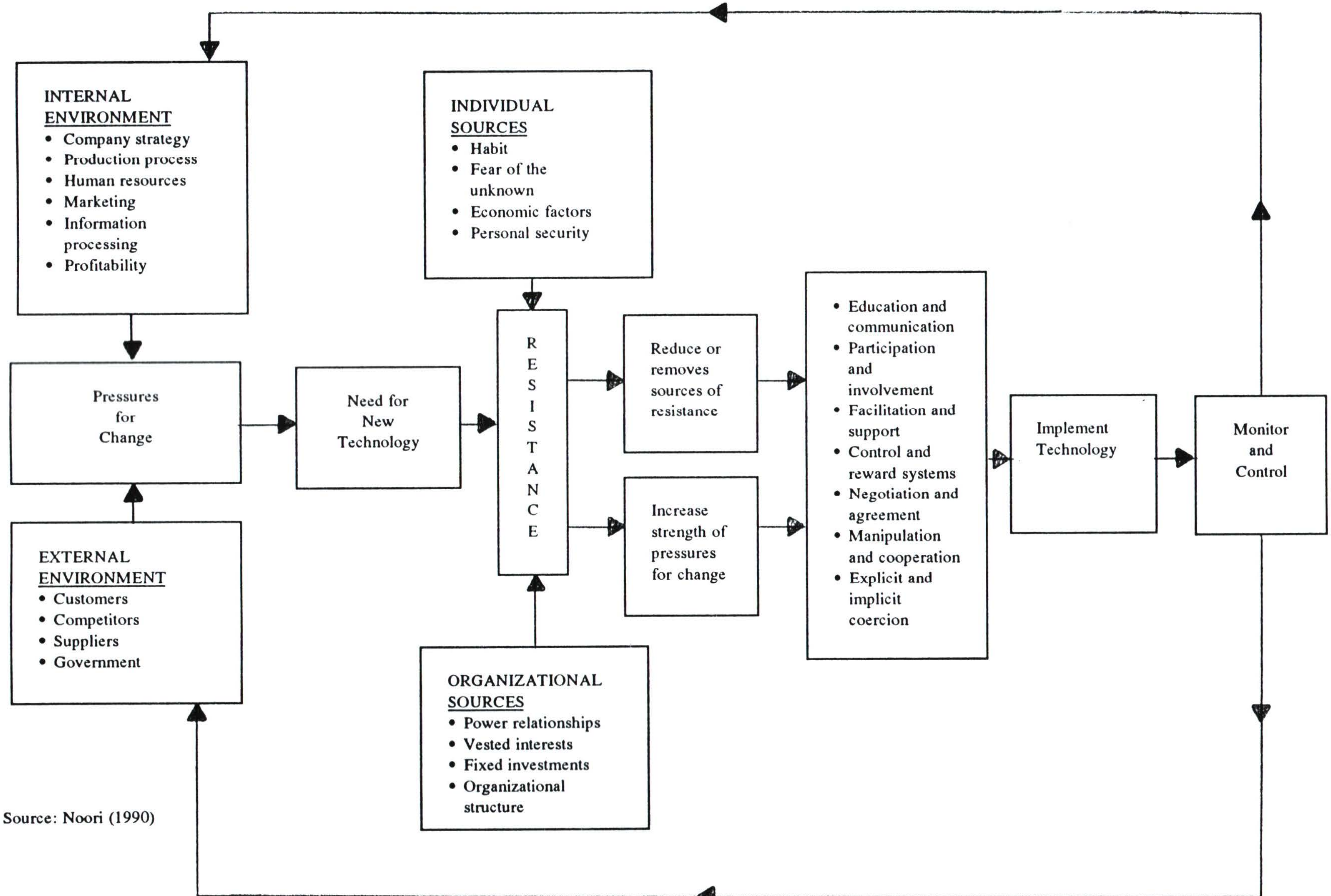
Since the scale and scope of technological change within an organization can be substantial, it is very common for people to resist the change in varying ways for different reasons. It is important then to be able to identify such resistance, as well as to know how it can be overcome.

2.5.1 Types of Resistance to Technology

There are different types of resistance to technology. Such resistance can be grouped into at least three categories: (1) people-oriented resistance, (2) system or technology oriented and, (3) resistance caused by the interaction of both systems and people (Laudon and Laudon, 1988).

People-oriented resistance deals with issues that are internal to the users or groups impacted by the technology, while system-oriented resistance focuses on the factors inherent in the design and application of a system or technology that create resistance to

FIGURE 1 - IMPLEMENTING TECHNOLOGICAL CHANGE WITHIN ORGANIZATIONS



Source: Noori (1990)

the system. Interaction resistance, as mentioned above, is brought about by the interaction of people and the technology in question.

Noori (1990), classifies resistance to technology into only two categories: employee resistance and middle management resistance. Employee resistance arises because the introduction of new technology can affect employees in various ways. People react psychologically to changes in job function, and changes in levels of social interaction, the net result of which can be lowered job satisfaction and instability. This can result in employees resisting technological changes. With regards to middle management, the implementation of new technology many times brings about a flatter organization structure where there is less need for middle managers. Thus middle managers may resist technological change for fear of losing their jobs.

Kotter and Schlesinger (1979), state that the four most common reasons people resist change are: (1) a desire not to lose something of value, (2) a misunderstanding of the change and its implications, (3) a belief that the change does not make sense for the organization, and (4) a low tolerance for change itself.

Often the sheer extent of technological change can overwhelm staff when they are expected to change too much, too quickly. In the face of such change people may consciously, and unconsciously, resist such change. It is paramount that management take the lead in determining what concerns employees have about the changes and then act quickly to mitigate these concerns.

2.5.2 Overcoming Resistance to Technology

There are numerous organizational and social processes that have been devised to overcome resistance to technological change; indeed these methods are as numerous as the types of resistance.

One of the most common strategies for overcoming resistance to change is to involve the affected persons in the implementation process. By letting employees participate in the implementation, potential resistors can learn directly what the technological change is, why it is required, and how it will affect them. Staff who participate in the change-management process can provide technical feedback and valuable practical advice to management that can reduce the amount of potential problems with the implementation. In addition, resistant employees may be 'won over' and led to feel that they have a personal stake in the change, if management invites them to participate in the change-management process (Kotter and Schlesinger, 1979; Noori, 1990).

Another method for reducing the level of resistance is to educate employees about the change before it takes place. This requires a commitment on the part of management to take the time and resources to communicate to staff what the nature of the change is and why it is happening. A program of education and two-way communication, where employees can ask questions of management, can greatly reduce resistance, especially if such resistance is based upon inadequate or inaccurate information and analysis (Kotter and Schlesinger, 1979).

Management can also diminish the level of resistance by being supportive of employees' needs during the change period. The provision of training in new skills before the change takes place, time off for staff after a demanding work period, or simply listening to staff, are all examples of such support (Noori, 1990). This kind of facilitation and support can be beneficial when fear and anxiety are the basis for the resistance to change (Kotter and Schlesinger, 1979).

Negotiation is another strategy that can be used to overcome resistance to technological change. With this method management can offer incentives to those who may cause resistance. Noori (1990) indicates that negotiation is particularly useful when it is obvious that certain employees are going to lose out as a result of the change yet their power to resist the change is significant.

Finally, management can deal with resistance coercively. In this case employees are forced to change by implicit and explicit threats that endanger the possibility of promotion or continued employment. Despite the fact that the use of coercion can many times produce unpredictable outcomes, organizations use this technique when the timing of the change is very important and where the changes will not be seen as favourable, regardless of how they are implemented (Kotter and Schlesinger, 1979). The use of coercion can also be very effective in overcoming many types of resistance as it can eliminate individuals who resist the change by firing them.

As one can see, there are numerous methods for reducing the level of resistance to technological change. What is needed then, is for organizations to develop a management style that will facilitate the efficient introduction of technological change.

The importance of adopting a proper management style has been well documented (Lawrence, 1954; Kotter and Schlesinger, 1979; Laudon and Laudon, 1988; and Noori, 1990). The following list provides an example of various processes that, when adopted by an organization, may help create a management style that reduces resistance to change:

1. Frequent and clear communication of goals;
2. Reduction of uncertainty wherever possible, while opposing the rigidity and inflexibility of the "one best way";
3. Reward systems that encourage flexibility and innovation;
4. Increased emphasis on a problem-solving orientation;
5. Commitment to a developmental view of human resources;
6. Development of a climate of trust and openness; and
7. The supporting of "team-playing" to maximize total organizational effectiveness (Noori, 1990).

Despite the amount of research that exists on the subject of managing resistance to technological change, this issue continues to be a major problem for many organizations. The question that remains to be answered is this: is the resistance to new technology related to the lack of understanding and education on the part of management, or is it simply that management fails repeatedly to see resistance as an issue to contend with?

2.6 Summary

Chapter Two has provided a review of some of the salient points regarding the impact of technological change on organizations. Included in this chapter was a discussion of the three main types of innovation, the various organizational characteristics that can effect innovation, and the importance of the role of organizational culture in the process of implementing technological change.

The chapter continued with a discussion on managing organizational and technological change. Attention was paid to the management of organizational resistance to technology and in particular, the types of resistance to technology and the various methods to overcome such resistance.

The importance of the human resource component when implementing GIS has been traditionally neglected or ignored (Somers, 1990; Sullivan and Miller, 1991; Keller, 1992). The importance of this component has been recognized for this study. A survey of attitudes and perceptions of key Ministry of Forests staff will yield information that can provide valuable insight into the amount and type of organizational change the Ministry is going through when implementing GIS. In addition, such a survey will yield information to help identify perceived impediments to implementation, as well as providing some insight into the kind of impact the use of GIS is having, and will have, on the Ministry and its business. Chapters Six and Seven discuss the results of the GIS user survey that was conducted on Ministry of Forests staff as part of this thesis.

CHAPTER THREE

GEOGRAPHIC INFORMATION SYSTEMS AND FORESTRY

3.0 Introduction

This chapter introduces and defines geographic information system (GIS) technology. The application of this information-management technology to the analysis and administration of our natural resources and forestry management is discussed. The intuitive benefits to be derived from moving traditional natural resource and inventory management and analysis into the computerized realm of GIS are highlighted. The chapter concludes by identifying common impediments that have been encountered when attempting to implement GIS installation in natural-resource agencies.

3.1 Geographic Information Systems

There is no universally accepted definition of what comprises a geographic information system (GIS). This is true despite the fact that this information technology has existed by name since the late 1960s when CGIS (the Canadian Geographic Information System) initiative was first formed in Ottawa, Canada (Tomlinson, 1987; Maguire, 1991). Thirty years later, there is still confusion with respect to what a GIS aims to do or should be capable of.

Some consider GIS a form of automated cartography. They state that GIS is "...simply a device to expand the use of maps" (Devine and Field, 1986). This group perceives everything that supports digital mapping as GIS. Others have stated that GIS is but one part of a large set of software or computer technology that deals with spatial data:

> GIS technology is often confused with other sciences and technologies that deal with spatial data handling. These include remote sensing, cartography, surveying, geodesy, photogrammetry and of course the 'father science to GIS', geography (Parker, 1988, p. 1547).

Finally, there exists a third group that insists that GIS is a digital technology that should aim first and foremost to support spatial analysis (Cowen, 1988).

Despite various opinions, a consensus is forming that a GIS is a computer-based technology that allows one to digitally store, edit, manipulate, analyze, query, create, display and output spatial data and associated attribute information. A GIS, in essence, is a computer technology that aims to combine computer-assisted drafting and mapping (CAD/CAM) with relational database management technology, cartometry and spatial analysis; a dynamic digital information technology for managing and analyzing spatial and associated non-spatial data (Burrough, 1986). What differentiates GIS from computer-assisted mapping and computer-assisted drafting is its ability to conduct cartometrics, notably topological overlays and queries achieved by explicit encoding of topological relationships in the spatial database (Keller, 1993).

For the purpose of the research reported here it is assumed, therefore, that a GIS is a digital-information technology that supports inventory and cartometric analysis of spatial data and associated attribute information. However, it cannot be guaranteed that all individuals who participated in the research survey reported in this thesis share the same vision of what a GIS is. Some may still think of GIS as simply a computer mapping technology. The reader is referred to Coppock and Rhind (1991) and Maguire (1991) for a more detailed discussion concerning the history and general definition of GIS.

For the purposes of this thesis it is important further to differentiate between 'stand-alone' and 'corporate' GIS. A stand-alone GIS refers to a GIS dedicated to a specific person or set of tasks, usually run on a personal computer. A stand-alone system will be expected to store relatively small databases, and to perform analytical tasks specific to an individual's research project. Such a system does not have to be accessible by multiple users, and generally does not have to conform to corporate standards. In this case 'read' and 'write' data privileges are always assumed.

A corporate GIS refers to a more sophisticated GIS which tends to reside on a networked computing platform where large volumes of data contained within the system must be simultaneously accessible to multiple users. This type of GIS must meet corporate standards, must meet the functional requirements of a broad set of users, and requires elaborate control over 'read' and 'write' data access privileges.

The research summarized in this thesis concerns itself predominantly with corporate GIS, although some of the opinions expressed by survey respondents may apply more to stand-alone GIS systems.

3.2 GIS and Resource Management

In the thirty years since inception, the GIS industry has grown into a multi-billion dollar industry with an estimated annual growth rate of 32 percent (Maguire, 1991;

Keller, 1992). Major contributors to this growth industry include natural resource agencies, together with the military, municipalities, utility corporations and direct marketing companies (GIS World, 1993). Indeed, there exist very few resource management agencies in the 1990s that have purchased some form of GIS technology. This holds true for both the public and private sector. Natural resource agencies thus are investing hundreds of millions of dollars in GIS. Why?

Traditionally, resource management professionals have stored information gathered about the surface of the land on paper maps. The paper map is intuitively appealing as a powerful medium for communicating the spatial distributions and spatial relationships of the diverse objects that cover the surface of the earth. However, the paper map has failed when it comes to cartometry and spatial analysis. Even basic tasks such as determining distance and area are time consuming and awkward when performed on a paper map. More complicated tasks, such as overlay analysis to determine, for example, what percentage of land is well drained and covered by old growth forest, become even more difficult and complicated to perform.

A digital GIS allows spatial objects such as point locations, lines, areas and surfaces to be stored in computer memory in what has become known as 'raster' or 'vector' layers (Burrough, 1986). Individual geographic objects are tagged with unique identifiers. Attribute data associated with the points, lines, areas and surfaces are stored in a conventional relational database management system, and are linked to the spatial database management system via the unique identifier tags.

The advantage of digitally storing all this information is that computers excel at efficient and quick processing of tedious routine calculations, as are required for most cartometric measurements. Calculations of area, distance, direction and volumes, therefore, become cheap and efficient once the spatial data is in the computer. Beyond basic cartometric measures, GIS which contain topologically encoded spatial databases (a requirement according to the definition put forth in Section 3.1) will also excel in processing topological queries including the following:

- What is upstream of ...?
- What is downhill from ...?
- What can I see from ...?
- How many occurrences are within ...?
- How many occurrences are within a specified distance of ... ?

Most powerful of all, however, is the computer's ability to conduct efficient overlay and buffer analysis.

Buffer analysis involves the explicit identification of land found within unweighted or weighted distances of point, line or areal features. A typical unweighted buffer analysis might be the identification of all land within 500 metres of streams. A typical example of a weighted buffer analysis might be the design of a noise corridor around a highway where the width of the corridor is dependent on the land use adjacent to the highway (i.e., noise travels far over lakes but gets muffled by trees).

Overlay analysis differentiates between visual and topological overlays. Placing transparent mylar maps on top of each other is an example of a visual overlay. It is possible to visually inspect the composite derived from overlaying the various layers, but it is not possible easily to report summary statistics. Topological overlay concerns a mathematical operation whereby the different layers superimposed on each other are physically combined into one new layer, and where all associated attribute data linked to the individual layers are recalculated for the derived composite map. This latter process of topological overlay requires a great deal of mathematical processing by the computer, and is therefore termed "processing intensive". However, it offers efficient data analysis capabilities hitherto unthinkable given time and labour constraints.

There are numerous other advantages to be derived from a strategy of switching to digital management of geographic data and associated attribute information traditionally stored on paper maps. Digital information storage and processing supports more efficient management of data modification as new and revised information becomes available. Since it can reduce the amount of time necessary to design and produce highly customized map information end-products, digital storage and processing can also reduce the costs associated with producing such materials. Finally, it makes the spatial data and associated attribute information available for advanced spatial analysis, statistical analysis, simulation and modelling. What makes GIS technology such a valuable tool in resource management is its ability to collate and organize large amounts of complex spatial and associated attribute information, and manipulate, analyze and display this information in such a way as to greatly enhance, and many times, simplify the resource planning and analysis processes (Aronoff, 1989).

The above are some of the obvious advantages that a GIS can offer to natural-resource management professions. These applications of GIS in management of resources should make it the de facto computer data analysis tool for resources management. Indeed, the last decade has seen a rapid increase of GIS installations in resource-management agencies. However, results have been mixed, with the majority of natural resource GIS installation initiatives failing to meet initial expectations, stalling or being abandoned altogether (Peuquet and Bacastow, 1991; Aangeenbrug, 1991; Keller, 1992). It has been well documented that other information system technologies, such as Management Information Systems have also suffered from limited success with implementation over the last twenty-five years (Bostrom and Heinen, 1977; Ginzberg, 1978; Laudon and Laudon, 1988; Sankar, 1991). However, it is important to note that it is the specialized database-management requirements of geographic data that distinguish GIS from other information technologies (Keller, 1992). It is these specialized spatial data-management requirements that are frequently not properly understood and managed during GIS implementation, that have subsequently lead to numerous problems and project failures (Brown, 1987; Green, 1987; Epstein, 1989; Peuquet and Bacastow, 1991; Keller, 1992).

The objective of the research summarized in this thesis is to investigate one such installation as a case study. The case study concerns a forestry GIS installation and it is worthwhile, therefore, to discuss briefly the potential role of GIS in forestry.

3.3 GIS in Forestry

Forest-resource management is becoming an increasingly complex process. It is no longer acceptable to manage forest resources for timber production alone. The current trends in forestry are towards ever-increasing demands for environmentally sound, multiple-use natural resource management, and growing public requests for accountability and justification of forest management activities (Maser, 1987; Young, 1988, Lertzman, 1991; Bradley and Lewis, 1992; B.C. MOF, 1992). There is a shift in emphasis away from the controlled exploitation of the forest resource toward more intensive forest management (Erdle and Jordan, 1984). This trend has led to the creation of new mandates in forest management that have severely challenged traditional, manual information-management processes (Richards and Eiber, 1985; Wientzen, 1990).

More intensive forest management implies increased requirements of the forest inventory database, improved access to related information, and the ability to integrate the diverse sources of data. These factors imply the need for better and more efficient methods of information management.

Prior to the arrival of digital GIS technology and satellite imagery, forest inventories were collected piecemeal, with one portion of the forest being inventoried at a time. Depending on the size of the forested area being covered, a particular inventory process might take up to several decades to complete. The information thus collected was placed in attribute tables that were summarized in reports, and then graphically displayed on paper maps.

When changes occurred to the inventory, both the tables and maps had to be updated. Using traditional methods of database management and analog mapping, these updates proved to be very time-consuming and expensive. In many instances they simply were not completed due to lack of budget, personnel and time.

Deriving customized information products from the general forestry inventory was a time and labour-intensive process, and delivery of the requested information products could take years. Aside from personal knowledge, basic inventory overview maps and summary tables comprised the usual information products available to the traditional forestry manager.

A study was conducted in the late 1980s for the United States Forest Service to evaluate the potential need for and use of GIS by that agency. The study requested information from professional forestry managers concerning their current and perceived information end-product needs to meet past and foreseen forestry management requirements. The report, conducted by Tomlinson and Associates Inc., concluded that the average U.S. National Forest Service office ideally required access to between thirty and sixty data sources and between thirty and sixty information end products to meet their mandates (NCGIA, 1989). The report indicated that between 60 and 90 percent of information products identified by the professional foresters could not be delivered efficiently and effectively by traditional inventory management practises; that is, between 60 and 90 percent of all information end-products required to manage the forests needed some form of digital information management capability (NCGIA, 1989).

What were these information end-products that the professional foresters were requesting? Tomlinson and Associates Inc. completed a report on the functional requirements specifications of the *Siuslaw National Forest Office*. This office requested sixty information products as described below:

- ten simple cartographic products generated by re-formatting, re-scaling and/or re-symbolizing traditional inventory data;
- two three-dimensional graphics products emphasizing topographic terrain;
- seven lists generated by combining the spatial data and associated attribute information stored in the traditional inventory;
- thirty-seven information products that would require simple cartometric GIS functions; and
- eight information products that would require advanced GIS analytical functions (NCGIA, 1989).

Given the above, the potential benefits to be derived by switching forestry inventory management and analysis to a digital format using GIS become obvious. A GIS can automate traditional manual mapping techniques, such as map compilation, printing, duplicating, and management of the associate attribute data. The advantages here are a reduced amount of time between inventory collection and derivation of information end-products, reduced map production costs, a more efficient mechanism for information update, and support of efficient customized access to the information. These added capabilities should ensure a more up-to-date and accurate forest inventory. Such an inventory is needed to assess the existing forest resource, to develop harvesting schedules and silvicultural treatment programs, as well as projecting future timber supplies (Peck, 1983; Leefers, 1989; Aronoff, 1989).

The use of GIS to update forest inventory maps is little more than automated cartography, which is simply using computer techniques to replace manual drafting procedures (Aronoff, 1989). The real advantage of GIS is the ability to analyze the digitally stored data in ways not possible before.

> The processing power of a GIS allows several alternatives to be evaluated relatively quickly. This has led to a qualitative change in the way many analyses can be approached. Plans can be progressively refined and re-evaluated to optimize a solution, a procedure that would be prohibitively expensive using manual techniques (Aronoff, 1989, p. 8).

Another advantage of using GIS in forestry-management and associated integrated-resource management is these systems' ability to support efficient complex spatial analysis, statistical analysis, modelling and simulation; to yield valuable information products for decision-making, hitherto unobtainable, and to yield innovative predictive models required for forest planning (Hermansen, 1989; Dick and Jordan, 1990; Baskerville and Moore, 1988).

It is not surprising that many foresters are using GIS to manage their inventory and to assist in analysis to provide comprehensive decision making and planning support when managing conflicting resource allocations (Hermansen, 1989). Over the last ten years the vast majority of forest-management agencies and companies have recognized the potential of GIS and have begun to implement GIS for use in their inventory and planning programs. This is evidenced by the fact that in the last decade every Canadian provincial government forest ministry has purchased a GIS. In addition, over forty major forest companies across Canada are in the process of adopting GIS technology (Dick and Jordan, 1990).

However, implementation difficulties have been encountered in most of these initiatives, although bureaucrats and professional resource managers are reluctant to admit to this in the literature (Keller, 1992). GIS technology obviously has much to offer modern forestry management, but the many benefits that this technology can bring appear to be reduced or obscured by the numerous problems experienced in the implementation attempts of large organizations (Dick, 1990). The objectives of this thesis, therefore, are systematically to analyze the social, organizational, and technical factors that influence the outcome of a GIS implementation in a natural resource agency, using the British Columbia Ministry of Forests as a case study. The goal of the research is to provide additional insight into how to make future corporate GIS implementation less problematic.

3.4 Corporate GIS Implementation

GIS is a complex information management technology that will cause considerable organizational change by its introduction and use (Aronoff, 1989; Somers, 1990). In virtually every case such change brings with it associated problems and challenges (Dick, 1990; Sullivan and Miller, 1991; Keller, 1992). The most common problems associated with GIS implementation can be organized into three groups:

1. lack of adequate planning;
2. ignorance of organizational and human resources issues; and
3. underestimation of data management concerns.

These three issues will be discussed briefly below.

3.4.1 Lack of Adequate Planning

Lack of adequate planning has been identified as the single greatest reason for GIS implementation failures (Levinsohn, 1989; Aronoff, 1989; Epstein, 1989; Aangeenbrug, 1991; Peuquet and Bacastow, 1991; Keller, 1992). In the past, GIS capabilities have been oversold by vendors, consultants, and project champions who are quick to proclaim the numerous benefits of GIS, while glossing over such issues as identification of information end-product needs, realistic long-term funding requirements, project schedules, procurement of executive support, development of realistic implementation plans with obtainable objectives, the importance of establishing an implementation pilot project, integration of GIS with business functions, and developing strategies for managing organizational change.

Ignorance and/or avoidance of the above issues have usually lead to severe administrative and human resource problems, threatening the long-term viability of any GIS implementation (Keller, 1992). The result has been that, in most cases, the main focus of GIS implementation has been on the selection of hardware and software. Project planning and human resource issues generally have been dealt with in an ad hoc manner, rather than through a detailed, proactive implementation plan.

This thesis aims to document these typical makeshift procedures using the case study as an example, pointing out where the pitfalls in implementation have occurred.

3.4.2 Organizational and Human Resources Issues

Failure to appreciate organizational and human resource issues usually leads to implementation problems (Somers, 1990). Research conducted by DeMarco and Lister (1987) and Jones (1981) found that 25 percent of major systems development projects (lasting twenty-five work years or more) failed to be completed, and that in the majority of these cases, it was not technological issues that caused the failure. Failures were attributed to the "sociology of the project team" (Levinsohn, 1989). Examples of common organizational and human-resources problems identified include: resistance to technological change, lack of innovative management styles, rigid organizational structures, overemphasis on short-term goals and annual budget processes, poor communication between end-users and system designers, ignorance of GIS technology itself, poor or nonexistent training, and the absence of an adequate user-support strategy (Epstein, 1989; Levinsohn, 1989; Keller, 1992).

One of the main purposes of this research is to analyze a GIS user survey conducted by the Ministry of Forests in an attempt to identify some of the sociological and organizational problems perceived by Ministry staff and management.

3.4.3 Data Management Concerns

Issues regarding data management generally end up as impediments to corporate GIS implementation once hardware and software are in place. Common problems associated with data management include; a poor understanding of data encoding and storage requirements to support efficient cartographic query and spatial analysis, antiquated or poorly designed database structures and management, data not readily available in a useable format for GIS users, and a lack of appreciation or utilization of historic investments in data processing and management (Brown, 1986; Aronoff, 1989; Epstein, 1989; Keller, 1992). The biggest single problem in this regard appears to be a poor understanding of the geographical components of data - essentially a failure to recognize the complexity and importance of spatial data, spatial relationships, and spatial analysis. It is notably a lack of consideration for the body of knowledge unique to the discipline of Geography, including a good understanding of cartographic and spatial-data management fundamentals that causes problems here, problems that are proving to be very expensive to remedy (Keller, 1993).

Given the considerable expenditures in time and money that are required to implement GIS in a large organization, it would appear reasonable to expect a considerable amount of literature discussing how to make the implementation process as un-problematic, efficient and cost effective as possible. It should come as a surprise, therefore, to learn that literature on this subject is sparse. Apart from the seemingly endless journal articles and conference proceedings that discuss, in most cases, implementation projects of questionable success, there exists very little published research that closely examines the fundamental organizational, sociological, management or personnel issues. As well, there exists a paucity of literature investigating the general misunderstanding of the complexity of spatial data and how this affects the implementation and use of GIS (Sullivan and Miller, 1991; Keller, 1992).

The goal of the research reported here, therefore, is an attempt to commence to fill this gap in the literature by analyzing the above noted issues in the context of the case study in an effort to provide some insight and possible recommendations as how best to alleviate many of the concerns raised.

3.5 Summary

This chapter has introduced and defined the geographic information system (GIS) technology. It was noted that there still exists some confusion concerning the exact capabilities that a GIS should provide. A working definition for the purpose of this research has been put forth. Differences between stand-alone and corporate GIS were commented upon.

The chapter moved on to introduce potential benefits that the GIS spatial information management technology might offer to resource management professionals. It was stressed that GIS offer efficient ways of storing map inventory, that they support efficient methods for conducting cartometric analysis, that they excel in buffer analysis and topological overlays, and that they support more complex spatial and statistical analysis and modelling.

The obvious role of and need for GIS to support changing forestry management practices and changing management mandates was the subject of the next section. The point was made that professional foresters are requesting access to a large number of information end-products that can only be generated by a GIS.

The chapter concluded by noting a number of problems associated with GIS implementation in large natural resource agencies, in the process placing the chapter content within the overall research goals reported in this thesis.

CHAPTER FOUR

THE BRITISH COLUMBIA MINISTRY OF FORESTS

4.0 Introduction

Chapter Four introduces the British Columbia Ministry of Forests. It includes a brief description of the history of the Ministry, its mandates and organizational structure. In addition, the chapter provides an overview of the Ministry's attempts to implement computer-assisted mapping and GIS capabilities in the 1970s and 1980s respectively. The chapter concludes with a brief discussion on the current status of the Ministry's GIS implementation initiative.

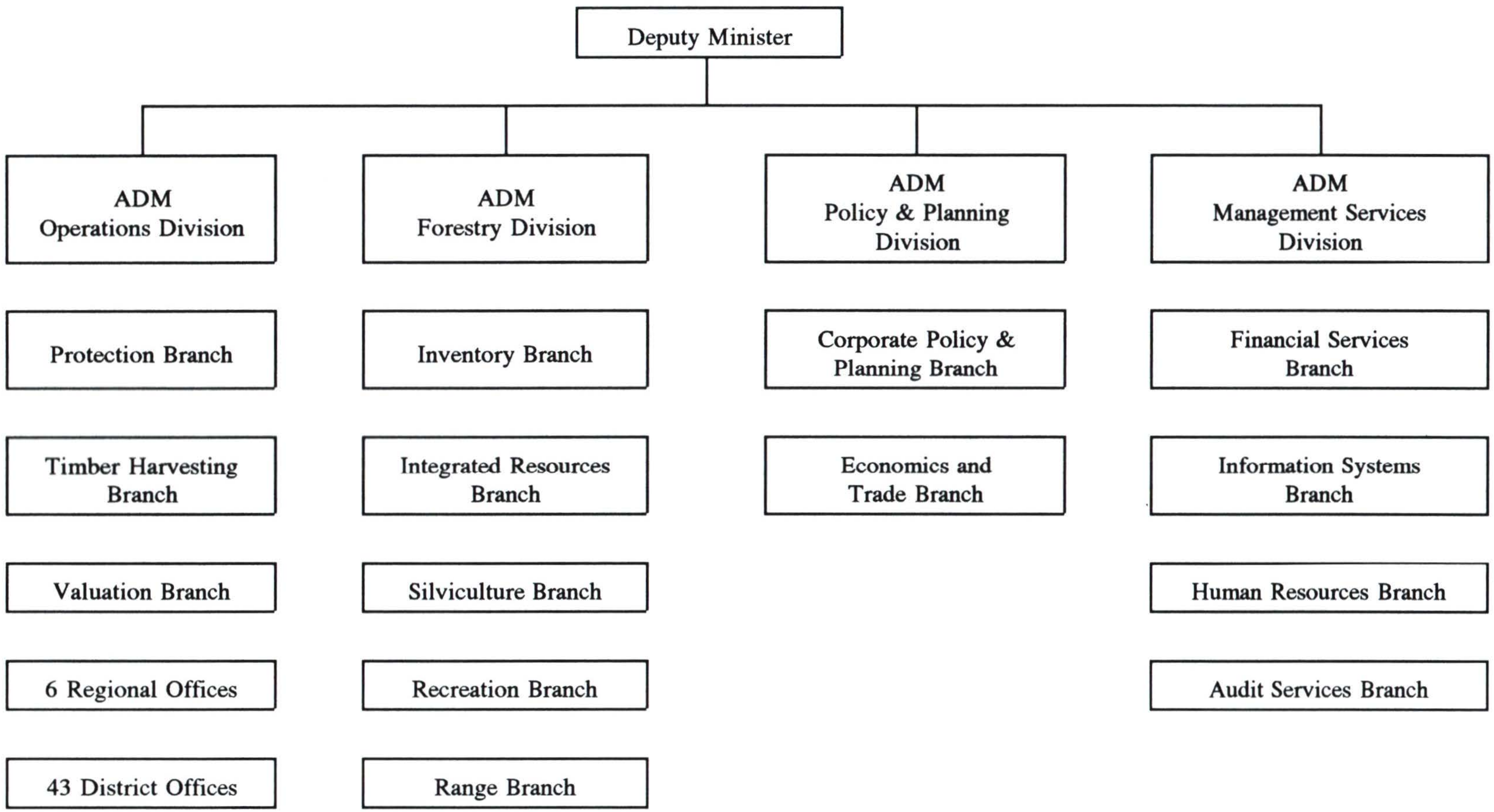
4.1 The Ministry of Forests

The B.C. Forest Service came into being with the passage of the Forest Act in 1912. For many years, the Forest Service was part of the Ministry of Lands. Currently the Forest Service is part of the Ministry of Forests. It was not until 1978 that the organizational structure of the Ministry of Forests (MOF) as we now know it was formalized with the passage of the Ministry of Forests Act.

The Ministry of Forests presently comprises four Divisions, namely Forestry, Operations, Policy and Planning, and Management Services and directly employs over 4000 people.

The four divisions are sub-divided into seventeen Branches (see Figure 2). The most important divisions, from the perspective of resource management, are Operations

FIGURE 2 - MINISTRY OF FORESTS ORGANIZATIONAL CHART



ADM = Assistant Deputy Minister

Source: B.C. Ministry of Forests (1993)

division (where the six Regional and forty-three District forest offices are managed) and the Forestry and Policy and Planning divisions (where the majority of the branches of the Forest Service are administered). The actual forest management operations take place between Operations and the Forestry division. The Branches define management policies and monitor programs for the Ministry as a whole. Currently the Ministry is undergoing substantial organizational changes that will see a greater emphasis placed on Branches in the role of supporting District offices in meeting their mandates.

It is the duty of Operations division to administer the forestry program through the Regional offices, which in turn oversee the administration of the program in the District offices. The District offices implement and monitor the Ministry's policies and programs at the local or field level. District offices, in essence, make up the "operational heart" of the ministry.

One may get the impression that the headquarters branches in Victoria exercise a large amount of control over District offices. This is misleading since each District Manager and his or her staff has a great deal of autonomy. It is debatable whether this autonomy is a deliberate effort by the Ministry to decentralize many of its functions, or arises because it is very difficult, and in many cases inefficient, to exert a great deal of centralized control in such a large organization.

4.2 The Role of the Ministry of Forests

The roles of the Ministry of Forests are predominately those of overseer and facilitator of the British Columbia private sector forest industry. The mission of the

Ministry, simply stated, is "to manage and protect the province's forest, range, and forest recreation resources for the maximum benefit of all British Columbians" (MOF Annual Report, 1989-90). The roles and responsibility of the Ministry of Forests are set out by the Ministry of Forests Act, 1978 as well as the revised Forest Act, 1978. Under these two acts the Ministry of Forests is required to provide a forest resource analysis every ten years to the provincial legislature. In addition, the Ministry of Forests is to provide the legislature with a five-year resource plan, similar in content to that of the ten-year resource analysis, albeit in greater detail and with specific emphasis on silvicultural activities.

The Ministry of Forests has an exclusive role in the management of B.C.'s forests. The Ministry has complete jurisdiction over 91 percent of the land base in B.C. (i.e., Crown land), or 86.4 million hectares of the province's total land base of 94.8 million hectares, of which 43.3 million hectares are productive forested land (B.C. MOF, 1992). The Ministry of Forests is directly involved in the management of forested lands within a Timber Supply Area and indirectly involved with lands within a Tree Farm Licence. The Ministry of Forests plays the pivotal role of establishing, implementing, and maintaining all the forest management policies and programs that directly affect the industry and other crown agencies alike.

4.3 Ministry Mandates and Business Functions

The major functions and mandates of the Ministry of Forests, like all government agencies, are codified in legislation. Section Four of the Ministry of Forests Act, 1978 details the purposes and functions of the Ministry of Forests as follows:

(a) encourage maximum productivity of the forest and range resources in the province;

(b) manage, protect and conserve the forest resources of the Crown, having regard to the immediate and long term economic and social benefits they may confer to the province;

(c) plan the use of the forest and range resources of the Crown, so that the production of timber and forage, the harvesting of timber, the grazing of livestock and the realization of fisheries, wildlife, water, outdoor recreation and other natural resource values are coordinated and integrated, in consultation with other ministries and agencies of the Crown and with the private sector;

(d) encourage a vigorous, efficient and world competitive timber processing industry in the province; and

(e) assert the financial interest of the Crown in its forest and range resources in a systematic and equitable manner.

In addition to these legislated mandates, the Ministry of Forests has various policies, corporate commitments and values, and ministry goals that guide the actions of the Ministry of Forests (MOF Annual Report 1989-90). These policies change over time, depending on variables such as economic and employment conditions, natural circumstances, (such as forest fire and pest infestations), and social and political values. A recent example of such a policy change is the formulation of the Forest Practices Code which will substantially change the timber harvesting and monitoring activities in B.C. This new policy became codified into legislation in the spring of 1994.

While many of the Ministry's mandates are set in legislation and thus relatively static, it is the various corporate values, ministry goals and policy mandates that change to give the Ministry of Forests flexibility in dealing with the changing issues and circumstances influencing forest management.

The Ministry of Forests thus uses non-legislated mandates and ministry goals to provide flexibility and timeliness to its business functions (Sullivan, 1992). An example of such flexibility can be seen in how the Ministry of Forests, over time, has included the encouragement of public involvement in the forest-management planning and decision-making processes of the Ministry as one of its corporate values (MOF Annual Report, 1989-90). Fifteen years ago this issue was not as important to the general public as it is now and, as a result, was not a published Ministry goal at that time.

4.4 A Chronology of the Ministry of Forests Attempts to Implement GIS

The B.C. Ministry of Forests was one of the first government agencies in Canada to automate and digitize its forest database and associated maps (Aronoff, 1989). This automation project began in 1978 and is still under way.

In the period prior to the automation initiative, all field information was manually recorded on history record cards and then transferred to hand-drawn maps. This was a very time-consuming and labour-intensive process.

With the passing of the Ministry of Forests Act in 1978, the Ministry of Forests, notably the Inventory Branch, was legislated to provide more detailed inventory information, in particular to conduct province-wide inventory updates every two years, with province-wide reinventories every ten years. Around the same time, there was also an initiative to convert the inventory maps to the metric scale. This would require the redrawing of existing forest cover maps.

The newly legislated responsibilities and the move to metrification led the Ministry to conclude that it should automate the Inventory Program with a Computer Assisted Mapping (CAM) system. At the same time a decision was made to convert the attribute and statistical inventory data stored on the historical record cards to digital form. To further enhance the update capabilities and accuracy of the forest cover, an initiative began around the same time to develop and use remote-sensing technology to aid in the forest cover update process. Using computer-assisted mapping software, all 7,000 B.C.G.S. forest cover maps are scheduled to be converted by end of 1994.

It was not until 1985 that the Ministry of Forests first began to explore the use of GIS for planning and analysis functions. A benchmark selection process was conducted by Ministry of Forests staff at this time. It lead to the selection of two different B.C. GIS software products as the geographic information systems; Pamap and Terrasoft GIS. Initial systems were installed in the six Regional forest offices as a pilot implementation project. In the spring of 1989 the Inventory Branch, along with the Integrated Resources Branch, began a large-scale implementation project to install GIS workstations in all forty-three District forest offices across the province. However, at this time there did not exist a well-defined vision for the use of GIS and there was only a very basic implementation plan. The plan was for the Inventory Branch to sponsor the use of the Pamap GIS for the purpose of forest cover map update and for the Integrated

Resources Branch to sponsor the Terrasoft GIS for planning and analysis work. This implementation was initially to take three years to complete. This schedule has had to be extended on numerous occasions due to various problems and oversights that have arisen concerning this initiative. Currently there are fewer than thirty GIS work-stations installed in the six Regional and twelve District offices.

Around the same time (i.e., mid to late 1980s) the Timber Harvesting Branch embarked on a plan to implement Computer Assisted Mapping (CAM) workstations to provide automated drafting facilities to all District offices. This CAM implementation has been called the Forest Atlas Mapping Automation Project (FAMAP). The estimated completion date for this project is 1998 and thus far has been relatively successful, with thirteen Districts implemented to date.

CAM implementation in the regions appears to be working successfully, in part, because the CAM technology used is relatively simple to operate, requires relatively little staff training and support, and has a definite purpose: predominantly, the drafting and updating of the Ministry of Forests "Forest Atlas" of legal lot descriptions and commercial cutting blocks. The CAM technology, therefore, simply automates existing manual tasks. It does not generate new information products, nor does it have any of the dynamic data analysis capabilities that a GIS possesses.

The implementation of GIS to date has had limited success, especially in Regional and District offices. Various constraints, such as lack of a corporate commitment and vision for GIS use, lack of comprehensive implementation planning, lack of up-to-date digital data, shortage of trained staff and failure to implement area-based forest-management frameworks have all restricted the use of GIS (Andersen Consulting, 1989). To date, the predominant use of GIS in the Ministry of Forests has been for basic planning and analysis projects such as the production of simple colour-theme maps and map overlays for small-scale integrated resource-management plans. A few District offices have attempted to use GIS for updating their forest cover maps in-house with varying degrees of success.

In the six months following the GIS implementation, it became obvious that this initiative was not progressing well. In the late fall of 1989 the Ministry of Forests commissioned a private GIS consulting firm to conduct a study that would analyze this implementation and come up with recommendations for improvement. One of the main recommendations that came out of this study was that the Ministry of Forests had not adequately prepared for this implementation and that, until a corporate GIS vision and comprehensive implementation plan was in place, the entire initiative should be placed on hold (Andersen Consulting, 1989). Consequently, the Ministry ceased any further implementation activities and focused on preparing a comprehensive plan. To date, the freeze on GIS implementation is still in force and a second, more comprehensive GIS strategic plan has recently been developed.

This new strategic plan has been called the Land Information Management Strategic Plan (LIM strategy). It differs from the former GIS strategic plan in that it does not focus solely on GIS technology. Instead GIS is seen as one of many tools used to manage land information. This new LIM strategy incorporates two main components.

The first component involves three major projects: (1) to restructure the MOF database into a fully relational format; (2) to complete the implementation of CAM facilities in every District office; and (3) to develop easy-to-use database reporting tools before the implementation of full function GIS resumes. An integral part of this component is the decentralization of the forest inventory update process from the Inventory Branch to District offices. Component One is scheduled for completion by the end of 1997.

The second component of the LIM strategy is to develop the knowledge, processes, and information systems in order to use forestry data and other resource information that is required for integrated resource management (LIM Strategic Plan, 1994). The main projects that comprise Component Two are the development of customized forest-planning software and the selection of a new decision-support platform or GIS that will meet the Ministry's future requirements. Component Two is estimated to be completed by the year 2000.

Currently the freeze on full function GIS implementation remains in effect. In the four years since the MOF ceased the initial GIS implementation, the pressure to obtain this technology from sites that do not have a GIS has been intense. In an effort to reduce this pressure the Executive GIS Steering Committee has established an approval process that must be completed before any new District is given permission to acquire GIS technology. The main purpose of this approval process is to educate prospective District sites to the realities and problems faced by Ministry staff currently using GIS. If a District office provides a well-thought-out business plan that incorporates the issues raised in the approval process document it can gain the necessary consent to proceed with acquisition.

4.5 Summary

This chapter has briefly discussed the history of the British Columbia Ministry of Forests. It has been emphasized that the Ministry is responsible for maintenance of an inventory of the provincial forest stands, and that the Ministry must produce five-year resource plans and ten-year resource analyses with specific emphasis on silvicultural activities. The Ministry has turned to computer-assisted mapping and GIS to assist in these mandates. Implementation of computer-assisted mapping to automate traditional mapping tasks appears to be well on its way. The Ministry is in the ninth year of attempting to implement GIS to support analysis and to yield new information products to support planning. However, the Ministry appears to be struggling with this initiative. Possible reasons for failure to implement GIS technology in a timely manner are discussed in the next chapter.

CHAPTER FIVE

CRITICAL ANALYSIS OF GIS INSTALLATION INITIATIVES AT THE MINISTRY OF FORESTS

5.0 Introduction

Chapter Four of this thesis identified that the Ministry of Forests has been struggling with attempts to implement GIS for provincial forestry resource analysis and integrated natural-resource planning.

Chapter Two showed that implementation of any corporate information system in a large organization is a formidable task. This is especially true for a new and evolving specialized information system such as GIS. Aronoff (1989), Somers (1990), and Antenucci (1991) concur that the very nature of GIS information technology brings with it profound organizational change that must be adequately planned and carefully managed if this technology is to achieve tangible benefits over time.

In Chapter Three it was noted that three major reasons can be identified that bring about a failure to implement GIS expediently; namely, lack of adequate up-front planning, human and organizational change issues, and data management concerns. The following pages examine many of the impediments that the Ministry of Forests has encountered, and include a discussion of some of the lessons that may have been learned.

5.1 Project Planning and Management Issues

Successful integration of GIS into an organization's information management system has the potential to impact virtually every aspect of an organization, ranging from changes in management procedures and processes of decision-making to routine data management and staffing issues (Sullivan and Miller, 1990). Not only will the implementation of a GIS fundamentally change the way in which certain corporate processes are performed, it can also create new business functions. These changes and new business functions must be identified and planned for at the outset of GIS implementation.

GIS implementation is very expensive and time-consuming. For an organization the size of the Ministry of Forests, data management, hardware and software alone will cost many millions of dollars. If one adds to this all the costs associated with staffing, training, and user-support issues, then GIS implementation becomes a major financial cost that will have to compete for resources with all the other programs and initiatives that a large organization has to fund in order to achieve its goals and deliver on its mandate.

Given the magnitude of change and of costs associated with implementing corporate GIS, it is imperative for an organization to carefully plan and manage implementation of this technology. It could easily be said that one of the single greatest flaws in the GIS implementation process of the Ministry of Forests is that it has failed to exercise adequate project planning and management.

From the start, the Ministry's implementation of GIS has lacked focus and objectives. There was an initial decision to implement GIS in 1985, but there have never been any specific reasons or objectives stated as to why GIS is to be implemented. The most precise objectives stated have been that GIS will "improve the Ministry of Forests's forest management capabilities." As well, there has been little, if any, acknowledgment of the use or need for this technology from the Ministry of Forests executive management. Implementation of this new information management system, therefore, was to go ahead without strong support from the senior executive. As a result, the implementation has suffered from a lack of profile and from failure to attract the resources necessary to implement it properly.

As already noted, initial GIS implementation began in 1985 with Branch and Regional offices receiving GIS workstations. However, it was not until 1989 that a formal budget was established for GIS implementation, and it was not until that same year that the need to formulate a training and user-support strategy was realized. It was only at the end of 1990, five years after buying into this information technology, that the first strategic plan for this initiative was produced; that is, five years after six Regional and ten District pilot sites had already been established.

It should not come as a surprise, therefore, that the Regional and District pilot sites spent several years struggling with this new information technology, and that these sites failed to produce tangible information products or benefits. These sites failed because: they were operating without any specific plans or guidelines for GIS use, they did not have ready access to digital data that could be used by this information technology, and they had received, at best, nominal training and limited staff to support this new information-processing technology.

By 1989 it had become obvious that the GIS implementation was not meeting with success. As a consequence, a GIS consulting firm was hired in late 1989 to review the Ministry's GIS implementation success. Their findings were submitted in 1990.

Implementing any new information technology in a corporation requires a dedicated organizational structure consisting of representatives from senior and middle management as well as support staff, that is, a team of individuals needs to be assembled from across the organization whose main task will be to plan and coordinate successful implementation of the information technology transfer (Epstein, 1989; Aronoff, 1989; Levinsohn, 1989; Keller, 1990). Results from the consultant's study confirmed that such a team of individuals had not been assembled.

The consultant's report, therefore, led the Ministry to form a GIS Executive Steering Committee in 1990. This Executive Steering Committee has been formed to address the constraints surrounding the Ministry's GIS implementation initiative as outlined in the consultant's report. This committee consists of the Directors of various GIS-related Branches of the Ministry of Forests. Its role is to coordinate the planning and management of GIS implementation and other data management projects throughout the Ministry of Forests. Before the creation of this committee, there was a great deal of confusion and lack of communication among the three branches of the Ministry that were involved in implementing GIS (Peat, Marwick, Kellog and Stevenson, 1991).

Several middle-management GIS committees formed prior to 1990 now reported to the GIS Executive Steering Committee. However, it is of interest to note that none of the members of these middle-management groups work on a full-time basis on the GIS implementation project. Accordingly, a problem with the Ministry's GIS implementation plans has been that the initiative has lacked personnel at senior and middle management dedicated full-time to its realization, and the entire project has suffered greatly and continues to do so.

The newly formed Executive Steering Committee in 1990 saw the need to halt any further GIS installations until many of the organizational and project management concerns could be rectified. Thereafter, a number of projects have been completed to resolve some of the technical and organizational constraints affecting the implementation.

To address some of the concerns regarding data management the GIS Steering Committee oversaw the development of an electronic data distribution system that can send digital data files to any District office in the province. In addition, the inventory data format standards have been kept static to eliminate the problems associated with continual changes to data formats. Most recently, a major initiative called the Inventory District Update Project began in late 1993. This project will see the complete decentralization of the update process for all Ministry forest cover maps. The completion of this project, scheduled for 1997, will allow every District office to complete inventory update functions in-house, thus allowing for the creation of more up-to-date and accurate inventory data than provided by a centralized update process. Finally, the Ministry is currently restructuring the inventory database to a fully relational format which should allow for better management and utilization of the database than is possible using the current flat ASCII file format. A relational database differs from a simple, continuous binary flat file in that data are stored in two-dimensional data tables that can relate or link data together through the use of common data columns or fields (Pfaffenberger, 1990).

The Steering Committee has also encouraged the development of several easy to use data viewing and reporting software tools. These tools will allow Ministry staff to perform simple, non-topological data reporting and desktop mapping that meet many of the basic mapping and reporting requirements.

Despite the efforts of the Ministry to deal with some of the major issues impeding the progress of the GIS implementation, no attempts have been made to study the Ministry's actual needs and requirements for GIS. The question of how a GIS can enhance an organization's effectiveness can usually be answered by performing what is called a Functional Requirements Study (Keller, 1990; Clarke, 1991). The need to complete such a study has been identified repeatedly during the last several years. Indeed, it is now recommended as a standard practice before any organizational GIS implementation (Rains, 1987; Lachowski, 1988; Aronoff, 1989; Emery, 1990; Clarke, 1991; Keller, 1992). Despite the obvious utility of such an exercise, the Ministry of Forests has not completed a comprehensive GIS requirements study.

It remains unclear, therefore, what benefits the Ministry hopes to derive from GIS implementation. It still has not been specified which information items presently collected, or those to be collected in the future ought to be managed by this new information technology. It still has not been specified what information end-products this new information technology is to produce and how these information products are to assist in forest management planning and decision making. Until a thorough Functional Requirements Study (FRS) is completed, it is unlikely that the implementation of GIS technology will accrue many benefits for the Ministry.

5.2 Data Management Concerns

It has been well established in the GIS industry and well documented in the literature that the most expensive and often the most time-consuming and problematic component of a GIS implementation is the design and creation of a suitable geo-referenced database (Burrough, 1987; Aronoff, 1989). Establishing a GIS database, on average, may account for between 50 to 80 percent of total GIS implementation costs (Brown, 1986; Sety and Chang, 1987; Morse and Hovey, 1990). Given the large amount of time and money it takes to establish a GIS database, it is thought by many that the creation and organization of the database should be well in hand, if not completed, before the distribution of any GIS hardware and software (Green, 1987; Epstein, 1989; Aronoff, 1989).

The Inventory Branch within the Ministry of Forests has established a very large, digital forestry database since 1978 using Computer Assisted Mapping (CAM) technology. When the decision was made to implement GIS in 1985, the perception at the time was that the costly process of digital GIS database creation had been virtually completed given the existence of this digital CAM database. The perception was that the

Ministry of Forests was in a very advantageous position indeed. What the Ministry failed to recognize was the considerable disparity between a less complex digital, cartographic, geo-referenced information database sufficient for computer mapping and the need for a topologically clean (i.e., verifying the logical consistency between data elements, linework and that all polygons are closed), digital, geo-referenced database required by GIS. Since the Ministry's cartographic database is essentially a collection of Cartesian coordinate line strings with no inherent structure, it lacks some of the more sophisticated editing, quality control, retrieval and analytical functions, (such as line and node connectivity relationships used for network analysis) needed by a GIS. These more advanced spatial database functions are provided with a database built using the topological database model (Aronoff, 1989).

A problem regarding data management – initially overlooked by the Ministry of Forests – that has profoundly hindered any GIS implementation initiative, therefore, concerns data structure and data integrity. What was not realized was that the structure of the Ministry's digital forest database is not readily compatible with GIS software requirements.

This is true for a number of reasons. First, the initial design and structure of the geo-referenced inventory database was created to suit the requirements of mainframe computing platforms used in the 1970s. As a result the database design has become antiquated and difficult to use since the introduction of faster, more powerful computer hardware. The complete digital database is artificially split in two, with one part containing the cartographic information (map files) and the other containing the forest attribute information (data files), stored as a giant, flat ASCII file. This database is not suitable for efficient access by a GIS, where graphics are linked directly to the spatial attributes and associated attribute information is stored in a relational database format.

Second, the digital forest cover map files that the Ministry of Forests has been collecting since 1978 have been entered by computer mapping software in a non-topological format that is not directly compatible with GIS. As a result, the forest inventory data exists in a format that cannot support basic topological analysis procedures, such as simple map overlays, without considerable manipulation of the digital geo-referenced database.

In order to better understand the above, let us look at an instance of how unsuitable the current database structure is for making even a minor change to the attribute database. At present, making a very simple modification to the attribute database such as adding, deleting or changing one database field, means that all 7000 individual database files for each corresponding 1:20,000 B.C.G.S. map sheet file must be completely restructured and reprocessed. This task that could take six months to a year to complete and cost tens of thousands of dollars. Therefore, it is unrealistic that this database can support the sophisticated data edit and manipulation requirements of GIS. To correct simple database editing problems such as this, various ancillary database management software has had to be developed to convert the existing database to a usable format for a GIS. This ancillary software has proven to be very complicated and time consuming to use.

As already mentioned, the Ministry purchased and set up GIS stations in selected Regions and Districts between 1985 and 1990. However, a major constraint that faced initial attempts by Regions and Districts to successfully implement GIS was the lack of clean, current, digital data. While it was known that the Ministry of Forest's Inventory Branch held a huge digital resource inventory database, no efforts were made to supply the pilot sites with data sets or map files. In hindsight this is understandable, since the Inventory Branch did not support data in the right format for use with a GIS. However, these issues were not understood by the parties concerned. Consequently, the GIS pilot installations, in many cases, proved to be a frustrating reminder of the lack of comprehensive planning associated with the GIS initiative and the problems of communication between the various administrative hierarchies in the Ministry.

A consulting study in 1989 clearly spelled out that the Ministry had failed to get their inventory database files ready to use with GIS pilot sites (Andersen Consulting, 1989). Given that this problem was only realized part way through the implementation, very little could be done to correct the situation immediately. It took further time to recognize and confront the fact that the past data storage and retrieval processes used in the Ministry of Forests were as antiquated as the database design itself, thus making the compilation and delivery of even the most basic data requests a lengthy procedure.

Despite this, the Inventory Branch did try to deliver data requested by the pilot sites. However as identified by the Anderson Consulting report, the Inventory Branch lacked the staff to cope with the large volume of data requested, leading to unacceptable turnaround times. An incoming request for data could take several months or more to be processed and delivered (Andersen Consulting, 1989).

Even worse, once delivered, the pilot sites would find the data to be of little use since it frequently did not conform to a known standard. This was because the Inventory Branch's data standards changed frequently between 1985 and 1990, making it very difficult to maintain a single standard for all to use. As a consequence, a considerable amount of additional time and contracting dollars had to go into cleaning and converting data to a known standard.

A more serious problem was the fact that many of the digital data and map files made available, especially those for the northern regions of the province, were not kept current. This caused a great deal of concern with Region and District staff, who, after they spent significant resources of time and money to clean up the data, discovered that the data could be out of date anywhere from two to ten years, or longer. Therefore, in many instances the data supplied were not useful for any legitimate forest planning exercises.

The data issues identified above only surfaced as serious management problems after the decision had been made to implement GIS and after pilot GIS sites had been initiated. It would appear, therefore, that the Ministry of Forests did not fully appreciate or comprehend the data requirements of GIS, and that the Ministry did not foresee what impact implementing and using a GIS would have on their existing digital database and database-management procedures.

Since 1990, the Ministry has tried to overcome many of the GIS related data management problems that surfaced between 1985 and 1990. Significant changes in data management procedures have taken place, with more changes to come over the next several years. First, a fixed standard has been identified and strictly adhered to for all forest inventory updates since early 1991. Second, an on-line electronic data catalogue has been developed that allows any Forest Service office to down-load any number of map and data files relatively quickly and easily, eliminating the need to order data files from headquarters branches. Currently, the Ministry is investigating a complete restructuring of the entire forest-cover digital database to a relational database format, as well as conducting a topological clean-process of all cartographic data, thereby bringing its digital data inventory up to GIS standards.

One of the lessons learned from the GIS pilots was that the two GIS software packages selected by the Ministry of Forests were too complicated and time-consuming for use in creating user-defined database queries and colour-themed maps. This, in conjunction with the fact that the majority of the District offices were still waiting for a GIS and in the meantime required some type of simple data analysis tool, led the Ministry to develop some basic database reporting tools that allow for the creation of ad hoc database queries accompanied with corresponding colour-thematic maps.

Finally, the Ministry of Forests is investigating changes that would see the entire forest inventory update process decentralized to District offices, allowing for maintenance of a more accurate, continuous update cycle at the local District office.

5.3 Human Resource Issues

The Ministry of Forests has faced significant reductions of staff over the last decade. These reductions have resulted from the provincial government's privatization plans to decrease expenditures and reduce the number of government employees, as well as periodic budgetary restraint measures. In 1980 the Ministry of Forests had over 5,500 employees. By 1990 this number had been reduced to 3,900 (Ministry of Forests Annual Reports, 1979 and 1989). The Ministry has had to meet the ever-increasing challenges and controversies surrounding forest management in B.C. with reduced staff and funding. Problems relating to lack of staff are most prominent in Regional and, especially, District forest offices. It is at these offices that the bulk of the work done by the forest service is carried out. Indeed, in many District offices, various Ministry programs such as Planning, Inventory, and Scaling, as well as the completion of silvicultural audits and monitoring activities, have been constrained due to a lack of adequate staff in the last several years.

With the use of GIS it was hoped that many aspects of forest management and planning would be enhanced and expanded without requiring subsequent increases in staffing. Yet soon after the Ministry's GIS implementation initiative got under way it was realized that additional staff were needed to fill new positions for GIS operators, and that the Ministry lacked professional or forestry staff with GIS experience (Andersen Consulting, 1989). It came as an afterthought to the GIS implementation decision that existing staff would require extensive training and repositioning, and that additional staff would need to be hired if tangible benefits were to be achieved with GIS.

At the time of the District GIS implementation, most District offices had no appropriate staff to fill the GIS operator position. Most offices assumed that this role could be filled by the often solitary and overworked manual drafting position.

Even if full-time GIS operators could be found, a second problem was encountered; namely, that virtually all of the existing professional foresters working for the Ministry of Forests, as well as most of the graduating foresters had little or no GIS experience. Consequently, there was a severe shortage of professional foresters with adequate GIS experience. However, it is these professional foresters that are expected to determine how to use GIS to enhance forest management practices. Other researchers have commented on the shortage of professional staff with GIS education and experience, a situation that remains a significant hindrance to GIS implementation in resource management and planning (Congalton, 1986; Chorley, 1988; Gorden and Soubra, 1992). The above problem has been attributed to the fact that many professional programmes, such as forestry and planning, have only offered courses in GIS in the last several years (Contant and Forkenbrock, 1986; Goodchild and Kemp, 1992). In short, the professional curriculum developers and educational institutions have generally been slow to respond to the need for GIS education.

Other human resource concerns that have had a substantial impact on GIS implementation are job classification, wages and career paths. Management within government has been concerned that after much time and money is spent on providing GIS training, staff members will leave the Ministry to work at higher-paying jobs in the private sector. Sullivan and Miller (1991) have stated that it is very likely that GIS trained staff will continue to leave the Ministry of Forests for other employment opportunities if the following issues remain unresolved:

1. new skills are not quickly incorporated into existing job duties;
2. there is no career path to follow once new skills have been acquired;
3. salaries are not commensurate with newly expanded knowledge, skills and abilities; and
4. management, professional and supervisory staff do not recognize or respond positively to this improved work force.

A challenge that faces the Ministry of Forests in its efforts to implement GIS, therefore, is that of establishing career paths, relevant job classifications and attractive wages that will help retain educated and trained GIS staff who are in high demand, as well as attract new GIS operators from outside the Ministry.

Formal recognition of human resource challenges facing GIS implementation came several years after the initiative had begun, and only after the pilot sites expressed the need for more staff. In late 1990 the Ministry hired a management consulting firm to investigate and document the possible solutions to these personnel issues. This study was completed in the spring of 1991 (Peat, Marwick, Stevenson and Kellogg, 1991). The main recommendations of this study were that the ministry needed to: (1) define organizational roles for the Ministry to manage, operate and support GIS; (2) write job descriptions and recommend new job classifications; (3) produce a staff development plan to help introduce GIS technology into the organization; and (4) develop an ongoing operational certified training program (Peat, Marwick, Stevenson and Kellogg, 1991).

This report was not favourably received by the Ministry as it was thought that the recommendations were too generic. Since this time virtually no work has progressed that deals with any of the human resources needs associated with the implementation.

5.4 Education and Training

One of the most important aspects of any successful GIS implementation is providing comprehensive GIS education to existing management and staff (Chock, 1990; Sullivan and Miller, 1991; Keller, 1992; Maher, 1992). There is a basic, yet profound, reason for this. Without adequate education and training, staff will be unable to understand and use GIS technology to its fullest potential to meet organizational goals. The role of education in GIS is to inform staff of what tasks or processes GIS can perform and the importance of these tasks. Hence, GIS education and follow-up training should enable staff to use this new technology to perform anticipated tasks properly and effectively. Given the amount of organizational change that a GIS can cause, it is also important to address GIS education and training issues at all levels within an administration; from senior executives, to middle management and administrative support, and to system operators (Wilke, 1990; Karten, 1990; Goodbrand, 1991; Antenucci, 1991; Maher, 1992). Despite the obvious advantage of staff with a solid understanding of GIS, the provision of a comprehensive education program is frequently the most neglected and poorly planned aspect of a GIS implementation initiative (Sullivan and Miller, 1991). This becomes evident from the following discussion.

First, the costs of educating and training staff are often not accounted for when preparing GIS installation budgets, and the risks and costs associated with inadequately educated and trained staff are seldom assessed. Second, there exists a prevalent management attitude that education and training programs are too costly and time-consuming, or conversely, not important enough to deserve much time and attention.

Despite failure to explicitly address training and education cost components in preliminary budgets, the Ministry of Forests estimated in 1991 that total training costs for the Ministry's GIS implementation had risen to almost three million dollars, virtually the same amount that had been spent to purchase GIS hardware and software for the Ministry (Sullivan and Miller, 1991). Other case studies have reported that training costs can be twice that of hardware and software acquisition (Sandquist, 1990). Management, therefore, should give GIS training and education the same profile and attention as other components of a GIS implementation.

The Ministry of Forests has been very slow in developing an education and training strategy when considering GIS implementation. This was due in part to a prevalent attitude of management in the latter half of the 1980s; namely, that developing and delivering training was less important than hardware and software acquisition. As a result, there was no provision for a formal training plan in the first three years of the GIS implementation. The attitude towards GIS education and training was to ship the hardware and software to the pilot sites, and to let the end users read the accompanying user manuals and figure it out for themselves (Sullivan and Miller, 1991).

Not surprisingly, this lack of adequate training created a great deal of frustration on the part of those staff whose job it was to work with GIS. It took much longer for staff to gain sufficient knowledge and skills to operate the GIS to a level where tangible benefits could begin to be realized. As a result, many Regional and District management teams, as well as professional staff, began to question the utility of GIS technology in the Ministry.

Management's attitude towards GIS education and training can be explained by the fact that the perception was that GIS is like any other software package, such as a word processor or spreadsheet. It was assumed that with nominal training and support GIS could be quickly and easily integrated into the daily working environment. The literature shows this to be far from true (Aronoff, 1989; Dick, 1990; Sullivan and Miller, 1991; Keller, 1992). Management failed to appreciate that GIS implied a fundamentally new way of viewing information and corporate data management, and that GIS software excels in failing to be "user-friendly."

A GIS can significantly change the way an organization handles its information management, change the rate and flow of information, or can even make requirements for new information (Somers, 1990; Keller, 1990). This implies that management ought to be educated in how to best manage the impact of this technology on the organization as a whole, as well as on end-users who will need training to carry out new or changed tasks. As a result, a well-thought-out education and training plan becomes vital to any successful implementation of GIS. Thus the education of senior and middle management should be one of the first priorities of any thorough GIS education and training plan. Such education can provide management with the knowledge to make more informed decisions regarding the many issues that surround the implementation of a corporate GIS (Goodbrand, 1991).

A comprehensive education and training plan for all levels of staff within the Ministry of Forests was developed in 1989. The plan was not implemented, however, until the middle of 1990. The development of this plan did not take place until after it was apparent that training was becoming an important issue in and of itself, and a specific Ministry-wide GIS training committee was formed to develop and deliver an annual training plan. The efforts of this training committee have met with relative success; the bulk of the education and training requirements for the Ministry has been achieved, including an educational seminar for senior executives and the current Minister.

5.5 GIS Support Infrastructure

GIS are computationally intensive and require access to the latest in hardware and software technology. GIS thus cannot be implemented without a substantial level of technical support to handle trouble shooting, supply an information hot-line, solve hardware problems and administer to software failures. It is unrealistic to assume that any one individual can handle all the above tasks, while carrying on the responsibilities of running day-to-day jobs on the GIS to meet a corporation's mandate. What GIS requires, therefore, is an adequate technical user-support infrastructure (Aronoff, 1989).

To adequately handle the GIS needs of a corporation as large as the Ministry of Forests, a support team must provide a wide range of services, including: supplying GIS users with prepared data sets; solving hardware and software problems; developing customized applications software; assisting with specific training needs; providing GIS project management strategies; and occasionally completing special GIS projects.

The Ministry of Forests has neither developed nor implemented a formal strategy for providing a user support infrastructure for GIS. All forms of support services to date have come about as a result of reactive, ad hoc measures, and not from a proactive support strategy. In the absence of any formal mechanism for providing end-user support, many Regional and District offices have experienced substantial constraints and delays in their ability to use GIS for their business needs. As a result, some Ministry staff have developed doubts concerning the utility of this technology simply because it is difficult to obtain adequate user support.

5.6 Software Constraints

The GIS industry is relatively new, with considerable variation in software products on the market. A great deal has been written about the capabilities of various GIS products and about the various benchmarking processes available when determining what GIS software should be purchased (Munro, 1983; Goodchild and Rizzo, 1986; Joffe, 1987; Aronoff, 1989; Pearce, 1990; Keller, 1990; Clarke, 1991). Despite the abundance of information available and the large number of consulting firms that specialize in GIS implementation, the Ministry of Forests decided to proceed with its software selection process without outside professional assistance. This action by the Ministry may have resulted in an inadequate GIS software selection process. As noted earlier, the Ministry went through a process of selecting two local British Columbia software suppliers to meet their GIS needs. The selection of two products appears to have come about, in part, because the Ministry was unable to decide what type of specific applications GIS would be used for, and as a result chose two software packages, as neither package could provide the full range of features that the Ministry thought they might require. The decision to choose two GIS software products developed and sold locally may also have been politically motivated.

Selecting two software packages means that data must be made available to suit the different format requirements of the two products (i.e., the two GIS products are not data format compatible), and that Ministry staff must learn to operate two packages. It is not surprising that this situation has led to a lot of confusion. Virtually no information or guidance was given to the pilot sites regarding which applications or tasks were most suited to this new technology, or which software package to use for what purposes. Pilot sites that had both GIS software packages were left on their own to determine the particular strengths and weaknesses of each software package, and what tasks each might perform best. This process wasted a considerable amount of time and money and resulted in a great deal of frustration.

It has frequently been suggested, both inside and outside the Ministry, that the Ministry should re-evaluate its GIS software needs, given the problems posed by the use of two different GIS software packages. Ironically, the two vendors have since merged under a larger corporation that continues to sell the two incompatible products.

5.7 The Need for a GIS User Survey

GIS has the potential to do much more than simply enhance an organization's information management processes. This information technology can fundamentally change the way in which an organization conducts its business and, accordingly, how people perform their jobs (Aangeenbrug, 1991; Somers, 1991; Keller, 1992).

GIS would be quite a challenge to implement if only technical and data management issues had to be addressed; indeed, the challenges of managing technology and data appear to occupy the bulk of all efforts that go into GIS implementation (Epstein, 1989; Keller, 1990; Sullivan and Miller, 1991). The fact that this approach ignores the sociological and organizational aspects (i.e., people issues) is one of the main reasons that so many difficulties and failures have been encountered in GIS implementation (Somers, 1990; Sullivan and Miller, 1991; Keller, 1992). The organizational impacts, or more precisely, the lack of appreciation and understanding of how to effectively manage the sociological and organizational changes resulting from modifications to corporate information management process, have plagued the Ministry of Forests efforts to implement GIS.

When implementing a technology that can greatly affect people in an organization, it is important to know how best to manage the resulting social and organizational change (Smircich, 1983; Laudon and Laudon, 1988; Aangeenbrug, 1991; Sankar, 1991). For that reason, one must examine the sociological and organizational aspects associated with GIS implementation in the Ministry of Forests.

In order to gain the required information and insight into what impacts GIS implementation might have on an organization, it should prove worthwhile to conduct a survey of the attitudes and perceptions of those individuals affected by the impending technological and organizational change (Smircich, 1983). By analyzing the attitudes and perceptions that GIS users in the Ministry have towards GIS, one may be able to better determine existing and future impacts of this technology on the Ministry's organizational culture (Sankar, 1990; Noori, 1991). Correspondingly, understanding the organizational change that GIS brings about means that such change could be managed more effectively.

The Ministry realized the need to conduct a study of the perceptions and attitudes of Ministry staff towards GIS. In 1991, such a study was completed by the author as an employee of the Ministry. The following chapters analyze the results of this attitudinal study. By analyzing the results of this research, it is hoped that insight and information will be gained that will assist in the formulation of recommendations, as to how the Ministry of Forests can help make its implementation of GIS less problematic.

5.8 Summary

This chapter has examined the various impediments that may be encountered and mistakes that may be made when implementing a large corporate GIS. The various impediments and problems have been examined in relation to the Ministry of Forests efforts to establish GIS. It has been argued that the Ministry paid little attention to tangible implementation goals, thorough project planning, information end-products needs, data-management issues, training and education needs, support needs and appropriate software benchmarking. More important from the perspective of this study, it has been demonstrated that the Ministry proceeded while giving insufficient thought to potential sociological and organizational impacts. The chapter concluded with a call for a survey of the Ministry GIS users to address the sociological and organizational hurdles of GIS implementation. Such a study is discussed in the following chapters.

CHAPTER SIX

GIS USER SURVEY METHODOLOGY

6.0 Introduction

This chapter introduces a GIS user survey that was conducted with employees of the Ministry of Forests. The objectives of the survey were to elicit information regarding employees' attitudes, perceptions, and motives as related to information management, mapping needs and GIS. Employees targeted by the survey were those who are or will be using GIS, as well as those who may be affected by it.

Elicitation and analyses of attitudes and perceptions of present and potential GIS users in the Ministry are expected to help determine the potential impacts of this information technology on the functions and mandates of the Ministry of Forests as perceived by these persons. Such analysis should help to identify those factors that inhibit or enhance the chances for successful GIS implementation. The argument is that perception and attitude research can provide valuable information as to the type and extent of structural change an organization is experiencing (Sankar, 1990; Noori, 1991).

6.1 The Research Study Proposal

In order to facilitate this survey, the researcher approached the Ministry of Forests with a proposal to conduct a study soliciting the reactions of selected Ministry of Forests staff to GIS technology, in anticipation that the data collected would allow management to better control GIS implementation. The study was proposed to the

Ministry in 1990. The proposal was approved for support and funding subject to the following criteria.

The survey was to be conducted as an integral component of a Ministry of Forests research project called the "Inventory Business Requirements Study." It was suggested that the survey be conducted to meet the needs of the Ministry, as well as the requirements for the author's graduate research. The survey, therefore, was specifically designed to meet the data requirements of both studies. As a result, some of the questions in the survey do not have direct bearing on the research discussed here and, therefore, will not be included in the analysis of the responses in the chapter to follow. It should be noted that the questions that made up this survey served a dual purpose for both studies. The interviews and questionnaires had to be administered by the author in the winter and spring of 1990-91 in order to comply with Ministry's requirements.

From the perspective of the graduate research requirements, a great deal of time and money was saved by combining the two data collection efforts. The only funding necessary to support the research was that required for travel to a number of the Regions and Districts, and for mailing and processing survey responses. A second advantage to completing a GIS perception and attitude survey approved and funded by the Ministry and conducted by one of its own employees is that people usually not easily reached during work or outside the work environment of the Ministry of Forests could be interviewed during regular working hours as part of their jobs, resulting in a very high survey response rate.

A possible disadvantage to the above method of survey can also be noted. The researcher was from within the organization itself. Those responding to the survey may thus have responded in a politically-motivated manner. However, this may not necessarily be a disadvantage as this is the very type of information and response that the survey aimed to elicit. This survey was undertaken by the author in 1991.

6.2 Survey Design, Sample and Response Rate

Two survey methods have been employed for data collection. Both semi-structured personal interviews and a mail questionnaire were used. The use of two interview techniques for one study is known to lower research costs and to improve data quality (Moser and Kalton, 1971; Dixon and Leach, 1980).

In the case of this survey a mail questionnaire was administered to approximately 40 percent of the total survey population in an effort to decrease costs and travel time during the data collection period. The majority of the respondents were interviewed in person, thus allowing for more in-depth data collection to take place.

The population interviewed consisted of various staff at all six Regional Forest Offices and all forty-three District Forest offices (i.e., ninety-seven respondents), making up a combined total of 159 persons out of a total survey population of 178 persons. Nineteen people from the total survey population were unavailable to take part in this survey. The following staff were surveyed to provide a representative cross section of Regional and District operations staff:

- Regional and District Forest Office Managers;

- Forestry Operations Managers;
- Planning/Inventory Resource Officers;
- GIS/Drafting Supervisors and Technicians.

The above staff were chosen as they had been identified by the Ministry as the key personnel involved with GIS implementation and use. In an effort to provide a measure of anonymity of the questionnaire respondents, as well as to encourage more candid responses, the questionnaire and interview forms were identified only with the use of a unique registration number.

For the purposes of this research, three slightly different questionnaires were used on three population sub-groups: namely, Regional and District office management, professional foresters, and technical staff. It was anticipated that the three groups might have differing attitudes and perceptions regarding GIS technology due to their job positions and subsequent experience with GIS. As a consequence, it was felt appropriate to ask all three sub-populations some questions relevant specifically to their position and experience.

There were twenty-two questions that remained the same on all three surveys. In the end, the questionnaire for the management group consisted of twenty-nine questions and the questionnaire for the foresters and the technical staff contained forty and thirty-seven questions each respectively. The forty question survey has been included as Appendix 1.

A pilot questionnaire was used on a representative sub-group of the study population to ensure that questions in the survey would be both relevant to the study population and to the objectives of the study itself. Specifically, an attempt was made to solicit the following information:

- individuals' perceptions of impacts and benefits of GIS implementation;
- unique or prominent forest management issues that could benefit from GIS use;
- individuals' perceptions of impediments to implementation of GIS;
- organizational impediments to GIS implementation; and
- individual staff expectations, attitudes, perceptions, and motives towards GIS.

The interview/questionnaire survey form was divided into three sections. The first section contains introductory or "opener" type questions to help ease the respondent into completing the questionnaire (Backstrom and Hursh-Cesar, 1981). Also found in this section are questions that relate to the function of various aspects of the forest inventory and planning programs in Regional and District forest offices.

The second section deals with perceptions and attitudes that respondents have towards GIS technology. Questions in this section also inquire as to the impact of GIS on daily operations.

The third section is comprised of questions regarding the structure and utility of the Ministry's forest inventory database in relation to operational needs and use with GIS. A point form description and explanation of each question is provided in

Appendix 2. These descriptions are divided into the three sections as found in the interview/questionnaire form.

Figure 3 shows a breakdown of the survey samples and the response rates. A total of seventy-six mail questionnaires were administered with a response rate of 82 percent. The questionnaires were sent to twenty-five of the forty-three District Forest Offices. In each of these offices a questionnaire was sent to the District Manager, the Planning/Inventory Forester, and the GIS/Drafting Technician. In total, ninety-seven structured personal interviews were conducted in all six Regional and eighteen District forest offices. In all, thirty-two Regional staff and 127 District staff were surveyed yielding a sample of 159 persons, with a combined response rate from the questionnaire and the personal interviews of 89 percent (see Figure 3).

The same questions were used for personal interviews and the mail questionnaire. However, it became obvious throughout the survey process that more detailed responses were being collected in the personal interview sessions. The following chapter discusses the survey results.

Figure 3 - Summary of Survey Responses

1) Questionnaire Responses					
Total number of questionnaires			76		
Total number of responses			62		
Questionnaire response rate			82%		
Questionnaire Breakdown	**# Sent**	**# Returned**	**% Returned**	**# Not Returned**	**% Not Returned**
Population Group					
- District Managers	25	18	72%	7	28%
- Foresters	26	22	85%	4	15%
- GIS/Drafting Technicians	25	22	88%	3	12%
2) Interview Responses					
Total number of interviews			97		
Interview Breakdown			# of Interviews		
Population Group					
- Regional Manager			4		
- District Managers			18		
- Operations Managers			12		
- Planning/Inventory Foresters			34		
- GIS/Drafting Technicians			29		
Total			97		
3) Combined Responses					
- Total number of Regional staff			32		
- Total number of District staff			127		
- Combined total of staff			159		
- Total number of possible survey population			178		
- Overall survey response rate			89%		

CHAPTER SEVEN

ANALYSIS AND INTERPRETATION OF SURVEY RESULTS

7.0 Introduction

This chapter summarizes and analyzes responses collected from the GIS user survey introduced in the previous chapter. This chapter reports frequencies of closed questions and content analysis summaries of open-ended questions, as well as providing some interpretation of the findings.

7.1 Methodology

Descriptive statistics and content analysis have been employed as the method of analysis for the closed and open questions in this survey respectively. Application of descriptive univariate statistics was most appropriate for closed questions given that the majority of these questions provided nominal responses and, therefore, were not suitable for more rigorous statistical analyses. However, an attempt has been made to use a non-parametric statistical test to study the significance of the correlation between the response between the three sub-population groups. The Spearman's rank order correlation coefficient test in combination with the Student's *t* test was used to analyze the results of question 1 from the survey to determine if there existed a significant correlation.

Content analysis on open-ended questions was conducted by first compiling all responses to any one open-ended question. The next step was to read all responses to a given question a number of times, in the process identifying common answers and concerns. This step led to the generation of a preliminary list of classified response categories. The next step involved coding all responses using the initial list of categories compiled. On a number of occasions, the list had to be revised one or more times before a satisfactory grouping of responses was achieved. For ease of reading and interpretation, replies to the open-ended questions commented upon in this chapter are highlighted using the *italic* style.

As already noted in Chapter Six, the survey population has been divided into three groups for analysis purposes. The first group, comprising of management staff, includes Regional and District forest office managers and their operations managers. The second group consisted of professional foresters, and the third group was made up of technical staff (i.e., drafting personnel and/or GIS operators). The three groups are analyzed separately since each is suspected of having different perspectives, roles, and responsibilities in regards to GIS implementation and use. However, summary statistics combining all three groups also are compiled and reported. For ease of presentation, all aggregated survey responses have been summarized in a tabular format. A brief written analysis is provided for each question.

As has already been noted, this survey was designed to provide information for a research study for the Ministry of Forests as well as for this graduate research. Some of the questions were included to satisfy the requirements of the Ministry. These questions have little relevance to this study. As a result not all the questions making up the survey will be compiled and analyzed for the purpose of this thesis. Notably, questions four to eleven, twenty-three to twenty-four, as well as questions twenty-seven and thirty-one have been omitted from this analysis.

7.2 Survey Results

7.2.1 Section One: Forest Management Issues and the Inventory Program

It was argued earlier that GIS is a tool that can be used very effectively in the resource management process (Burrough, 1988; Aronoff, 1989; Keller, 1993). By knowing the nature and extent of the resource management issues facing the Ministry one ought to be able to determine the relative information management needs of the Ministry, and begin to identify the specific functional requirements of GIS that might yield new or improved information end-products. Questions One to Three thus ask respondents to describe and rank the forest management issues prominent in their respective Regional or District office and to evaluate how well they feel these issues are being handled by the Ministry. Table 7.2.1.1 summarizes responses to Question One.

It would appear that there exists general agreement between the three population groups as to the ranking of the relative importance of forest management issues throughout the province. *Integrated resource management* issues came out as the number one issue for all three groups, with *resource use conflicts, forest inventory, public relations, timber management* and *silviculture* issues taking up the middle. *Native land claims, reforestation, pest and fire management* and *recreation and range* concerns occupied the lower end of the ranking scale.

Table 7.2.1.1

In your opinion what are the most pressing forestry management issues facing your office?

Management	Foresters	Technical
Ranking:		
1. Integrated Resource Management	1. Integrated Resource Management	1. Integrated Resource Management
2. Resource Use Conflicts	2. Resource Use Conflicts	2. Timber Management
3. Public Relations and Timber Management	3. Forest Inventory	3. Forest Inventory
4. Forest Inventory	4. Fish/Wildlife	4. Reforestation
5. Fish/Wildlife	5. Timber Management	5. Resource Use Conflict
6. Native Land Claims and Silviculture	6. Public Relations	6. Silviculture
7. Reforestation	7. Native Land Claims	7. Public Relations
8. Pest Management	8. Reforestation	8. Fire Management
9. Fire Management	9. Silviculture	9. Fish/Wildlife
10. Recreation	10. Fire Management	10. Pest Management
11. Range	11. Pest Management	11. Native Land Claims
12. No answer (n/a)	12. Recreation	12. Range
13. n/a	13. Range	13. n/a

The statistical analysis performed on this question indicates that there is a significant level of correlation between the three population sub-groups. The results of the Spearman's rank order correlation coefficient and the Student's t test show a r_s = 0.91 between the management group and the foresters, a r_s = 0.69 between the management group and technical group, and a r_s = .70 between the foresters and the technicians. All three of these correlations are significant at the alpha = 0.05 level.

The small differences between the study groups could be attributed to the different perspectives of management staff, foresters and technical staff due to their job position and function. To demonstrate, management staff ranked *public relations* and *native land claims* issues higher than both the foresters and technical staff.

Question Two asks the respondents to describe the prominent or unique forest management issues that exist within the jurisdiction of their Regional or District office. This question was intended to act as a follow-up to Question One, and also to identify any issues that might not be listed in the choices given in the first question. Overall, responses given here confirm those given in Question One. *Integrated resource management (IRM)*, *resource-conflict issues* and *increasing public concern* and *involvement* are listed by each group as the dominating forest management issues in the province. The importance of the need to *enhance the current forest inventory database for improved accuracy, timeliness* and *more site-specific resolution for local resource-use planning* comes out strongly in the second group of issues. In addition, the need to *move the inventory database towards a relational format* was stressed for increased utility for end-users (see Table 7.2.1.2).

Table 7.2.1.2

Describe any prominent or unique forest management issues in your Region or District.

Management	Foresters	Technical
Ranking: 1. IRM, RUC, Public Involvement	IRM, RUC, Public Involvement	IRM, RUC, Public Involvement, Slow Data Transfer
2. Inadequate Forest Inventory, Native Land Claims, Old Growth Preservation, Timber Supply	Inadequate Planning Systems, Poor Data Management, Inadequate Forest Inventory, Lack GIS	Inadequate Forest Inventory, Timber Supply, Poor Data Management Fish/Wildlife, Recreation
3. Landscape Aesthetics, Forest Monitoring, Recreation, Non-Timber Inventories	Forest Monitoring, Native Land Claims, Old Growth Preservation	Lack GIS, Inadequate Forest Inventory

Key:

IRM = Integrated Resource Management
RUC = Resource Use Conflict

Issues identified in responses to question two that were not identified in question one were: *the need to change and improve current forest planning systems, old growth and wilderness preservation, the lack of adequate human and budgetary resources to carry out the Ministry's mandate, the need for improved inventory data management and distribution*, and *the need for GIS technology to deal with the many pressing issues currently facing forest management* in British Columbia. Of interest is that issues of *data management and GIS* were predominantly mentioned by technical staff and foresters, less so by management. This could be explained by the fact that many foresters and technical staff deal with GIS and data management issues as part of their daily work. Management staff have much less direct involvement with such detailed, technical issues as these. Question Three asks the respondents to what degree they feel that their Regional or District offices are handling the unique or prominent forest-management issues that confront them. The largest number of respondents (38 percent) stated that they felt that they were handling only some of the issues facing them. Another 25 percent felt they were handling most of the issues. Only 6 percent reported that they were handling all the issues, while 8 percent stated that they were handling only a few (see Table 7.2.1.3).

Of interest to note is the higher than average '*no response*' replies for management. This may be a consequence of the fact that management is more reluctant to admit that they are not meeting expectations.

It would appear that *integrated resource-management, management of an up-to-date forest-inventory, timber-management* and *solutions to resource-use conflict* dominate

Table 7.2.1.3

To what degree do you feel that your office is meeting or handling these unique or prominent issues?

	All		Most		Some		Few		None		Don't Know		No Response		Total Responses	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Management	3	2	11	7	19	22	0	0	1	0.5	0	0	18	11	52	100
Foresters	4	3	14	9	30	19	8	5	0	0	0	0	0	0	56	100
Technical	3	2	15	9	11	7	4	3	1	0.5	5	3	12	8	51	100
Total	10	6	40	25	60	38	12	8	2	1	5	3	30	19	159	100

the Ministry's daily business. It would also appear, that there are serious concerns with respect to *current data-management practises* and that *lack of GIS* has been recognized as a key issue. Finally, it would seem that the majority of respondents are struggling to meet job expectations; they appear unable to meet their own expectations of what should be done on a daily basis to meet business mandates and goals.

The fourth question of the survey asks how a number of typical forest management reporting functions are performed by Ministry staff at present. This question was only posed to foresters and technical staff, given that management would be end-users of these information products and would not be directly involved in their creation. The question specifically asks how the respondents complete forest inventory area/volume reports and colour-thematic maps.

An area/volume report usually consists of a query or set of queries of the forest inventory database for a specific set of inventory attributes. An example of such a query would be a table that displays the area in square kilometres and the timber volume measured in cubic metres, giving a breakdown by tree species for a defined planning area.

An example of a colour-thematic forestry management map would be a map displaying the above mentioned database query showing the various tree species in different colours to depict the areal distribution of the species throughout the area of interest.

Table 7.2.1.4 summarises results for Question Four. With respect to area/volume reporting, the largest number of respondents state that they use Statistical Analysis

Table 7.2.1.4

Outline how inventory projects such as area/volume reports or summaries and colour coded maps are currently performed in your office?

	a) Area/Volume Reports						b) Colour Coded Maps					
Done by:	Foresters		Technical		**Total**		Foresters		Technical		**Total**	
	#	%	#	%	#	%	#	%	#	%	#	%
SAS	18	32	8	16	**26**	**24**	n/a	0	n/a	0	**0**	**0**
DBMS	30	54	3	6	**6**	**6**	n/a	0	n/a	0	**0**	**0**
GIS	7	13	7	14	**14**	**13**	7	16	7	14	**14**	**13**
By hand	2	4	0	0	**2**	**2**	8	14	11	22	**19**	**18**
Branch	18	32	7	14	**25**	**23**	4	7	5	10	**9**	**8**
Region	5	9	3	6	**8**	**7**	10	18	5	10	**15**	**14**
Contractors	2	4	3	6	**5**	**5**	13	23	7	14	**20**	**19**
Don't know	0	0	8	16	**8**	**7**	1	2	5	10	**6**	**6**
No response	1	2	12	24	**13**	**12**	12	21	12	23	**24**	**22**
Total Responses	56	100	51	100	**107**	**100**	56	100	51	100	**107**	**100**

Key:

SAS = Statistical Analysis Software
DBMS = Database Management Software (e.g. dBASE 3+, FoxPro)

Software (24 percent). Only 14 percent replied that they use a GIS. A large percentage (i.e., 35 percent) replied that they had somebody else (Inventory Branch staff, Regional staff or contractors) perform the necessary reports for them, not commenting in any more detail on the actual preparation process. It is interesting to note that 7 percent of the respondents did not know how this information product was generated. This suggests that a portion of Ministry staff who work directly in the Forest Inventory Program do not know how to complete standard inventory reports such as simple area/volume report, and that relevant training should be provided to rectify this situation.

Colour-coded or themed maps appear to be produced either manually or by GIS (18 and 13 percent respectively). A total of 41 percent of respondents noted that somebody else prepared the information products for them, not specifying any more detail about the actual production process. Again, 6 percent did not know how these information products were generated. It should be noted that the number of responses for the use of an in-house GIS for colour map production is limited to the current number of District GIS pilot sites.

Question Five asked respondents how they complete various phases of the inventory update process. Responses to this question were divided into three sections as shown in Table 7.2.1.5.

The first section covers the preparation of the forest-cover attribute data lists and history source materials. The forest-cover attribute data lists comprise the records of actual inventory timber cruises. Here, data are collected in the field about attributes such

Table 7.2.1.5

How do you currently complete these phases of Inventory Update?

	Foresters		Technical		Total	
	#	%	#	%	#	%
a) Preparation of attribute lists and history source materials						
In-House	27	48	22	43	49	46
Contract-Out	1	2	2	4	3	3
Both	20	36	13	25	33	31
No Response	8	14	14	27	22	20
Total Responses	56	100	51	100	107	100
b) Forest-cover map graphics preparation						
In-House	27	48	23	45	50	47
Contract-Out	10	18	7	14	17	16
Both	11	20	7	14	18	17
No Response	8	14	14	27	22	20
Total Responses	56	100	51	100	107	100
c) Forest-cover map digitizing						
In-House	3	5	2	4	5	5
Contract-Out	40	71	30	59	70	65
Both	5	9	5	10	10	9
No Response	8	14	14	27	22	20
Total Responses	56	100	51	100	107	100

as tree age, height and diameter, percentage of crown closure and timber volume. History source materials comprise maps and records that contain information on areas where activities such as timber harvesting, forest fires, insect infestations and silvicultural activities have taken place in the forest during the interim two-year period before the official forest-cover map is updated.

Survey results state that 46 percent of the first phase of inventory update is completed using Ministry staff, while 3 percent of respondents have opted to contract out the entire work process. 31 percent use a combination of in-house staff and contractors to get this job done. It would appear, therefore, that the bulk of this phase of the inventory process is completed by Ministry staff, although contractors do play a significant role.

The second section of this question centres on forest-cover map preparation. The preparation of the forest-cover map deals with the work conducted to prepare the digital map files that are to be updated. This involves collecting all the history maps and records and the forest-cover attribute lists and checking them for completeness and accuracy.

The survey results indicate that the majority of forest-cover map preparation is completed by Ministry staff in-house (47 percent). Contracting out all the work was reported by 16 percent, while 17 percent use a combination of Ministry staff and contractors. Contractors, therefore, appear to play a more important role in this phase of the inventory process.

The third section focuses on forest-cover map digitizing. The map digitizing process entails the use of computer assisted mapping software to electronically redraw and edit linework that make up individual forest-cover polygons in order to accurately reflect changes that have occurred to the forest land base over a two-year update period.

Results from the survey denote that a large majority of respondents have opted to contract out their inventory update map digitizing tasks to private sector mapping companies (65 percent). Only 5 percent note that this work is done entirely in-house. Responses to the last section indicate that capabilities to digitize in-house do not exist in a large percentage of the Ministry's Regional and District offices. In hindsight, the survey should have included in this question whether the latter is by choice or due to staffing or budgetary constraints, a question that would have yielded additional insight.

7.2.2 Section Two: Impact of GIS on Regional and District Office Operations

This section of the survey sets out to solicit responses concerning the impact of GIS on Regional and District office operations. The first question in this section leads into the subject by asking what experience respondents have had with GIS.

Approximately two-thirds of the study population stated that they had some experience with GIS, while 21 percent recorded that they had no GIS experience at all. In order to determine the degree of familiarity with this technology, respondents' knowledge of GIS was ranked on an ordinal scale differentiating between low, medium and high experience (see Table 7.2.2.1). For someone to be placed in the high category implied two weeks or more of GIS training, six months or more experience as a GIS

Table 7.2.2.1

Have you had <u>any</u> experience with GIS?

	Management #	%	**Foresters** #	%	**Technical** #	%	**Total** #	%
Yes	25	48	48	86	29	57	102	64
High	0	0	13	27	11	38	24	24
Medium	3	12	12	25	8	28	23	23
Low	22	88	23	48	10	34	55	54
No	10	19	8	14	15	29	33	21
Don't Know	1	2	0	0	0	0	1	1
No Response	16	31	0	0	7	14	23	14
Total Responses	52	100	56	100	51	100	159	100

<u>Key to ratings for "yes" answers</u>:

High = 2 weeks or more GIS training. 6 months or more experience as GIS operator, and/or 1 year or more "hands on" GIS forest management project experience, and/or directly supervise GIS staff. Attendance at GIS conferences and GIS demonstrations, GIS readings.

Medium = 1 week or less GIS training. Less than 6 months experience as GIS operator, and/or less than 1 year experience using GIS for forest management projects, and/or supervise or work with GIS staff. Attendance at GIS conferences and GIS demonstrations.

Low = Attendance at a GIS conference and/or GIS demonstration.

operator and/or one year or more direct experience with GIS. A respondent would be placed in the low category if the full extent of their GIS experience was attendance at a GIS conference or vendor demonstration. All others were grouped in the middle category.

Of the 102 respondents that reported having any GIS experience, 24 percent could be classified in the high experience category, 23 percent in the medium category and 54 percent in the low category. It is of interest to examine the relative distribution of GIS experience among management, foresters and technical staff. Management appears to be the group least familiar with GIS. None of the management staff interviewed were rated highly familiar with this information technology. Foresters, more than any other group, claim familiarity with GIS (86 percent). However, it is the technical staff that has the highest percentage of GIS expertise, with 38 percent having a high level of familiarity with GIS technology.

The above findings suggest that management has had relatively little exposure to GIS, (i.e., 88 percent of management staff were rated as having a "low" level of experience with GIS) and that management has not dedicated time to exploring how this information technology might help access information and meet business mandates. Technical staff and foresters, on the other hand, appear to be much more aware of GIS technology. The higher level of experience that foresters and technical staff appear to have with GIS, compared to that of their management counterparts, can be explained by the fact that it is not part of managements' job function to have detailed technical knowledge and hands-on working experience with GIS. However, the result of management not having a good understanding of the technical capabilities and organizational impact of this technology could seriously impede the Ministry's implementation and use of GIS.

When asked what kind of impact GIS has had, or could have on the ability to manage the forest resource (Question Fourteen), 50 percent opted for an unqualified positive impact with another 39 percent noting a qualified positive impact (see Table 7.2.2.2). Only one respondent replied negative impact and 4 percent stated that they did not know. Many respondents gave examples of how GIS technology does or would allow them to more effectively do many of the tasks they presently complete manually or with other technology. They also commented on the fact that this information technology would allow them to perform new information-processing tasks or procedures that they were not able to do without GIS. There emerged a strong consensus in favour of the use of GIS to enhance forest management. Indeed, the general perception appears to be that GIS could play a fundamental role in transforming the Ministry. Numerous respondents stated that only with the use of GIS would the Ministry be able to complete tasks and conduct analyses needed to regain public and professional confidence in its ability to conduct its business in an age of ever-increasing public demands for higher levels of integrated-resource management.

The following are examples of concerns expressed by those that endorsed GIS with qualifying statements (39 percent). The most common concern raised was that of the *inadequacies of the forest inventory database*. Criticisms were made regarding

Table 7.2.2.2

What kind of impact has/would GIS had/have on your office's ability to manage the forest resources?

	Management		Foresters		Technical		Total	
	#	%	#	%	#	%	#	%
Positive Impact	25	48	25	45	29	57	79	50
Negative Impact	0	0	0	0	1	2	1	1
Positive but... (qualified + impact)	17	33	28	50	18	35	63	39
Don't know	3	6	1	2	2	4	6	4
No Response	7	13	2	4	1	2	10	6
Total Responses	52	100	56	100	51	100	159	100

the *lack of accuracy, precision and quality* of the database especially for *small-scale or watershed-level planning applications*. Comments were also made about the *length of time it took to update the inventory* data. Several respondents provided examples where it took over five years to complete an inventory update. Another common concern voiced, especially from the management group, was that the Ministry *lacks the organizational infrastructure* to go ahead with proper GIS implementation. Specifically, concerns were raised with respect to *lack of fully trained staff, inadequate user support services, insufficient budgetary commitment, the absence of a detailed implementation plan* and *lack of executive support and direction* to properly support the use of GIS.

Question Sixteen of the survey asks if GIS technology has assisted forest service staff in meeting the Ministry's mandates and duties more effectively and efficiently (see Table 7.2.2.3). The majority of respondents answered "yes" to this question (89 percent). However, as was true for the previous question, many of those who answered "yes" qualified their answers (41 percent).

Different reasons were given as to why GIS could help the forest service meet its mandates more effectively. Again, consensus appears to be that without the use of GIS technology, it will become *increasingly difficult to conduct integrated-resource management to the extent and quality demanded by the public*. Numerous respondents thought it worthwhile to comment that the Ministry is *losing credibility with both the forest industry and the public because it is lacking the data integration and analysis capabilities* that GIS technology could provide. A number of respondents noted that the

Table 7.2.2.3

Would/Has a GIS assist/ed your office in meeting its mandates and duties more effectively and efficiently?

	Management		Foresters		Technical		Total	
	#	%	#	%	#	%	#	%
Yes	19	37	33	59	23	45	75	47
Yes but... (qualified Yes answer)	28	54	19	34	18	35	65	41
No	2	4	4	7	2	4	8	5
Don't Know	3	5	1	2	6	12	10	6
No Response	0	0	0	0	2	4	2	1
Total Responses	52	100	56	100	51	100	159	100

ability of GIS *to analyze various resource-management scenarios* or *to answer "what if" questions, to integrate non-timber resource data*, and *the capability to perform continuous inventory update* will greatly benefit the Ministry in meeting its goal to more effectively manage the forest resource.

Respondents who answered this question with a qualified "yes" gave the following reasons for doing so: they note that *the Ministry executive lacks true leadership, interest and direction in regards to the use of GIS technology* in the Ministry. They cite *lack of funding, poor management planning, lack of technical support, lack of proper training and poor spatial-data management* as examples of the Ministry's lack of direction for GIS implementation. Several respondents stated that the Ministry *does not have a clear idea as to how GIS technology would fit into the forest-planning process* and that *if the current non-area based planning methodologies or procedures do not change to area-based methods this technology cannot be used effectively*. Many indicated that, early on, *GIS technology was greatly oversold to the ministry, only then to be poorly implemented over the next several years*, all of which has *lead to a great deal of frustration on the part of Regional and District staff.*

The next question in the survey inquires as to whether GIS could assist or had assisted in conducting inventory updates and reinventory procedures more effectively. A total of 62 percent of the respondents answered "yes", with 20 percent responding positively with a qualifying statement (see Table 7.2.2.4). Those who answered with an unqualified "yes" cite numerous reasons for their endorsement. Most comment on the obvious advantage of GIS *to update digital inventory data. Continuous and faster*

Table 7.2.2.4

Would/Has a GIS help/ed you in conducting your Inventory Program (i.e. re-inventory and inventory updates) more effectively and efficiently?

	Management		Foresters		Technical		Total	
	#	%	#	%	#	%	#	%
Yes	13	25	33	59	21	41	67	42
Yes but... (qualified Yes answer)	14	27	8	14	10	20	32	20
No	4	8	11	20	5	10	20	13
Don't Know	8	16	2	4	8	16	18	11
No Response	12	24	2	4	7	14	21	13
Total Responses	52	100	56	100	51	100	159	100

inventory update, better data reporting and *data integration capabilities* are listed as other reasons why GIS can enhance the forest inventory process.

13 percent answered "no" to this question. Most of the reasons given here have already been noted earlier. They were: *a lack of accurate inventory data*; *chronic data distribution problems*, *data resolution problems for small-scale planning*; and the *lack of trained staff*; *inadequate user support services* and *confusion produced by using two GIS software platforms*.

Next, respondents were asked to comment on how they had used or would use GIS technology. The two main responses were for *forestry planning and analysis* (70 percent) and for *forest inventory update mapping* (48 percent). Table 7.2.2.5 reports on the more specific tasks as mentioned by respondents. In regards to planning and analysis applications the most frequently mentioned use of GIS was for *the production of forest inventory database reports and colour-coded maps*. The next most common uses were for *the creation of local resource-use plans*, *digital terrain models*, *the production of timber supply plans* and *network or road analysis*. Others reported using GIS for *computer-assisted mapping*.

The next three questions focus on the issues surrounding the provision of end-user support for Ministry staff using GIS. The first question provides the respondent with a choice of various options for providing end-user system support by asking them to identify the best overall method for providing such support from a list of options. The option that gained the most support was *a centralized Ministry support centre that would deliver support to all Ministry GIS users* (see Table 7.2.2.6). This option was favoured

Table 7.2.2.5

How have/would you use/used a GIS at your disposal?

	Management		**Foresters**		**Technical**		**Total**	
	#	%	#	%	#	%	#	%
Planning and Analysis	30	58	50	89	31	61	111	70
			(out of 50)		(out of 31)			
Inventory Reports and Colour-Themed Maps	0	0	19	38	18	58	37	23
Digital Terrain Models, 3D views	0	0	6	12	8	26	14	9
Local Resource-Use Plans (small scale)	0	0	10	20	6	19	16	10
Timber Supply Area Plans (large scale)	0	0	2	4	2	6	4	3
Network (Road) Analysis	0	0	2	4	4	13	6	4
Inventory Update	14	27	36	64	27	54	77	48
Computer Assisted Mapping	0	0	8	14	8	16	16	10
Don't Know	0	0	0	0	3	6	3	2
No Response	8	15	6	9	6	12	20	13
Total Responses	52	100	56	100	51	100	159	100

Table 7.2.2.6

What would be the best option for providing support for GIS?

	Management		**Foresters**		**Technical**		**Total**	
	#	%	#	%	#	%	#	%
Ministry Single Point of Contact Help Desk	0	0	28	50	23	45	51	32
Branch or Region Help Desk	12	4	18	32	13	25	33	21
GIS Vendor Help Desk	0	0	6	11	4	8	10	6
Other	0	0	2	4	1	2	3	2
Don't Know	0	0	0	0	3	6	3	2
No Response	50	96	2	4	7	14	59	37
Total Responses	52	100	56	100	51	100	159	100

by 32 percent of the respondents. After this the option of having *individual headquarters Branch or Regional support centres* was chosen by 21 percent of the respondents. The last option of having *help desks established by the GIS vendors* was favoured by only 6 percent of this group. Of interest here is that management does not appear to favour the *centralized Ministry support centre* option.

When asking respondents to rate the quality of support they now receive from both the Ministry and from vendors of GIS, the majority of the responses were split between "good" and "fair" (12 and 13 percent respectively). Only 3 percent rated the quality of support provided as "excellent." Table 7.2.2.7 suggests that there is quite a divergence of opinion with regard to this question. Of interest here is the high percentage of response rate by management to this question relative to the previous question, and the fact that management appears to rate support poorer than foresters and technical staff, with technical staff the group with the largest divergence of opinion.

The next question asks respondents to comment whether the level of support provided for GIS needs to improve (see Table 7.2.2.8). 67 percent of the respondents answered "yes" to this question, while only 8 percent answered "no".

The majority of the open-ended comments from respondents stated that support for GIS could be improved by: (1) providing *basic computer skills and better GIS training and documentation*; (2) *reducing the length of time it takes to get data files from the Inventory Branch*; (3) *improving Inventory data quality control*; (4) *providing more support visits to District offices by Branch and Regional GIS staff*; and (5) *better overall*

Table 7.2.2.7

How would you describe the support that now exists for GIS?

	Excellent		Very Good		Good		Fair		Poor		No Opinion		No Response		Total Responses	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Management	0	0	1	2	3	6	14	27	9	17	4	8	21	40	52	100
Foresters	1	2	5	9	13	23	3	5	2	4	3	5	29	46	56	100
Technical	3	6	5	10	3	6	4	8	2	4	4	8	30	69	51	100
Total	4	3	11	7	19	12	21	13	13	8	11	7	80	50	159	100

Table 7.2.2.8

Does the GIS support you now receive need to improve?

	Management		**Foresters**		**Technical**		**Total**	
	#	%	#	%	#	%	#	%
Yes	38	73	48	86	21	41	107	67
No	3	6	3	5	7	14	13	8
Don't Know	1	2	3	5	13	25	17	11
No Response	10	19	2	4	10	20	22	14
Total Responses	52	100	56	100	51	100	159	100

communication and coordination from the Branches regarding GIS implementation and use.

Question Twenty-five asks respondents to describe any needs and requirements in regards to producing inventory database reports and maps for routine operations and special projects. The results for this question are reported in Table 7.2.2.9. For analysis purposes, the wide-ranging responses to this question were divided into three groups: (1) training concerns; (2) human and technical resources issues; and (3) management issues.

Most responses concern training issues. 35 percent of the respondents stated that they *needed GIS training*. Such a high figure is attributable to the fact that the majority of the survey population *do not currently have GIS technology at their disposal*. Another 33 percent said that they *required training to use database management software to complete customized database reports and queries*. 15 percent *required training on using and understanding the forest inventory database*. The remaining responses were divided between *basic forest inventory training*, *computer training* and *training using Statistical Analysis Software*.

The second group of responses deals with human and technical resources. 30 percent of the respondents stated that they *lacked GIS hardware and software*. The next most common requirements listed were the *need for more staff* and the *provision of easy-to-use inventory reporting software* at 14 percent each. After this came requirements for *colour plotting hardware for use with a GIS*, a *wider range of inventory reports supplied by the Inventory Branch*, and more GIS related *"how to" reference*

Table 7.2.2.9

Describe your needs and requirements, if any, in regards to producing database reports and maps for routine inventory operations and special projects.

	Foresters		Technical		Total	
	#	%	#	%	#	%
a) **Training** - Database Management Software Training	18	32	17	33	35	33
- GIS Training	16	29	21	41	37	35
- Inventory Database Training	12	21	4	8	16	15
- Basic Computer Training	7	13	1	2	8	7
- Basic Inventory Training	7	13	0	0	7	7
- Statistical Analysis Software (SAS) Training	5	9	0	0	5	5
b) **Resources** - More Staff	10	18	5	10	15	14
- GIS Hardware and Software	18	32	14	27	32	30
- Canned Reporting Software	11	20	3	6	14	13
- Colour Plotter	0	0	11	22	11	10
- Better GIS Manuals	0	0	4	8	4	4
- GIS Project Management Handbook/Cookbook	1	2	4	8	5	5
- Branch Canned Reports	8	14	0	0	8	7
c) **Management and Coordination** - Improved Inventory Data Management and Distribution	9	16	14	27	23	21
- Improved Planning for GIS Implementation	8	14	5	10	13	12

documentation and user manuals. The inadequacy or lack of certain technical resources can directly impact the human resources of an organization. Without the proper technology and tools to do the job it becomes very difficult or impossible to complete certain tasks, resulting in possible staff frustration and job dissatisfaction. This situation was evidenced by the results of the survey when respondents stated that they lacked GIS hardware and software to complete required forest-management analysis projects, and colour plotters to produce colour-themed maps for public meetings.

Management issues made up the last group of responses for this question. 21 percent of the respondents reported that the *management and distribution of inventory data needs to be greatly improved*. The main concerns reported here centre on the *antiquated methods of database management employed by the Inventory Branch*, the *lack of adequate data quality control* and the lack of *more timely methods of data distribution*. Another issue raised was the *lack of comprehensive project planning and management of the Ministry's GIS implementation initiative*. 12 percent of the respondents stated that there needs to be *more coordination and long-term planning to make the implementation of GIS more successful*.

Question Twenty-six asks the respondents to list the most common information and data requests that they receive. Results are tabulated in Table 7.2.2.10. The most common information request is for *forest inventory area/volume reports* (74 percent). The two next most common requests reported were *colour-thematic and GIS overlay maps*, and *standard Ministry of Forests forest-cover maps* (67 and 56 percent respectively). The three next highest percentages reported were for *Ministry*

Table 7.2.2.10

Describe the most common requests for information and data that you receive from Ministry staff, other ministries and the private sector?

	Foresters		Technical		Total	
	#	%	#	%	#	%
Forest-Cover Maps	22	39	38	75	60	56
Recreation Maps	5	9	13	25	18	17
Logging Road Maps	0	0	15	29	15	14
Topographic Maps, TRIM Maps	2	4	9	18	11	10
Colour-Themed Maps, GIS Mapping and Overlays	38	68	34	67	72	67
GIS Digital Terrain Models	4	7	8	16	12	11
Inventory Area/Volume Reports	50	89	29	57	79	74
Inventory Attribute Files	3	5	2	4	5	5
Inventory Branch Summary Reports	12	21	0	0	12	11
Timber Supply Area Reports and Files	4	7	0	0	4	4
Air Photos and Satellite Imagery	0	0	12	24	12	11
Growth and Yield Data	4	7	0	0	4	4
No Response	6	11	13	25	19	18

of Forests recreation maps (17 percent), *logging road maps* (14 percent), *digital terrain models, forest inventory summary reports* and *air photos and satellite imagery* (11 percent each), and *topographic and Terrain Resource Information Mapping (TRIM)* maps (10 percent). The important point to note from the results of this question is that the majority of the respondents (67 percent) are requested to regularly provide colour-themed maps, GIS maps and map overlays. Since these types of mapping products can only be produced from a GIS, this is further evidence of the Ministry's need for this technology.

The next question asks if respondents are able to meet all the data requests directed to their office. The results for this question are reported in Table 7.2.2.11. 22 percent state that they are able to satisfy all information requests directed to them. However, there appears to be a difference of opinion between the foresters and technicians. Only 11 percent of the foresters answered "yes" to this question, compared to 33 percent of the technicians. A total of 53 percent of the respondents reported that they could not satisfy all the information requests directed to them. The most frequent reasons given as to why they are not able to meet these requests are that they *did not have the data or information readily available* and that they *required a GIS to create the information products required* of them. As well, respondents commented that there were *problems with the Ministry's data distribution*, and that *it takes too long to get digital inventory data from the Inventory Branch*. Respondents reported that *when the data are made available to a Region of District office it is already out of date and/or lacking adequate quality control*. Also mentioned is the *lack of staff and financial resources to meet the*

Table 7.2.2.11

Are you able to meet all the information and data requests that are directed to your office?

	Foresters		Technical		Total	
	#	%	#	%	#	%
PART A						
Yes	6	11	17	33	23	22
No	38	68	19	37	57	53
Don't Know	1	2	7	14	8	7
No Response	11	20	8	16	19	18
Total Responses	56	100	51	100	107	100
PART B - Major Reasons Cited for Inability to Meet Information Requests						
Data distribution problems	9	16	8	16	17	16
Do not have the data needed	19	34	4	8	23	21
Data is in wrong format	5	9	2	4	7	7
Data is not current enough	9	16	7	14	16	15
Data is not accurate enough	3	5	8	16	11	10
Data is not site-specific enough	4	7	0	0	4	4
Inventory lacks non timber values	1	2	1	2	2	2
Lack money and staff	11	20	3	6	14	13
Too many requests, lack enough time	15	27	1	2	16	15
Need a GIS	15	27	6	12	21	20

the increasing numbers of requests for data, especially from the public.

Questions Twenty-nine and Thirty focus on the need for developing graphical user interfaces and software programs to make the use of complicated GIS software easier and, thereby, to decrease the amount of training required in order to use a GIS. When asked if the creation of such programs would be beneficial, 73 percent of the respondents stated "yes", while only 2 percent replied with a "no" (see Table 7.2.2.12). There appears to be a considerable level of interest in this option.

When asked what type of applications and tasks should be simplified or automated by the use of specific GIS application programs, 76 percent selected *colour-thematic map production* and 74 percent chose *forest inventory area/volume report generation* (see Table 7.2.2.13). The remaining responses all dealt with *batch processing of common GIS functions such as digital terrain model creation* (13 percent), *map overlays* (9 percent), *map merging* (7 percent) and *conversion of digital ASCII forest inventory data into files useable by GIS* (7 percent).

7.2.3 Section Three: Forest Inventory Database Requirements

The last section of the survey focuses on data management issues that surround the Ministry's implementation and use of GIS technology. There are nine questions included in this section. These nine questions seek to solicit responses from the interviewees concerning the utility, accuracy, currency, resolution, and data management procedures of the forest inventory database for use with GIS technology and current forest-resource

Table 7.2.2.12

If you have/had a GIS do you think that the development and use of user interfaces or simplified, special "canned" application programs would benefit the use of GIS in your office?

	Foresters		Technical		Total	
	#	%	#	%	#	%
Yes	48	86	30	59	78	73
No	2	4	0	0	2	2
Don't Know	2	4	11	22	13	12
No Response	4	7	10	20	14	13
Total Responses	56	100	51	100	107	100

Table 7.2.2.13

If you have/had a GIS what type of applications and tasks would you like to see automated or simplified by the use of specific GIS applications programs?

	Foresters		Technical		Total	
	#	%	#	%	#	%
Colour-coded or themed map production	50	89	31	61	81	76
Inventory Area/Volume report generation	49	88	30	59	79	74
Batch processing of GIS functions						
GIS map overlays	8	14	2	4	10	9
Digital Terrain Models	10	18	4	8	14	13
Conversion of Inventory attribute file for GIS use	8	14	0	0	8	7
GIS Map Merging	5	9	3	6	8	7
No Response	6	11	8	16	14	13
Total Responses	56	100	51	100	107	100

management requirements. A decision was made to ask questions exclusively about the forest inventory database since it is this database that functions as the primary source of forestry data in the province. Other forestry databases exist. However, none of them play as important a role as the Ministry of Forests Inventory Database for use as baseline digital data for basic forest-management processes.

The first question in this section asks the respondents if the current forest inventory database meets their day to day requirements. The respondents were asked to respond to this question on a six class 'Likert Scale', ranging from "always" to "never." Results are shown in Table 7.2.3.1. Only 3 percent answered "always", while 25 percent answered "most of the time." The largest response group fell under the "some of the time" category (39 percent).

What are more illuminating are the reasons respondents provide as to why the database meets their needs only most or some of the time. The two most frequent reasons cited are *the amount of time it takes for inventory data to be processed and distributed at the Inventory Branch* (30 percent), and the fact that *when the data does arrive from the Inventory Branch it often is considerably out of date* (29 percent). The next most common reasons given are *lack of accuracy and quality control in the data received from the Inventory Branch*, and the fact that *the current forest inventory database contains an inadequate amount of information on non-timber resources such as data on soils, non-commercial tree species, fish and wildlife data, range, recreation and silvicultural information* (26 percent). Additional reasons given for the lack of utility of the inventory database was *the inadequate level of resolution of the data* and how

Table 7.2.3.1

Does the current Inventory Database meet your requirements for the tasks and projects you work on?

PART A	Always		Most of the time		Some of the time		Seldom		Never		Don't know		No response		Total response	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Management	0	0	10	19	20	38	6	12	1	2	0	0	15	29	52	100
Foresters	2	4	17	30	30	54	3	5	0	0	3	5	1	2	56	100
Technical	2	4	13	25	12	24	1	2	0	0	11	22	12	24	51	100
Total	4	3	40	25	62	39	10	6	1	1	14	9	28	18	159	100

PART B - Major Reasons Why Inventory Database Does Not Meet Business Requirements

	Management		Foresters		Technical		Total	
	#	%	#	%	#	%	#	%
Not site-specific enough	13	25	20	36	0	0	33	21
Not current enough	11	21	22	39	13	25	46	29
Not accurate enough	16	31	18	32	7	14	41	26
Cartographic quality control problems	5	10	12	21	12	24	29	18
Branch Data processing and distribution delays	14	27	17	30	17	33	48	30
Lacks non-timber data	16	31	24	43	1	2	41	26

inventory data could not be accurately used on a watershed-scale of planning (21 percent). The last major reason given was *the lack of adequate quality control for the digital forest-cover maps* (18 percent).

The following question asks the respondents if they think that the current structure and format of the forest inventory database needs to be changed (Table 7.2.3.2). The responses from this question were mixed, with 35 percent of the respondents reporting that *the database does need to change its structure and format* and 21 percent saying *it does not*. Of interest here is that 30 percent of the survey population answered that they did not know if the database structure needed to change, with the majority of those in this category coming from the technical sub-group of the survey population.

Numerous reasons were given by those who stated that the database structure needed to change. 22 percent state that *the database needs to incorporate non-timber resource data*. 13 percent reported that *the quality control of the inventory data needs to be improved to enhance the accuracy and utility of the data*. Some respondents stated that *the database needs to move to a relational database format* (11 percent), while others said that there needs to be *more Region and District staff input to the overall management of the database* (10 percent). Others made requests that *the time required to complete inventory map updates and forest reinventories be changed from their average time frame of two years for update and ten years for re-inventory, to a continuous update process* (8 percent). Requests were made also for the *creation of a corporate-wide database for all ministry staff to use*, to *change the database to*

Table 7.2.3.2

Do you think that the structure and format of the Inventory Database needs to be changed?

	Foresters		Technical		Total	
	#	%	#	%	#	%
PART A						
Yes	26	46	11	22	37	35
No	13	23	10	20	23	21
Don't Know	13	23	19	37	32	30
No Response	4	7	11	22	15	14
Total Response	56	100	51	100	107	100
PART B - Major Reasons Why Inventory Database Needs to be Changed						
Need to add other non-timber resource data	22	39	2	4	24	22
Need more user input to database management	9	16	2	4	11	10
Need to move to a relational GIS database format	8	14	4	8	12	11
Reduce the time to complete updates and reinventories	3	5	6	12	9	8
Need better data quality control	5	9	9	18	14	13
Need more site-specific data	6	11	0	0	6	6
Need more accurate data	5	9	1	2	6	6
Need to create corporate-wide database	6	11	2	4	8	7

contain more site-specific data, and that *the accuracy of the inventory data be improved.*

Question Thirty-four of the survey asked the respondents if they have any concerns or questions regarding Inventory database standards for both the digital graphic map files and the inventory attribute files (Table 7.2.3.3). 33 percent reported "yes" to this question, while 26 percent answered "no", with 17 percent reporting that they did not know.

The most common reason given for answering "yes" was *a lack of adequate quality control that existed for the digital files*, implying that *a great deal of time is spent correcting errors in these files that should have been corrected by Inventory Branch staff* (16 percent). Other common causes for concern are *the lack of adequate support from headquarters staff in use of the inventory database*, *lack of accuracy of the inventory data*, *the need for the creation of standards for the inclusion of non-timber resource data*, and that *the data standards were too inflexible to meet Region and District operational needs*.

Table 7.2.3.4 displays the results from question thirty-five which asked the respondents if they currently integrate other resource information, such as wildlife, fisheries, soils, and geological data into the forest inventory database. The majority of the respondents (30 percent) stated that they already *incorporate other non-forestry data into the inventory database*. 15 percent stated that they never do, 12 percent reported that they do most of the time, 9 percent that they seldom do, while only 5 percent said that they integrate non-forestry data on a regular basis.

Table 7.2.3.3

Do you have any concerns or questions regarding the Inventory data standards (i.e. both forest cover map files and inventory attribute files)?

PART A	Management #	Management %	Foresters #	Foresters %	Technical #	Technical %	Total #	Total %
Yes	12	23	27	48	13	25	52	33
No	9	17	19	40	14	27	42	26
Don't Know	8	15	6	11	13	25	27	17
No Response	23	44	4	7	11	22	38	24
Total Responses	52	100	56	100	51	100	159	100
PART B - Major Concerns Regarding Inventory Data Standards								
Lack of adequate data quality control	7	13	12	21	6	12	25	16
Lack of accuracy	5	10	4	7	0	0	9	6
Data not site-specific enough	2	4	4	7	0	0	6	4
Improve Branch data support	3	6	5	9	4	8	12	8
Data standards change too often	4	8	3	5	1	2	8	5
Need standards to add non-forest resource data	2	4	6	11	2	4	10	6
Standards are too inflexible, do not meet needs	8	15	3	5	2	4	13	8

Table 7.2.3.4

Do you currently integrate other resource information/data into the Inventory database?

	Always		Most of the time		Some of the time		Seldom		Never		Don't know		No response		Total response	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Foresters	1	2	11	20	22	39	7	13	11	20	1	2	3	5	56	100
Technical	4	8	2	4	10	20	3	6	5	10	17	33	10	20	51	100
Total	5	5	13	12	32	30	10	9	16	15	18	17	13	12	107	100

The next question seeks to determine the frequency with which Ministry staff use satellite imagery and air-photos to complete forest inventory map updates (Table 7.2.3.5). 35 percent reported that they use satellite imagery some of the time, 17 percent stated that they use it most of the time. 9 percent of the survey population reported that they seldom use satellite imagery, 16 percent stated that they never use it, 3 percent said that they always use this type of data.

The purpose of questions Thirty-nine and Forty was to determine the need for forest service staff to have GIS technology available in order to give them the ability to easily integrate into the forest inventory database other types of geographic or spatial data that are not found in the inventory database, as is the case with fish and wildlife data or satellite imagery and TRIM data.

As mentioned earlier the inventory database is divided into two sections; one containing all the graphic information for the forest-cover map files, the other containing all the forest-cover attribute files. This method of split database management appears to cause considerable problems for anyone wishing to use the database files in a relational database management system or a GIS. Question Thirty-nine, therefore, asks the respondents if there is a need to improve the coordination or linkage between the two components of the forest inventory database structure (Table 7.2.3.6).

30 percent noted a need to improve the linkage between the two components of the inventory database. A large number of the respondents in this category stated that *the database should be transformed into a relational database management format to allow for much easier database manipulation and more powerful analysis and reporting*

Table 7.2.3.5

Do you currently use satellite imagery data to complete your Inventory updates?

	Always		Most of the time		Some of the time		Seldom		Never		Don't know		No response		Total response	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Foresters	1	2	11	20	22	39	7	13	10	18	1	2	4	7	56	100
Technical	2	4	7	14	15	29	3	6	7	14	6	12	11	22	51	100
Total	3	3	18	17	37	35	10	9	17	16	7	7	15	14	107	100

Table 7.2.3.6

Is there a need to improve the coordination or linkage between these two components of the Inventory Database?

	Foresters		Technical		Total	
	#	%	#	%	#	%
Yes	23	41	9	18	32	30
No	6	11	0	0	6	6
Don't Know	20	36	5	10	25	23
No Response	7	13	37	73	44	41
Total Responses	56	100	51	100	107	100

capabilities. 6 percent reported that the database should not change from its current format and structure. A large group (64 percent) selected not to respond to this question or said that they did not know how to answer. There are several possible reasons for this lack of response. It may well be that most of the survey population do not fully comprehend the details of how data are digitally encoded and managed in the Ministry. As well, the majority of respondents do not have access to GIS and, therefore, are not familiar with the current database encoding problems. Finally, it is possible that few respondents had the opportunity to use or manipulate the inventory database outside of the standard format in which they receive it from the Inventory Branch.

Over the last ten years, as the demand for smaller scale, site-specific planning has increased, the accuracy of the Inventory database has come into question. Question Forty asks respondents to rate the accuracy of the Inventory database for different levels of planning from large-scale Timber Supply Areas to small-scale development plans (i.e., timber harvesting plans).

The response for these question have been divided into two tables. Table 7.2.3.7a displays the combined results from all three survey population sub-groups, while Table 7.2.3.7b presents the results of each of the three population sub-groups by percentage.

By analyzing the results from Table 7.2.3.7a one can see that there is a higher level of confidence in the accuracy of the database for larger planning scales such as timber supply plans and regional plans. A trend can be seen in the summary of results for this question that clearly shows that as the scale of planning decreases, so do the quality ratings that respondents give for the accuracy of the database.

Table 7.2.3.7a

How would you describe the accuracy and resolution of the Inventory Database for use in the following?

PART 1 - Combined Responses for All Three Survey Population Sub-Groups

	Excellent		Very Good		Good		Fair		Poor		Very Poor		No Opinion		No Response		Total Responses	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Timber Supply Plans	0	0	13	8	43	27	30	19	9	6	5	3	34	21	25	16	159	100
Regional Plans	1	1	3	2	41	26	32	30	9	6	1	1	47	30	25	16	159	100
Local Resource-Use Plans	0	0	2	1	20	13	43	27	31	19	8	5	29	18	26	16	159	100
Watershed Plans	0	0	2	1	12	8	28	17	37	23	15	9	36	23	29	18	159	100
Development Plans	0	0	1	1	10	6	30	19	39	25	21	13	30	19	28	18	159	100
Totals	3		21		126		163		125		50		176		133		159	100

Table 7.2.3.7b

How would you describe the accuracy and resolution of the Inventory Database for use in the following?

PART 2 - **Total Percentage of Responses for All Three Survey Population Sub-Groups (i.e. Management, Foresters and Technical (M|F|T))**

	Excellent			Very Good			Good			Fair			Poor			Very Poor			No Opinion			No Response		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Timber Supply Plans	0	0	0	8	14	2	21	43	16	25	25	6	6	7	4	4	4	2	27	4	35	10	4	35
Regional Plans	2	0	0	2	4	0	19	45	12	29	23	8	2	11	4	2	0	0	33	14	43	12	4	33
Local Resource-Use Plans	0	0	0	2	0	2	8	18	12	29	45	6	27	21	10	4	9	2	19	4	33	12	4	25
Watershed Plans	0	0	0	2	0	2	6	13	4	17	27	8	25	36	8	13	11	4	25	11	33	12	4	41
Development Plans	0	0	0	2	0	0	10	5	4	13	30	12	27	39	6	15	18	6	21	4	33	12	4	39

For the timber supply planning category the highest number of the responses were placed in the "good" (27 percent) and "fair" (19 percent) rating. The responses for the regional plans were very similar to those for timber supply plans.

At the next lowest level of planning one can see the ratings decline. For local resource-use plans the highest number of responses is found in the "fair" and "poor" categories at 27 and 19 percent respectively. At the watershed level of planning the ratings decline even further with 23 percent rating the database as "poor" and 17 percent as "fair." The results for development planning scale are similar to those for watershed plans with 25 percent of respondents rating the database as "poor", 19 percent as "fair" and 13 percent as "very poor." Only one respondent from the entire survey population rated the accuracy of the Inventory database as excellent for use at the regional planning scale.

By examining Table 7.2.3.7b one can see how the three survey population sub-groups in the survey rated the accuracy of the Inventory database. A general trend that can be observed here is that the management sub-group tends to rate the accuracy of the database higher than the forestry group for use in smaller-scale planning. Conversely, the forestry sub-group rates the database accuracy higher than the management and technical groups for use in larger-scale planning, as well as generally rating the level of accuracy lower for use at smaller-scale planning. This can be attributed to the fact that the members of the forestry sub-group work directly with the database at all planning scales as part of their daily work, and therefore are much more familiar with the issue of database accuracy in forest planning.

The last question of the survey asks respondents if the accuracy of the Inventory database needs to be improved. The summary of the results of this question can be seen in Table 7.2.3.8. In each of the survey population sub-groups, the majority of respondents stated that the accuracy of the database does indeed need to improve. The largest majority of "yes" answers were seen in the foresters sub-group with 89 percent, followed by 63 percent for the management group, and 45 percent for the technical group.

There was also a sizeable percentage of respondents in the management and technical sub-groups that either did not respond to this question (twenty-nine and eighteen percent respectively) or answered that they "don't know" (2 percent and 31 percent respectively). This high percentage of "don't know" and no response answers can be explained in that both the management and technical groups have far less education and experience with the Inventory database than the professional foresters and, as a result, they appear to find it more difficult to answer this question in a meaningful way.

7.3 Interpretation of Survey Results

Chapter Three identified three key areas that prove to cause problems in most GIS implementation initiatives. These three key areas were: (1) inadequate project planning concerns; (2) data management issues; and (3) organizational and human resource issues. Results obtained from the survey indicated that these three areas were also a source of problems in the Ministry of Forests GIS implementation.

Table 7.2.3.8

Does the accuracy of the Inventory data need to be improved?

	Management		**Foresters**		**Technical**		**Total**	
PART 1	#	%	#	%	#	%	#	%
Yes	33	63	50	89	23	45	106	67
No	3	6	2	4	3	6	8	5
Don't Know	1	2	2	4	16	31	19	12
No Response	15	29	2	4	9	18	26	16
Total Responses	52	100	56	100	51	100	159	100
PART B - Major reasons why the Inventory database needs to be improved.								
Needs to be more site-specific	13	25	14	25	8	16	35	22
Need more field work, and sample plots	8	15	18	32	5	10	31	19
Need a link to silviculture data	3	6	5	9	0	0	8	5
Need to add other resource data	14	27	13	23	7	14	34	21
Need more frequent inventory updates and reinventories	7	13	8	14	4	8	19	12
Need to improve database management	7	13	5	9	0	0	12	8
Improve data quality	12	23	16	29	15	29	43	27

7.3.1 Inadequate Project Planning

The results of the GIS user survey provide numerous examples of how the Ministry's implementation efforts suffered from inadequate planning. Not a single response came forth in which a positive comment was made about the planning effort that went into this project. Numerous respondents commented that what little planning did go into the implementation initiative lacked proper focus, adequate resources and achievable objectives (see Table 7.2.3.9 in particular). Respondents felt that GIS technology was oversold to the Ministry with too much attention focused on the benefits GIS could bring, and not enough attention paid to the specific reasons why the Ministry required this technology and how it would be integrated into Ministry mandates and everyday business functions. Many respondents stated that the implementation lacked executive support, and that the project therefore suffered the neglect inherent in a lack of profile within the Ministry. This lack of profile, in turn, contributed to the inadequate planning effort for the project and to a lack of any long-term funding procurement for project completion. It would appear that the pilot phase of the project was ad hoc and was rushed ahead while limited funding was still available, well before the Ministry was ready for it to take place. Although, many respondents acknowledged that the implementation was not proceeding well, they also stressed that they required GIS technology immediately in order for them to become more effective in their work.

The Ministry did not have a formal budget or training plan for the first three years of this implementation, and the first detailed implementation strategy emerged several years after project initiation.

Only nominal attempts appear to have been made to investigate the organizational impact and change that GIS technology would have on the Ministry. Two consulting reports were commissioned that yielded little insight. It would appear that it was simply assumed that GIS technology was required by the Ministry and therefore it would be incorporated into the Ministry as easily, for example, as the installation of a new telephone system. Management did not fully comprehend the effect that this technology would have on the functional capabilities of the Ministry, staffing requirements and expectations, nor the tremendous impact on data management and use.

7.3.2 Data Management Issues

The survey results reveal that the Ministry introduced GIS technology without first substantially modifying its digital geographic database and accompanying procedures, policies and systems for managing these data. Scores of issues were raised by respondents that concerned the Ministry's management of resource data. This subject was by far the most prominent issue raised by the respondents in the survey. Concerns were expressed regarding the lack of accuracy, precision and quality of the data, especially for watershed scale planning applications (see Tables 7.2.3.1. to 7.2.3.8), and regarding the insufficiency of non-timber related resource information required for true multiple-resource planning. Respondents stated that it was very difficult to add new information to the existing database, and that it took an inordinate length of time to go through the process of updating the forest inventory data. A great number of complaints were also made about the length of time it took to transfer data from headquarters offices back to District offices after reinventory or updates were performed. Many respondents lamented the fact that the Ministry could not simplify overall database management by moving towards the creation of a single corporate database wherein all resource data would be managed in a relational format, thus making the data much easier to use with GIS technology.

It would appear that the Ministry of Forests was at one time in a very advantageous position with respect to GIS implementation, as it started an initiative almost twenty years ago that would see the conversion of all its analog attribute and cartographic data into a new digital format. However, this extensive digital database unfortunately was not in a format to be readily used by a GIS, since it was created in both a non-topological and non-relational format. Recognition of the need for topological data managed in a relational format has only recently been identified as a major GIS implementation issue to be resolved.

7.3.3 Organizational and Human Resources Issues

The most frequent comments from the survey regarding organizational and human resources issues focused on the problems caused by inadequate training, end-user support and staffing levels needed to continue with the implementation. Respondents stated unequivocally that without more training and better user support they would not be able to use GIS with any measure of real success. Several comments were made by respondents in the management sub-group regarding the fact that there was not a detailed plan to even guide the implementation in the first place (see earlier discussion of results found in Tables 7.2.2.2 to 7.2.2.4 and 7.2.1.6 to 7.2.1.9).

Many respondents came to the conclusion that using GIS technology would require more staff, not less as assumed by some of the implementation planners. In addition, there were a number of replies, particularly from the professional and technical sub-groups, that mentioned a very real need for the Ministry executive and regional and district management teams to become better educated in what exactly GIS technology is, why the Ministry needs it, and how to properly implement it.

Comments were also made about the lack of communication that existed between the various levels of management. Many respondents felt isolated and excluded from the implementation process and, therefore, did not fully understand what was taking place. Some respondents sharply criticized the implementation's failure to properly take into account the problems and issues faced by the very staff the technology was supposed to benefit. This common sentiment appears to have resulted in a several instances of open resistance to GIS implementation.

7.4 Summary

This chapter opened by discussing the methodology that was employed in analyzing the results from the GIS user survey used in this thesis. The remainder of the chapter reported on the frequencies and results of closed questions and content analysis summaries of open-ended questions.

In analyzing and summarizing the results of the survey, three main points become evident: (1) that the Ministry of Forests is directly involved in various complex integrated-resource management issues, many of which (respondents stated) could be managed more effectively by using GIS technology; (2) that Ministry operations staff feel that GIS is a required tool for enhancing current forest management; and (3) that there are numerous management, organizational, and data management issues and problems that must be clearly identified and resolved before the implementation of this technology will become effective.

CHAPTER EIGHT

RECOMMENDATIONS, SUMMARY AND CONCLUSION

8.0 Introduction

This chapter contains a series of recommendations on how to enhance the overall GIS implementation process in general, and specifically for the Ministry of Forests. These recommendations are based on the literature and research findings reported in the previous chapters, as well as on the history of the Ministry of Forests GIS implementation.

Despite numerous articles and conference proceedings that describe successful GIS implementation projects, it has become clear that there exist many problematic GIS implementation initiatives, including numerous projects that fail outright (Dick, 1990; Aangeenbrug, 1991; Sullivan and Miller, 1991; Peuquet and Bacastow, 1991; Keller, 1992). It is understandable that few have chosen to publish accounts of the implementation problems and failures. However, such descriptions would be useful for two reasons. First, they would provide an element of reality and truthfulness in a seemingly biased documentation of GIS implementation. Second, they would provide an excellent source of information for those wishing to implement GIS with a greater level of success, as there is usually much to be learned from others' mistakes.

The main purpose of this research has been to examine a case study of a GIS implementation project that has faltered over the last decade, and in particular to provide recommendations on how to improve the implementation process and to help fill this gap in the literature.

8.1 Recommendations

After reviewing the literature, the history of the Ministry of Forests GIS implementation initiative, and the results of the GIS user survey, it becomes obvious that the Ministry's GIS implementation efforts have not been successful to date. In an effort to improve the level of understanding of the GIS implementation process, a series of recommendations have been formulated to assist current and future implementation efforts. These recommendations are in two sections. The first section contains a set of general GIS implementation recommendations. The second set of recommendations provided here pertain solely to the case study.

8.1.1 General Recommendations on GIS Implementation

The recommendations proposed here have been placed in the approximate order in which they take place in a typical GIS implementation. Some of the tasks and processes that are recommended here last for only a short period during the implementation such as the tasks mentioned in recommendations two, three, five, six, eight and nine. Other tasks will need to be performed over the long-term or until the implementation project is complete, or on an continual basis such as those tasks mentioned in recommendations one, three, four and seven.

The following general recommendations are proposed:

1. **Develop a thorough understanding of exactly what the mandate of the organization is. This will help answer the question of why you want a GIS and what it will be used for.**

   Without an adequate understanding of what an organizations' mandate or business is, it is unlikely that implementation of GIS technology will be successful. To make the use of GIS cost effective and beneficial to an organization as a whole, it must be determined how and where in the organization the technology will be used. If the use of GIS is not directly related to the mandate of the organization it can be difficult over the long term to justify the need for GIS and to determine what benefits its use will bring.

2. **Develop a GIS education program for all relevant personnel, including executive management and project planning staff early on in the project.**

   Such an education program should provide the necessary information and knowledge to understand what a GIS is, how GIS implementation can impact an organization, and how to best manage the implementation and the resulting organizational change. This knowledge can be obtained early on in the implementation planning process, and thus hopefully reduce the number of problems and issues that may arise later on. In order for such an education program to be well received by the broad cross section of staff who would be involved, it is important to ensure that the information included here is not of a detailed technical nature.

3. **Take the time and effort to study the organizational culture to determine how the technology will be received, what the impacts of GIS implementation will be and how these impacts can be best managed.**

   In order for a new technology to be successfully implemented the organizational culture must be considered. The means by which new technology is implemented must be consistent with the organizational value system and mandate. If sufficient internal resources do not exist to study the organizational culture and make recommendations on how to manage the organizational change subsequent to GIS implementation, then hiring of a management consultant should be considered.

4. **Determine what end-products (e.g., maps and reports) will be required from the use of the GIS over the short and long term.**

   By identifying what geographic information end-products will be needed early on in the implementation planning process the answers to the important question of how the GIS will be used can be answered. Completing this task early on in the implementation can also help identify what existing tasks, procedures and policies may need to be modified or what new ones need to be created in order to deal with the new business processes and functions that can arise from using a GIS.

(An example of such a new business function would be the need for the creation of a policy to facilitate the possible sale of the new digital data, maps and reports created by a GIS.)

5. **Complete a Functional Requirements Study (FRS) based on end-user feedback before commencing a pilot implementation. This must include a thorough examination of existing and future GIS data functionality requirements.**

The completion of a Functional Requirements Study is a basic requirement of any large-scale implementation of GIS. By conducting a FRS most of the difficult questions and problems surrounding the introduction of technological change (i.e., GIS) can be identified and resolved before they become a significant threat to the success of the implementation. Particular attention should be placed on GIS data requirements and information end-product needs in completing a FRS.

6. **Identify GIS project champions that have a high level of interest, good project management skills and sufficient profile in the organization to assist in the implementation.**

The literature stresses the importance of finding GIS project champions that can keep the implementation project alive even when management loses interest, when problems arise, when funding is limited and when staff resist the implementation. Many times the success or failure of an implementation is determined by the existence of talented GIS project champions. It is also important to remember to provide meaningful rewards and recognition for the hard work provided by these individuals.

7. **Realize the importance of promptly and thoroughly managing the human resource issues related to GIS implementation and use. A system of periodic staff surveys should be established to ensure that the human resource issues are being satisfactorily dealt with.**

   There should be careful examination of the impact of GIS implementation on issues such as staffing levels, workload, training opportunities, job classifications, and career paths. Resistance to the implementation can occur if staff perceive that these issues are not handled properly. A specific mechanism to facilitate dialogue between staff and management concerning GIS implementation should be put in place.

8. **Conduct a thorough benchmark selection process with input from the Functional Requirements Study.**

   The benchmark selection process should at the very least consist of user-needs analysis to ensure that the correct GIS functionality and adequate software user-friendliness will be present. Sufficient time must be spent on devising the actual benchmark tests that competing GIS vendors will be evaluated on to ensure that all the required functionality is rigorously tested using "real" data under "live" testing conditions with input and review comments from GIS end-users.

9. **Use the GIS project champions to complete a pilot phase for the implementation to identify and resolve possible problems.**

Good GIS project champions should have the expertise, enthusiasm and management support to complete the pilot phase successfully. Such individuals should have the political power within the organization to obtain all the resources and finances to push the project through when problems arise or if funding becomes scarce.

8.1.2 Case Study Recommendations

The recommendations provided here are also listed in the approximate order in which they take place in a typical GIS implementation project. Recommendations one, two, four to seven and nine are all tasks that need to be completed in the short term until the implementation of GIS in the Ministry is complete. Recommendations three, eight and ten to twelve are tasks and processes that will need to be completed on a continual basis.

The following specific recommendations are proposed for the Ministry of Forests:

1. **That the Ministry of Forests continue with GIS implementation only after a thorough Functional Requirements Study is completed and a detailed corporate vision for how GIS will be used in the Ministry is developed.**

   Both the results from the survey and the current state of forest management in B.C. indicate that the Ministry must complete its implementation of GIS. Many of the survey respondents stressed that if the Ministry is to regain much needed public credibility it cannot afford to miss out on the improved spatial information management capabilities of a GIS to meet the growing demands for improved integrated-resource management. However, without first completing a Functional Requirements Study to determine why the Ministry requires GIS and how it should be used, the Ministry will continue to struggle with GIS implementation regardless, of how great its need for GIS may be.

2. **Provide more introductory "What is a GIS" education for all Ministry staff to increase knowledge level and interest in GIS.**

   After reviewing the progress of the Ministry's GIS implementation and reviewing the results of the survey reported in this thesis, it becomes evident that there still exists a lack of understanding regarding what a GIS is, and what it does. Due to the lack of success of the pilot implementation in 1989, there exists a significant level of scepticism regarding the Ministry's need for GIS. A factual presentation on GIS fundamentals, including a realistic appraisal of GIS capabilities, would be effective in raising the confidence and interest level in this technology.

3. **Create a new Ministry GIS committee structure. Make one of the members of the Ministry Executive the chair to increase profile and accountability of these committees.**

The current GIS committee structure has not worked well. The committees meet infrequently, and there is a lack of accountability in regards to getting projects completed on time. There currently exists more than twelve GIS related committees in the Ministry. Many of these committees have overlapping jurisdictions which makes the committee reporting structure confusing, as well as leading to much duplication of work.

4. **Dedicate at least three full-time staff members to work on implementation to get the project completed on time.**

Without dedicated staff working on the implementation it is unlikely that the large amounts of work required to develop and carry out a coordinated implementation plan will be completed in a timely manner. Without dedicated personnel set aside to work on GIS implementation, this initiative will continue to get side-tracked and delayed by existing staff who work on this project only when they find time left over from their regular duties.

5. Hire a GIS Implementation Consultant to provide information on how the Ministry can effectively manage the organizational change that is inherent in any GIS implementation.

The Ministry does not seem to adequately understand, nor appreciate the impact and the resulting organizational change GIS technology can bring about. This is evidenced by the lack of adequate planning that has gone into the implementation project to date. Little if any concern has been paid to effectively managing the organizational change associated with this GIS implementation. By hiring an outside GIS implementation consultant the Ministry could achieve two things. First, they could have this very important aspect of the implementation adequately dealt with, as there does not seem to be Ministry staff that are willing or able to deal with it. Second, the use of an outside consultant would help introduce some much needed objectivity to the implementation. An objective viewpoint may also help in identifying what aspects of the Ministry's organizational culture have either assisted or impeded the implementation and use of GIS. This could help in part in dealing with the problematic issue of headquarter Branches not fully understanding the needs of District offices due to the inherent decentralized structure of organization as large as the Ministry of Forests. In this case such a viewpoint may aid in recommending ways in which Branch offices could become more acquainted with the needs and requirements of District offices in regards to GIS, and in the process improve the Ministry implementation planning efforts.

6. **Allow for more staff involvement in the implementation process and improve the level of communication regarding the implementation to reduce the level of resistance and potentially strengthen the perceived need for GIS.**

The results from the survey indicate that many Ministry staff do not know why the Ministry is implementing GIS or how it should be used. The results also show that some respondents felt that they had little input into the implementation planning process even though the purpose of the implementation was to provide GIS to assist them in their work. The implementation would precede with less staff resistance and the technology could be adopted more easily in the daily-work environment of the Ministry if Region and District staff had more of a say in how GIS was to be implemented.

7. **Determine where in the Ministry GIS is required and for what purposes. Do not implement GIS in sites, or for tasks that it is not well suited for. Use Regional GIS support centres or GIS consultants to complete required work if appropriate.**

It may not be cost effective to implement GIS in every District office if adequate support and analytical services can be provided by Regional Offices, or by the GIS consulting community. This could decrease the amount of training and support infrastructure required and help make the Ministry's use of GIS more cost effective.

8. **Develop area-based forest planning methodologies that can take advantage of the spatial information management capabilities of a GIS. This would imply a move away from the current strata-based methods.**

Unless area-based planning methodologies are developed the Ministry will not be able to use GIS technology to its full potential in assisting in enhancing the forest management process. It is a matter of the Ministry revising and updating their planning methods to take advantage of the advanced spatial-information management capabilities of a GIS.

9. **Create a corporate topologically-correct database in a relational format that can easily incorporate new information.**

With a relational database designed on a topological data model, the Ministry would be able to update and revise the inventory database more quickly and easily than it can now, as well as provide more sophisticated spatial analysis capabilities. From an integrated-resource management perspective, this would allow for a much more useful and dynamic inventory database as the incorporation of new types of resource data is much simpler than at present.

10. **Establish more field work to ground check data to improve accuracy and precision, develop more exhaustive quality assurance procedures, and decrease the time it takes to complete forest-cover map update and re-inventories.**

The results from the survey strongly indicated that the majority of Ministry staff feel that current inventory data lacks proper quality assurance and is not accurate and precise enough to meet the Ministry's needs. Investigations need to be made as to how to reduce the time it takes to complete forest inventory update and reinventory processes, including the acceleration of the project to decentralize these tasks to Region and District offices.

11. **Investigate methods to provide more site-specific data for small-scale planning needs.**

The demands for more smaller-scale or watershed-level integrated-resource management plans are increasing overtime. Without the inclusion of more site-specific data in the Inventory Database the Ministry will not be able to adequately meet these needs as identified in the survey results.

12. **Re-evaluate the GIS training and support needs for the Ministry. The provision of both training and user support services need to be enhanced if Ministry is to make the use of GIS cost effective.**

Overall the use of GIS in the Ministry has not met with much success to date. Staff need to be trained on how to complete specific tasks/outputs, not just take generic GIS vendor training. User support needs can be reduced by the selection of more user-friendly GIS software, the further development of simplified GIS applications software and the provision of more relevant training.

8.2 Summary

The objective of this thesis has been to study the organizational impediments to the implementation of GIS. This research has focused on the GIS implementation initiative of the Ministry of Forests as a case study. The specific aim of this thesis has been to analyze a relevant case study in order to provide more insight into why GIS implementation is such a problematic process, and as well to provide a set of recommendations from which current and future implementation initiatives could benefit.

Chapter Two provided a literature review on the subject of the impact of technological change on organizations. Reviewed here were various ideas on how to manage organizational change and the resistance to change that the introduction of new technology can bring. It was noted in this chapter that management has traditionally neglected or ignored the importance of properly managing human resources and the resulting organizational change brought about by a GIS implementation. Chapter Three offered a description of what a GIS is, and why it is useful to resources management, with a special emphasis on the use of GIS in forest management. A key point discussed in this chapter was that performing detailed integrated-resource management without the use of GIS technology is no longer appropriate. The chapter concluded with a discussion on some of the more prominent problems associated with GIS implementation; namely, implementation project planning, organizational and human resource concerns, and spatial data management issues. The role, mandates and business functions of the B.C. Ministry of Forests were the subject of Chapter Four. Included in this chapter was a detailed chronological account of the Ministry's attempt to introduce GIS over the last nine years.

In this chapter we learned that the Ministry of Forests is struggling in its implementation of GIS. Chapter Five provided a critical analysis of the Ministry's implementation effort based on the chronology found in Chapter Four. This chapter provided justification for the need for a survey to help assess the impact and success of the GIS implementation. Chapter Five described in detail how the Ministry failed to establish any tangible goals for the implementation. Not enough attention was paid to; adequate project management, the identification of GIS information end-products, numerous spatial data management issues, training, education and end-user support needs, and proper benchmarking procedures prior to software selection. Chapter Six defined the methodology used in the development and delivery of the GIS user survey that was administered to Ministry GIS users for the purposes of this thesis. The following chapter provided a detailed description, analysis, and interpretation of the results of the survey. Further interpretation of the survey results indicated that Ministry's GIS implementation suffered from; (1) a lack of adequate implementation planning and project management, (2) an underestimation of the Ministry's spatial-data management needs in relation to its use of GIS and, (3) a disregard for the organizational and human resource issues associated with the implementation of GIS. Three main points were concluded from analyzing the survey results. The first point mentioned was that the Ministry is directly involved in numerous, complex, integrated-resource management issues that could be managed more effectively by using GIS. The second point discussed was that the majority of Region and District staff feel that GIS is a necessary tool for improving forest management in B.C. The last point identified was that there are many management, organizational and data management issues and problems that need to be identified and resolved before the use of GIS will become effective for the Ministry. Chapter Eight concluded the thesis by providing a set of recommendations on GIS implementation.

8.3 Conclusion

Studying the history of the Ministry's GIS implementation project and the results of the GIS user survey strongly suggests that the Ministry of Forests was not ready to introduce GIS when it did. This does not imply that the Ministry does not need GIS. On the contrary, it becomes clear from the research that the Ministry can benefit from the spatial information management capabilities of GIS technology. However, some nine years after the initial decision to use this technology the Ministry continues to struggle with the GIS implementation. The Ministry of Forests, like many other agencies (including the U.S. Forest Service and the Ontario Ministry of Natural Resources), appears to have rushed ahead with a decision to implement GIS without fully understanding or preparing for the organizational impact of such a decision. Little thought was given to the effect on data management procedures, human resources management, and overall business functions. Most of the Ministry's implementation planning effort appears to have gone into the selection and purchase of hardware and software, not into a full-fledged Functional Requirements Study to identify why a GIS might be needed.

Without a Functional Requirements Study to provide some direction regarding the use of GIS, Ministry staff have faltered in their attempts to adopt this technology. When the initial implementation plan came out in 1990, it still did not answer the fundamental question of why the Ministry was going to use GIS, and how it would go about doing this. There has been no attempt to define a vision for the use of GIS in the Ministry. There has also been a considerable amount of confusion as to what exactly the mandate of the Ministry of Forests is, beyond what is broadly defined in legislation. Lack of a clear mandate has complicated the process of developing a vision for GIS use.

It is not unusual for resistance to occur when implementing a new technology, especially when there is a lack of understanding of how the new technology will be used. In the case of the Ministry's implementation initiative a great deal of misunderstanding existed due to the absence of sufficient communication of the objectives of this project. From its inception all planning for the implementation was conducted by senior management in headquarters Branches. It was not until 1989 that a formal committee structure was established that included membership of a few Region and District office staff. Apart from sporadic attempts to circulate minutes from committee meetings, limited circulation of a few consulting reports, and an aborted attempt at a newsletter, there has not been a concerted effort to communicate the goals of this new technology implementation to Ministry GIS users.

Due to the lack of communication regarding the implementation project there exists a significant amount of confusion regarding the use of GIS and its implications for the Ministry. The pilot implementation has not met with much success. This has consolidated a belief among some Ministry staff that GIS use will not be beneficial, and as a result, some Ministry staff (particularly management staff) are reluctant to use GIS.

The problems identified by survey respondents about insufficient organizational infrastructure appears to have plagued the implementation from the very beginning. The first formal GIS training plan was not developed until three years after the initial implementation. To this date, the Ministry has not developed a thorough user support plan to deal with pressing issues such as who will provide user support and how. A strategy for the management of the Ministry's employees who are affected by the use of GIS has never been completed. Consequently, issues such as the creation of new GIS job classifications, reporting structures and career paths for GIS staff have not been addressed.

There appears not to have been a meaningful attempt made by the implementation planners to investigate, identify and manage the possible ways in which GIS technology will impact the Ministry. The emphasis of the implementation has been predominately on the selection of the GIS hardware and software and, of late, on the provision of simple reporting tools and minor data management improvements. Only in the last three years has any attention been paid to issues such as improving the quality of training and making much needed changes to the inventory database structure. However, these corrective efforts have met with only partial success as the Ministry is still enforcing its freeze on further GIS implementation. There still are numerous organizational change management issues that remain unresolved. It would appear that the Ministry still has not fully understood the importance of managing organizational culture in order to improve the success rate for introducing a major new information management technology like GIS.

The Ministry would benefit by completing some of the tasks that they overlooked in the first place. Most important of these tasks is the completion of a Functional Requirements Study that would allow the Ministry to form ideas about, and find answers to, key implementation issues that remain unresolved. A thorough Functional Requirements Study should help determine why a GIS is needed, what specific tasks the GIS will be used for, what impacts the GIS will have on the organization, and the kind and extent of resources required for implementation. Most importantly, a FRS would help identify what information end-products are desired from this technology, and in the process, answer the very important, yet often overlooked question, why implement GIS? While conducting a Functional Requirements Study is not argued to be a 'cure-all' for the Ministry, it does represent a logical starting point.

BIBLIOGRAPHY

Aangeenbrug, R. (1991). "A Critique of GIS." in Maguire, D., Goodchild, M. and Rhind, D. (eds.) Geographical Information Systems: Principles and Applications, New York: John Wiley and Sons, vol. 1, pp. 101-107.

Andersen Consulting, (1989). British Columbia Ministry of Forests District GIS Review, Vancouver, BC: Andersen Consulting Company, Ltd.

Antenucci, J. (1991). "Sign Up or Sign Off: Gaining and Maintaining Support for GIS." in Heit, M. and Shortreid, A. (eds.) GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 25-28.

Antenucci, J. and Brown, K. et al., (1991). Geographic Information Systems: A Guide to the Technology, New York: Van Norstrand Reinhold.

Antenucci, J. and Christie, H. (1993). "The Trend Towards Implementation Services." Proceedings from GIS, '93, 7th Annual GIS Symposium, Vancouver, BC: pp. 639-646.

Aronoff, S. (1989). Geographic Information Systems: A Management Perspective, Ottawa, Canada: WDL Publications.

B.C. Forest Resources Commission. (1991). The Future of Our Forests, Victoria: Queens Printer.

B.C. Ministry of Forests. Annual Report, 1979-80. Victoria: Queens Printer.

B.C. Ministry of Forests. Annual Report, 1989-90. Victoria: Queens Printer.

B.C. Ministry of Forests. Annual Report, 1990-91. Victoria: Queens Printer.

B.C. Ministry of Forests. (1992). Forest Management in British Columbia, Victoria: Queens Printer.

B.C. Ministry of Forests. (1989a). Getting in Touch: A Guide to the Ministry of Forests, Victoria: Queens Printer.

B.C. Ministry of Forests. (1993). Getting in Touch: A Guide to the Forest Service, Victoria: Queens Printer.

B.C. Ministry of Forests. (1989b). Integrated Resources Branch, The Use of Geographic Information Systems in Forestry, Victoria, B.C.

B.C. Ministry of Forests. (1990). GIS Strategic Plan, Victoria: Information Systems Branch.

B.C. Ministry of Forests. (1994). Strategy for Management of Land Information, Victoria: GIS Steering Committee, Information Systems Branch.

B.C. Ministry of Forests and Lands. Annual Report, 1978-79, Victoria: Queens Printer.

Babbie, E. (1990). Survey Research Methods, (2nd ed.), Belmont, CA: Wadsworth Publishing Co.

Baskerville, G. (1986). "Understanding Forest Management", Forestry Chronicle, vol. 62, no. 2, pp. 339-347.

Baskerville, G. and Moore, T. (1988a). "Forest Information Systems that Really Work." The Forestry Chronicle, vol. 64, no. 2, pp. 136-140.

Baskerville, G. (1988b). "GIS and the Decision Making Process." Proceedings of the GIS Conference - Forestry GIS: The Next Step, Edmonton, Alberta: Canadian Forestry Service, pp. 10-15.

Bauer, J. (1988). "GIS: Identifying and Justifying the Need." Proceedings of the GIS Conference - Forestry GIS: The Next Step, Edmonton, Alberta: Canadian Forestry Service, pp. 42-44.

Beatty, C. (1986). "Tall Tales and Real Results: Implementing a New Technology for Productivity." Business Quarterly, Vol. 51.

Bedeian, A.G. (1989). Organizations: Theory and Analysis, Toronto: Dryden Press.

Bikson, T. (1987). "Understanding the Implementation of Office Technology." in R. Kraut. (ed.), Technology and the Transformation of White Collar Work, London: Lawrence Erlbaum Associates.

Bostrom, R. and Heinen, J. (1977). "MIS Problems and Failures: A Socio-Technical Perspective, Part 1: The Causes." MIS Quarterly, September, pp. 17-32.

Bostrom, R. and Heinen, J. (1977). "MIS Problems and Failures: A Socio-Technical Perspective, Part 2: The Application of Socio-Technical Theory." MIS Quarterly, December, pp. 11-28.

Bradley, D. and Lewis, B. (1992). "Ecological Economics: Integrating Natural and Social Dimensions." Journal of Forestry, vol. 90, no. 2, pp. 30-33.

Brown, C. (1987). "Implementing a GIS, What Makes a New Site a Success." Proceedings of American Society for Photogrammetry and Remote Sensing, GIS Workshop, Atlanta, GA: pp. 12-19.

Britan, G. (1981). Bureaucracy and Innovation, London: Sage Publications.

Burrough, P. A. (1987). Principles of Geographical Information Systems for Land Resources Assessment, (Monographs on Soil and Resources Survey No.12). Oxford: Clarendon Press.

Cash, C. and Fox, R. (1992). "Elements of Successful Project Management." Journal of Systems Management, September, pp. 10-11.

Chambers, D. D. (1986). "Development and Application of a Pilot GIS for the U.S. Forest Service: Tongass National Forest." 1986 ACSM-ASPRS Annual Convention, Technical Papers. Vol. 3; GIS. Washington, DC: American Society of Photogrammetry and Remote Sensing, pp. 162-171.

Chock, M. (1990). "The Other Costs of Geographic Information Systems." Proceedings of the GIS/LIS '90 Conference, vol.2, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 526-531.

Chrisman, N. R. (1986). "Fundamental Principles of Geographic Information Systems." Proceedings of Autocarto 8, Eighth International Symposium on Computer-Assisted Cartography, Baltimore, MD: American Society for Photogrammetry and Remote Sensing, pp. 32-41.

Chrisman, N. R. (1987). "Design of Geographic Information Systems Based on Social and Cultural Goals." Photogrammetric Engineering and Remote Sensing, vol. 53, no. 10, pp. 1367-137.

Clarke, A. (1991). "GIS Specification, Evaluation and Implementation." in D. Maguire, M. Goodchild, and D. Rhind, (eds.), Geographical Information Systems: Principles and Applications, New York: John Wiley and Sons, vol. 1, pp. 477-489.

Clarkson G., W. G. Management Consultants Ltd, (Sept. 1, 1990). "Information Systems Strategy for Ministry of Forests, Inventory Program." Vancouver, B.C.

Congalton, R. (1986). "GIS Specialist: A New Breed." Proceedings of the GIS Workshop, Atlanta, GA: American Society of Photogrammetry and Remote Sensing, pp. 37-42.

Contant, C. and Forkenbrock, D. (1986). "Planning Methods: An Analysis of Supply and Demand." Journal of Planning Education and Research, vol. 6, no. 10.

Coopers and Lybrand Consulting Group, (1987). The Challenge of Technology Change in Canadian Municipalities. Ottawa: Employment and Immigration Canada.

Copeland, K. (1991). "The Enabling Effect." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 7-10.

Coppock, J. and Rhind, D. (1991). "The History of GIS." in D. Maguire, M. Goodchild, and D. Rhind, (eds.), Geographical Information Systems: Principles and Applications, New York: John Wiley and Sons, vol. 1, pp. 21-43.

Corbin-Charmin, E. (1993). "GIS Project Management Handbook." Proceedings from GIS, '93, 7th Annual GIS Symposium, Vancouver, BC: pp. 631-637.

Corwin, R. (1973). Reform and Organizational Survival, New York: John Wiley & Sons, Inc.

Couch, D. (1991). " GIS - Is It Cost Effective? A Case Study." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 45-46.

Council of Forest Industries of British Columbia. (1990). B.C. Forest Industry Fact Book, 1990, Vancouver, B.C.

Cowen, D.J. (1988). "GIS vs. CAD vs. DBMS: What are the Differences?" Photogrammetric Engineering and Remote Sensing, Vol. 54, No. 11), pp. 1551-1555.

Crain, I. and MacDonald, C. (1983). "From Land Inventory to Land Management: The Evolution of an Operational GIS." in B. Wellar, (ed.), Automated Cartography: International Perspectives on Achievements and Challenges. Ottawa: Steering Committee for the 6th Intl. Symposium, vol. 1, pp. 41-50.

Cully, M. (1990). "What We'd Do Over, If We Had It To Do Over Again." Proceedings of the GIS/LIS '90 Conference, vol. 1, Anaheim CA: American Society for Photogrammetry and Remote Sensing, pp. 182-190.

Daft, R.L., (1992). Organizational Theory and Design, New York: West Publishing Co., Ltd.

Dangermond, J. (1986). "The Software Toolbox Approach to Meeting the User's Needs for GIS Analysis." 1986 ACSM-ASPRS Annual Convention, Technical Papers, Vol. 1; GIS. Washington, DC: American Society of Photogrammetry and Remote Sensing, pp. 66-75.

Dangermond, J. (1991). "Where is the Technology Leading Us?" Forestry Chronicle, Vol. 67, no. 6, pp. 599-603.

de Meyere, J. (1989). "Training of the GIS Professional." Proceedings of the National Conference on GIS, Ottawa: Canadian Institute of Surveying and Mapping, pp. 872-879.

de Neufville, R. and Croissant, J., (1991). "A Policy for Technical Leadership." URISA Journal, Washington, DC: Urban and Regional Information Systems Association, pp. 7-15.

DeMarco, T. and Lister, T. (1987). Peopleware: Productive Projects and Teams, New York: Dorset Publishing Co.

Devine, H.A., and Field, R.C. (1986). "GIS Applications in Forestry." Journal of Forestry, September, pp. 35-41.

Devine, H.A. and Field, R.C. (1986). "The Gist of GIS." Journal of Forestry, August, pp. 17-22.

Dick, R. (1990). "GIS: The Right Stuff." in R. Dick, and G. Jordon, (eds.), Forest Management and Geographic Information Systems (Volume 1 - Beginnings), Fredericton, NB: FIRST, Inc., pp. 131-137.

Dick, R. and Jordan, G (1990). "GIS Activity in Canadian Forestry." in R. Dick, and G. Jordon, (eds.), Forest Management and Geographic Information Systems (Volume 1 - Beginnings), Fredericton, NB: FIRST, Inc., pp. 144-176.

Dickinson, H. and Calkins, H. (1988). "The Economic Evaluation of Implementing a GIS." International Journal of Geographical Information Systems, vol. 2, pp. 307-327.

Diers, C. (1992). "Common Mistakes in Implementing an HRIS." Employment Relations Today, Autumn, pp. 265-271.

Dixon C.J. and Leach, B. (1980). "Questionnaires and Interviews in Geographical Research." Concepts and Techniques in Modern Geography No. 18, London: City of London Polytechnic and Thames Polytechnic.

Dunningham, A. and Thompson, S. (1989). "Use of Geographic Information Systems in New Zealand Forestry Applications." Commonwealth Forestry Review, Vol. 68, No. 3, pp. 203-213.

Emery, H.A., (1990). "Functional Requirements: What and How to Manage." Proceedings of the GIS/LIS '90 Conference, vol. 2, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 517-525.

Epstein, M. (1989). "20 Factors That Make or Break GIS Projects." Proceedings of the National Conference on GIS, Canadian Institute of Surveying and Mapping, Ottawa: pp. 470-473.

Erdle, T. and Jordan, G. (1984). "Computer-based Mapping in Forestry: A View from New Brunswick." Canadian Forest Industries, Vol. 104, No. 4, pp. 38-46.

Fisher, J. and O'Toole, R. (1989). "Mapping Resource Conflicts in the Yellowstone." Forest Watch, Vol. 10, No. 5, pp. 10-14.

Forrester, N. and Vanderwall, K. (1987). "Implementation of a GIS on a National Forest: Operational Realities." Proceedings of GIS '87, 2nd Annual International Conference on GIS, San Francisco, CA: American Society for Photogrammetry and Remote Sensing, pp. 187-195.

Forestry Canada, (1990). "Forestry Facts." Ottawa: Minister of Supply and Services.

Forestry Canada, (March, 1989). FRDA Report 089: A Technical and Operational Comparison of GIS as Applied to the Canadian Forest Industry, Vancouver, BC: Forestry Canada.

Gattiker, U.E. (1990). Technology Management in Organizations, London: Sage Publications.

Ginzberg, M. (1978). "Steps Towards More Effective Implementation of MS and MIS." Interfaces, vol. 8, no. 3, May, 1978, pp. 57-63.

GIS World (1993). 1993 International GIS Source Book, (4th ed.), Fort Collins. CO: GIS World Inc.

Goodbrand, C. (1991). Educational and Geographical Information Systems." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 61- 63.

Goodchild, M. and Rizzo, B. (1986). "Performance Evaluation and Workload Estimation for Geographic Information Systems." International Journal of Geographical Information Systems, vol. 1, no. 1, pp. 67-76.

Goodchild, M. and Kemp, K. (1992). "NCGIA Education Activities: The Core Curriculum and Beyond." International Journal of Geographical Information Systems, vol. 6, no. 4, pp. 309-320.

Gottsegen, J. (1990). "Institutionalizing GIS Implementations for Long Term Support." Proceedings of the GIS/LIS '90 Conference, vol. 2, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 904-909.

Gorden, R.L. (1969). Interviewing: Strategy, Techniques, and Tactics, Homewood, Illinois: The Dorsey Press.

Gordon, W. and Soubra, N. (1992). "GIS and Planning in the USA: Selected Municipal Adoption Trends and Educational Concerns." International Journal of Geographical Information Systems, vol. 6. no. 4, pp. 267-278.

Grady, R. (1989). "An Integrated Approach to GIS for Large Government and Corporate Users", Proceedings of the National Conference on GIS, Ottawa: Canadian Institute of Surveying and Mapping, pp. 495-500.

Green, K.M. (1987). "Critical Management and Technical Considerations When Planning for a GIS Acquisition." Proceedings of the International GIS Symposium, Volume 3, Association of American Geographers, Arlington, VA: pp. III-245-256.

Greiner, L. and Barnes, L. (1970). "Organizational Change and Development." in G. Dalton, P. Lawrence, and L. Greiner, (eds.), Organizational Change and Development, Homewood, Ill: Richard D. Irwin, pp. 121-143.

Grymes, C. (1987). "Implementing GIS Technology for Federal Land Management Tasks - Turning the Dream into Reality." Proceedings of the International GIS Symposium, Volume 3, Association of American Geographers, Arlington, VA: pp. III-229-238.

Hage, J. (1987). "Reflections on New Technology and Organizational Change." in J. Pennings and A. Buitendam, (eds.) New Technology as Organizational Innovation, Cambridge Mass: Harper & Row Publishers, Inc., pp. 261-276.

Hage, J. and Aiken, M. (1970). Social Change in Complex Organizations, New York: Random House, Inc.

Hage, J. and Dewar, R. (1973). "Elite Values Versus Organizational Structure in Predicting Innovation." Administrative Science Quarterly, Vol. 18, No. 3, pp. 279-290.

Hall, R.H. (1982). Organizations: Structure and Process, Englewood Cliffs, NJ: Prentice-Hall, Inc.

Hermansen, C. (1989). "The Practical Application of GIS in Forest Resource Management." Proceedings from GIS '89 Symposium, Vancouver, BC: pp. 89-101.

Holsti, O.R. (1969). Content Analysis for the Social Sciences and Humanities, London: Addison-Wesley Publishing Co.

Jameson, D. (1991). "Comments by Donald A. Jameson, Computer Science and Telecommunications Staff, USDA Forest Service." Speaking notes from GIS '91, Plenary Session 3, GIS '91 Intl. Symposium on GIS, Vancouver, BC.

Joffe, B. (1986). " Evaluating and Selecting a GIS System." Proceedings of GIS '87, 2nd Annual International Conference on GIS, San Francisco, CA: American Society for Photogrammetry and Remote Sensing, pp. 138-145.

Johnson, K. (1987). "Natural Resource Modelling in the Geographic Information System Environment." Photogrammetric Engineering and Remote Sensing, vol. 53, no. 10, pp. 1411-1415.

Jones, C. (1981). "Programmer Productivity: Issues for the Eighties." New York Institute of Electrical and Electronic Engineers, New York.

Jordan, G. and Erdle, T. (1990). "GIS and Forest Management: What We Have Learned in New Brunswick." Canadian Institute of Surveying and Mapping Journal, vol. 43, no. 3, pp. 287-295.

Karten, N. (1990). "Educating Management on End-User Computing." Canadian Data Systems, July, pp. 26-27.

Keller, C.P. (1990). "Issues to Consider When Developing or Selecting a GIS Curriculum." Proceedings of GIS '90, An International Symposium on GIS, Vancouver, BC: pp. 527-533.

Keller, C.P. (1990). "Planning Geographical Information Installation." Manuscript prepared for the Planning Institute of B.C., Department of Geography, University of Victoria.

Keller, C.P. (1992). "An Introduction to Geographic Information Systems: A Seminar for Ministry of Forests Executive Management." (Seminar Notes, February 20, 1992), Victoria, BC: Ministry of Forests, Inventory Branch.

Keller, C.P. (1993). "Thoughts on the Relationship Between Geographic Information Systems and Resource Management." in H. Foster (ed.), Advances in Resources Management: Tributes to W.R. Derrick Sewell, London: Belhaven Press, pp. 295-312.

Kent, R. (1989) Installing Change: An Executive Guide for Implementing and Maintaining Organizational Change, Winnipeg, Manitoba: Pragma Press, Inc.

Kesner, R.M. (1988). Information Systems: A Strategic Approach To Planning and Implementation, Chicago: American Library Assn.

Kevany, M. (1987). "A Critical Evaluation of the Proliferation of Automated Mapping Systems in Local Government." Proceedings of the International GIS Symposium, Volume 3, Association of American Geographers, Arlington, VA: pp. III-165-177.

Kokoshke, A. (1991). "How GIS Affects the Work of a Field Forester." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 51-52.

Kolb, D. (1970). "An Organization Development Approach to Consulting." Sloan Management Review, Fall, pp. 51-65.

Kotter, J. and Schlesinger, L. (1979). "Choosing Strategies for Change." Harvard Business Review, March-April, pp. 106-114.

Lachowski, H. (1988). "The Forest Service GIS Story." Proceedings of the 2nd Annual U.S. Forest Service Remote Sensing Applications Conference, Salt Lake City, UT: USDA Forest Service, pp. 83-89.

Lake, R. (1993). "Corporate Resource Management Systems." Proceedings from GIS, '93, 7th Annual GIS Symposium, Vancouver, BC: pp. 613-622.

Lamont, R. (1991). Avoiding Surprises in Selecting and Setting Up a GIS." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 71-74.

Laudon, K. and Laudon J. (1988). Management Information Systems: A Contemporary Perspective, New York: MacMillan Publishing Company.

Lawrence, P. (1954). "How to Deal with Resistance to Change." Harvard Business Review", May-June, 1954.

Lee, A. (1989). "A Scientific Methodology for MIS Case Studies." MIS Quarterly, March, 1989, pp. 33-50.

Lee, Y. and Zhang, G. (1989). "Developments of Geographic Information Systems Technology." Journal of Surveying Engineering, vol. 115, no. 3, pp. 304-323.

Leefers, L. (1989). "Analysis Tools for Forest Plan Implementation." Proceedings of the 1989 Society of American Foresters National Convention, Spokane, WA: Society of American Foresters, pp. 283-289.

Leggat, K. and Buckley, D. (1991). "Implementing GIS into Alberta's Integrated Resource Planning Program." Forestry Chronicle, vol. 67, no. 6, pp. 604-609.

Lertzman, K. (1990). "What's New about 'New Forestry'? - Replacing Arbocentrism in Forest Management." Forest Planning Canada, Vol. 6, no. 3, pp. 25-28.

Levinsohn, A. (1989). "So you Bought a GIS - Now What?" Proceedings of GIS '89, International GIS Symposium, Vancouver, BC: pp. 125-132.

Levinsohn, A. and Brown, S. (1991). " GIS and Sustainable Development in Natural Resources Development." in M. Heit, and A. Shortreid (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 17-21.

Machiavelli, N. (1516). "The Prince." in B. Penman, (ed.), The Prince and other Political Writings, (1981), London: Everyman's Library.

Maclean, A. and Winterberger, K. (1992). "An Introduction to GIS: An Editorial." Journal of Forestry, Vol. 90, no. 11, p. 5.

Madill, R. (1977). "So You Need a GIS?." Proceedings of the 2nd Annual Workshop of the National Capital Geographic Information Processing Group, Ottawa: Canadian Forestry Service.

Maffini, G. (1990). "Beyond Information Management." Proceedings of the GIS/LIS '90 Conference, vol. 1, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 476-486.

Maggio, R.C. (1990). "Planning for a GIS Installation in a Local Government." Proceedings of the GIS/LIS '90 Conference, vol. 1, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 413-420.

Maguire, D. (1991). "An Overview and Definition of GIS." in D. Maguire, M. Goodchild, and D. Rhind, (eds.), Geographical Information Systems: Principles and Applications, New York: John Wiley and Sons, vol. 1, pp. 9-20.

Maher, R.V. (1992). "Institutional Change and Technology: A Framework for GIS Training and Education at Ministry of Natural Resources." Manuscript for a Presentation at the National Conference on GIS, Ottawa: Canadian Institute of Surveying and Mapping.

Marble, D.F. and Sen, L. (1986). "The Development of Standardized Benchmarks for Spatial Database Systems." Proceedings of the 2nd International Symposium on Spatial data Handling, Seattle, WA: International Geographic Union, pp. 489-498.

March, J.G. and Simon, H. (1980). "Planning and Innovation in Organizations." in J. Litterer, (ed.), Organizations: Structure and Behaviour, New York: John Wiley & Sons.

Martin, F. (1985). "Using a GIS for Forest Land Mapping and Management." Journal of Photogrammetric Engineering and Remote Sensing, vol. 51, no. 11, pp. 1753-1759.

McCrary, S. and Kincaid, J. (1990). "A Survey of Local Government Application of GIS and AM/FM Systems." Proceedings of the GIS/LIS '90 Conference, vol. 1, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 421-431.

McFarland, R. (1990). "GIS Implementation Strategies for the Small Municipal Environment." Proceedings of the GIS/LIS '90 Conference, vol. 1, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 174-181.

Meckley, B. (1987). "Determining Your GIS Requirements: The Critical First Step." Proceedings of the International GIS Symposium, Volume 3, Association of American Geographers, Arlington, VA: pp. III-257-269.

Moch, M. and Morse, E. (1977). "Size Centralization and Organizational Adoption of Innovation." American Sociological Review, Vol. 42, No. 5, pp. 716-725.

Montgomery, G. (1990). "Organizing a GIS Multiparticipant Project - Getting Started." GIS World, June/July, Fort Collins, CO: pp. 62-64.

Monty, J. (1987). "What Do Cells Have To Do With Forest Resource Statistics?" The Forestry Chronicle, Vol. 63, No. 1, pp. 20-22.

Morse, B. and Hovey, S. (1990). "Data: The Foundation of a Land Information System." Proceedings of the GIS/LIS '90 Conference, vol. 1, Anaheim CA: American Society for Photogrammetry and Remote Sensing, pp. 273-282.

Moser, C.A. and Kalton, G. (1972). Survey Methods in Social Investigation, (2nd Ed.), London: Heinemann Educational Books, Ltd.

Moulton, B. and Raber, B. (1985). "Computer Applications for Intensive Forest Management." Proceedings of the 1985 ACSM-ASPRS Fall Convention, American Society of Photogrammetric Engineering and Remote Sensing, pp. 11-25.

Munro, P. (1983). "Selection Criteria for GIS - In Retrospect." Proceedings of the International Conference on Renewable Resource Inventories for Monitoring Changes and Trends, Corvallis, OR: Society of American Foresters, pp. 273-275.

Murphy, D. (1991). "Implementing GIS Technology in a Forest Inventory System." in Heit, M. and Shortreid, A, (eds.) GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 305-306.

NCGIA (1989). Applications Issues in GIS, National Centre for Geographical Information Analysis: Core Curriculum Series.

Noori, H. (1990). Managing the Dynamics of New Technology, Englewood Cliffs, NJ: Prentice-Hall, Inc.

Nutt, P. (1988). "Tactics of Implementation." Academy of Management Journal, vol. 29, no. 2, pp. 230-261.

Onsrud, H. and Pinto, J. (1991). "Diffusion of Geographic Innovations." International Journal of Geographical Information Systems, vol. 5, no. 4, pp. 447-467.

Onsrud, H., Pinto, J. and Azad, B. (1992). "Case Study Research Methods for Geographic Information Systems." Journal of the Urban and Regional Information Systems Association, vol. 4, no. 1.

Oskamp, S. and Spacapan, S. (1990). "People's Reaction to Technology." in S. Oskamp, and S. Spacapan, People's Reaction to Technology, London: Sage Publications, pp. 9-29.

Parker, H.D. (1988). "The Unique Qualities of a Geographic Information System: A Commentary." Photogrammetric Engineering and Remote Sensing, Vol. 54, No. 11, pp. 1547-1549.

Parker, H.D. (1986). "What is a Geographic Information System." Proceedings of GIS Workshops, Annual Conference of the American Society of Photogrammetry and Remote Sensing, Atlanta, GA: pp. 72-81

Pearce, N. (1990). "Taking the Risk Out of System Selection." Mapping Awareness, vol. 4, no. 1, Jan-Feb. pp. 33-37.

Peat, Marwick, Stevenson and Kellogg. (1991). Human Resource and Organizational Changes Required to Support Geographic Information Systems in the Ministry of Forests, Vancouver, BC: Peat, Marwick, Stevenson and Kellogg Management Consultants.

Peck, T. (1983). "Geographic-Based Inventory System - A Necessity With Our Intensive Forest Management." Proceedings of an International Conference on Renewable Resource Inventories for Monitoring Changes and Trends, Corvallis, OR: Society of American Foresters, pp. 286-287.

Pennings, J. (1987). "On the Nature of New Technology as Organizational Innovation." in J. Pennings and A. Buitendam, (eds.), New Technology as Organizational Innovation: The Development and Diffusion of Microelectronics, Cambridge, MA: Ballinger Publishing Co.

Perkins, S. (1990). "Down with Dejavu - Making Change Stick in Your Organization." Proceedings of the GIS/LIS '90 Conference, vol. 2, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 749-761.

Peuquet, D. and Bacastow, T. (1991). "Organizational Issues in the Development of Geographical Information Systems: A Case Study of the U.S. Army Topologic

Information Automation." International Journal of Geographical Information Systems, vol. 5, no. 3, pp. 303-319.

Pfaffenberger, B. (1990). Ques's Computer User's Dictionary, Carmel, Indiana: Que Corporation.

Pinto, J. and Slevin, D. (1987). "Critical Factors in Successful Project Implementation." IEEE Transactions on Engineering Management, vol. EM-24, no. 1 February, 1987, pp. 22-27.

Power, J.M. (1988). "Decision Support Systems for the Forest Insect and Disease Survey and Pest Management." Forestry Chronicle, pp. 132-135.

Rains, M.T. (1987). "The Role of GIS in Spatial Resource Information Management: A Forest Service Perspective." Annual Convention of the American Society for Photogrammetry and Remote Sensing, San Francisco, CA: pp. 111-121.

Reed, C. (1992). "Trends in GIS Technology - What Are The Impediments?" Proceedings from GIS, '92, 6th Annual GIS Symposium, Vancouver, BC: pp. D-2,1-4.

Revised Statutes of British Columbia. (1979). Chapter 140: "Forest Act." (Consolidated 1989), Victoria, BC: Queens Printer.

Revised Statutes of British Columbia. (1979). Chapter 272: "The Ministry of Forests Act." (Consolidated 1988), Victoria, BC: Queen's Printer.

Richards, D. and Eiber, T. (1985). "The Application of GIS in Forest Inventory and Multiple-Use Resource Management Modelling." Proceedings from FORS/FPRS Software Solutions: A Computer Symposium, pp. 70-77.

Richardson, S. (1989). "Innovation and Information Technology." Commonwealth Forestry Review, Vol. 68, no. 3, pp. 171-180.

Robin, S.S. (1965). "A Procedure for Securing Returns to Mail Questionnaires." Sociology and Social Research, Vol. 50, pp. 24-35.

Rose, D. and Hoganson, H., et al., (1988). "An Integrated Approach to Forest Planning and Decision-Making." Proceedings of the Society of American Foresters 1988 Annual Convention, Rochester, NY: Society of American Foresters, pp. 289-293.

Saarinen, T.F. (1969). Perception of Environment, Resource Paper No.5 Commission on College Geography, Association of American Geographer, Washington, DC.

Saarinen, T.F. (1971). "Research Approaches and Questionnaire Design." in W.R.D. Sewell, and I. Burton, (eds.), Perceptions and Attitudes in Resources Management, Resource Paper No. 2), Ottawa: Dept. of Energy, Mines and Resources, pp. 13-25.

Sanders, W.B. and Pinhey, T.K. (1983). The Conduct of Social Research, New York: Holt, Rinehart and Winston.

Sandquist, J. (1990). "Defining Target Groups for GIS Product Training." Proceedings of the GIS/LIS '90 Conference, vol. 2, Anaheim, CA: American Society for Photogrammetry and Remote Sensing, pp. 532-541.

Sankar, Y. (1991). Management of Technological Change, New York: John Wiley and Sons.

Schiff, M. (1971). "The Definition of Perceptions and Attitudes." in W.R.D. Sewell, and I. Burton, (eds.), Perceptions and Attitudes in Resources Management, Resource Paper No. 2), Ottawa: Dept. of Energy, Mines and Resources, pp. 13-25.

Selden, D. (1987). "Success Criteria for GIS." Proceedings of the International GIS Symposium, vol. 3, Arlington, VA: Association of American Geographers, pp. III-239-243.

Sety, M.L. and Chang, K. (1987). "A Rationale for Considering the GIS Data Base an Asset." Proceedings of 2nd Annual International Conference on GIS, American Society of Photogrammetry and Remote Sensing, San Francisco, CA: pp. 122-127.

Sewell, W.R.D. and Wood, C.J.B (1971). "Environmental Decision-Making and Environmental Stress: The Goldstream Controversy." Proceedings of the Annual Meeting of the Canadian Association of Geographers pp. 33-44.

Sharun, C. (1992). "GIS Two Years after the Purchase - Where Are We?" Proceedings from GIS, '92, 6th Annual GIS Symposium, Vancouver, BC: pp. D1-2-6.

Shepherd, I. (1991). "Information Integration and GIS." in D. Maguire, M. Goodchild, and D. Rhind, (eds.), Geographical Information Systems: Principles and Applications, New York: John Wiley and Sons, vol. 1, pp. 337-361.

Shumway, C. (1986). "Summary of Forest Service GIS Activities." 1986 ACSM-ASPRS Annual Convention, Technical Papers, Volume 3: GIS, Washington, DC: pp. 49-53.

Shuswap Nation Tribal Council, (1992). Going In Style: A Tale of GIS in the Shuswap Nation, Shuswap Nation Tribal Council.

Somers, R. (1990). "Local Government GIS: Organizing for Success." GIS World, August/September, pp. 90-101.

Smircich, L. (1983). "Concepts of Culture and Organizational Analysis." Administrative Science Quarterly, 28(3).

Smith, D. and Tomlinson, R. (1992). "Assessing Costs and Benefits of Geographical Information Systems: Methodological and Implementation Issues." International Journal of Geographical Information Systems, vol. 6, no. 3, pp. 247-256.

Smith, J. and Prisley, S. (1987). "Positioning GIS in the Management Hierarchy: The Forestry Experience." Annual Convention of the American Society for Photogrammetry and Remote Sensing, San Francisco, CA: pp. 38-45.

Smith, J. and Prisley, S. (1991). "The Ultimate Compromise: Situating GIS in the Organizational Hierarchy." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 47-49.

Smith, T. and Menon, S., et al. (1987). "Requirements and Principles for the Implementation and Construction of Large-Scale Geographic Information Systems." International Journal of Geographical Information Systems, vol. 1, no. 1, pp. 13-31.

Smith, T. and Tomlinson R. (1992). "Assessing Costs and Benefits of Geographical Information Systems: Methodological and Implementation Issues." International Journal of Geographical Information Systems, vol. 6, no. 3, pp. 247-256.

Stanley, L. (1988). "You are Buying a GIS! - Why?" Proceedings of the GIS Conference - Forestry GIS: The Next Step, Edmonton, Alberta: Canadian Forestry Service, pp. 45-52.

Stanley, L. and Pepper, G. (1989). "GIS Implementation - An Integrated Approach." Proceedings of the National Conference on GIS, Ottawa: Canadian Institute of Surveying and Mapping, pp. 487-494.

Stutheit, J. (1990). "GIS Procurements: Weighing the Costs." GIS World, April-May, Fort Collins, CO: pp. 69-70.

Sullivan, S.A. and Miller, C.R. (1991). "GIS Training and Education - The Need for a New Approach." in M. Heit, and A. Shortreid, (eds.), GIS Applications in Natural Resources, Fort Collins, CO: GIS World Inc., pp. 65-70.

Swanson, D. (1971). "Public Perceptions and Resource Planning.", in W.R.D. Sewell, and I. Burton, (eds.), Perceptions and Attitudes in Resources Management, Resource Paper No. 2), Ottawa: Dept. of Energy, Mines and Resources, pp. 91-97.

Thompson, M. (1993). "Operational Considerations for GIS Implementation for Tropical Resource Management." Proceedings from GIS, '93, 7th Annual GIS Symposium, Vancouver, BC: pp. 623-629.

Tichy, N. (1983). Managing Strategic Change, Toronto: John Wiley and Sons.

Tomlinson, R. (1987). "Current and Potential Uses of Geographical Information Systems: The North American Experience." International Journal of Geographic Information Systems, Vol. 1 No. 3, pp. 203-218.

Tomlinson, R. (1984). "Geographic Information Systems - A New Frontier." The Operational Geographer, vol. 5, pp. 31-36.

Tomlinson, R. (1989). "Presidential Address: Geographic Information Systems and Geographers in the 1990's." The Canadian Geographer, vol. 33, no. 4, pp. 290-298.

USDA Forest Service. (October, 1988). "National GIS Plan, Vision, Objectives, Principles, and Assumptions about the National GIS Implementation Plan." (Component A, Action Item 2 of 5). Washington, DC.

USDA Forest Service. (Feb., 1989). "National GIS Plan: National Geographic Information Structure." (1 of 5). Washington, DC.

USDA Forest Service. (Sept., 1989). "National GIS Plan: Integrated Information Management Program; GIS Feasibility Study and Benefit and Cost Analysis, Executive Summary." (Component C, Action Items 2 and 3). (3 of 5). Washington, DC.

USDA Forest Service. (Sept., 1989). "National GIS Plan: Integrated Information Management Program, GIS Feasibility Study and Benefit/Cost Analysis, Extract." (Component C, Action Items 2 and 3). (4 of 5). Washington, DC.

USDA Forest Service. (Sept., 1989). "National GIS Plan: Integrated Information Management Program, GIS Feasibility Study and Benefit/Cost Analysis." (Component C, Action Items 2 and 3). (5 of 5). Washington, DC.

Weisberg, H., et al., (1989). An Introduction to Survey Research and Data Analysis, (2nd ed.), Boston: Scott, Foresman and Co.

Welch, D. (1987). "Mainframe to Micro: GIS Needs Analysis and Product Selection for End Users in Canada's National Parks." Proceedings of GIS '87, 2nd Annual International Conference on GIS, San Francisco, CA: American Society for Photogrammetry and Remote Sensing, pp. 148-155.

Wellar, B. (1990). "Science, Applications, Coherence and GIS: Seizing the Moment." Proceedings of the GIS/LIS '90 Conference, Anaheim, CA: American Association of Geographers, pp. 854-871.

Wientzen, B. (1990). "Great Northern Paper: Managing a Forest with GIS." GIS World, Vol. 3, April, pp. 31-33.

Wilcox, D. (1990). "Concerning 'The Economic Evaluation of Implementing a GIS." International Journal of Geographical Information Systems, Vol. 4, no. 2, pp. 203-210.

Wilke, T. (1990). "Survey Targets - GIS Educational Needs." GIS World, June-July, Fort Collins CO: pp. 90-92.

Wilkens, A. (1983). "The Cultural Audit: A Tool for Understanding Organizations." Organizational Dynamics, vol. 12, no. 2.

Winkle, P. (1991). "Digital Forest Management: Canfor's Experience." Forestry Chronicle, vol. 67, no. 6, pp. 630-635.

Wood, R. and Houle, P. (1991). "Organizational Issues Affecting Technology Initiatives." Journal of Systems Management, November, pp. 17, 39.

Woodward, J. (1980). "Technology and Innovation." in J. Litterer, (ed.), Organizations: Structure and Behaviour, New York: John Wiley & Sons.

Wright, S. and Morley, D. (eds.), (1989). Learning Works: Searching for Organizational Futures, Toronto: The ABL Group.

Zaltman, G., Duncan, R. and Holbeck, J. (1973). Innovations and Organizations, New York: Wiley Interscience.

Zarzycki, J. (1989). "Building the Foundation for a Geographic Information System." Proceedings of the National Conference on GIS, Ottawa: Canadian Institute of Surveying and Mapping, pp. 427-438.

Zastava, D. (1989). "Multiparticipant GIS Projects - Technical and Funding Allocation Issues." Proceedings of the National Conference on GIS, Ottawa: Canadian Institute of Surveying and Mapping, pp. 851.2-851.6.

APPENDIX A

COPY OF THE QUESTIONNAIRE SURVEY

MASTER **10/90**

Inventory Branch
Business Requirements Study
Interview Questions/Questionnaire

REGISTRATION NUMBER: ____ DATE:

This questionnaire is divided into three main sections. Section 1 contains basic questions regarding District inventory programs. Section 2 concerns the impact of GIS on District operations, and section 3 deals with questions regarding Inventory data requirements.

Thank you for taking the time to complete this questionnaire.

Section 1. District Inventory Program

1. In your opinion, what are the most pressing Forestry Management issues, that face your office?
(Please rank in order of importance from 1- 13)

______ Integrated Resource Management
______ Wildlife/Fisheries
______ Native Land Claims
______ Resource Use Conflicts
______ Public Relations
______ Reforestation
______ Forest Inventory
______ Pest Management
______ Fire Management
______ Range
______ Recreation
______ Silviculture
______ Timber Management
______ Other (please describe) ________________________________

2. Please describe any responsibilities, duties or concerns and issues unique to your District office, in regards to Forestry Management. (Please list in order of importance)

____
____
____
____
____
____

3. To what degree do you feel that your office is meeting/handling these responsibilities, duties, concerns and issues unique to your District?

______ all ______ most ______ some ______ few

______ none ______ don't know ______ not applicable

4. What is the annual budget for the Inventory Program in your District? (exclusive of salaries)

____

5. How many persons/FTE's do you have working in the Inventory Program in your office? ____

6. Please list the job title/classifications of those persons that work in the Inventory program and the percentage of time that they spend working on inventory tasks?

____
____
____
____
____
____

7. Is a larger Inventory budget or more staff/FTE's required to run the Inventory program in your office.

a) Budget; ______ Yes ______ No ______ Don't know

b) Staff; ______ Yes ______ No ______ Don't know

8. Please list the jobs or tasks that you spend most of your time working on. Please list in descending order.

____
____
____
____
____
____

9. How would you describe the quality of the documentation and manuals that are provided by the Inventory Branch such as the Inventory Manual, etc.?

____
____
____

10. Please outline how inventory projects such as area/volume reports or summaries and colour coded maps are currently performed in your office?

____
____
____
____
____
____

11. How do you currently complete these phases of inventory updates:

a) Preparation of attribute lists (ie. FS810's) and history maintenance source preparation?

______ In-house ______ Contract out ______ Both ______ Other

b) Graphics update preparation? (ie. forest cover inventory)

______ In-house ______ Contract out ______ Both ______ Other

c) Map digitizing?

______ In-house ______ Contract out ______ Both ______ Other

12. What map scale would be most appropriate to meet the majority of your needs in providing information for staff and private sector clients (ie. for inventory planning projects, reports, etc.)?

______ 1:2,000 ______ 1:5,000 ______ 1:10,000
______ 1:15,000 ______ 1:20,000 ______ 1:50,000
______ 1:100,000 Other; ________________________________

Section 2 **Impact of GIS on District Operations**

13. Have you had any experience with GIS?

______ No ______ Yes ______ Don't know

If you answered yes, please describe your experience briefly.

____
____
____

14. What kind of impact would/has the use of a GIS would have on your office's ability to manage the forest resources in your District?

____
____
____

15. Would/Has the use of a GIS assist/ed in your office meet its mandates and duties more effectively and efficiently? (ie. assuming that all your hardware/software, staffing and training needs, etc. were all met).

______ Yes ______ No ______ Don't know

If you answer yes or no, please explain your answer.

____
____
____

16. Would/Has a GIS help/ed you in conducting your Inventory program (ie. re-inventory and inventory updates) more effectively or efficiently? (ie. assuming that all your hardware/software, staffing and training needs, etc. were met)

______ Yes ______ No ______ Don't know

If you answered yes or no, please explain your answer.

____
____
____

17. If you had/have a GIS station please describe how the use of GIS would/has affect/ed Inventory related functions and operations of your office?

____
____
____

18. How would/have you use/d a GIS station if you had one at your disposal? (Please rank the uses in order of importance). (eg. analysis projects, inventory updates, etc.)

____
____
____

19. What would be the best option for providing support for GIS and Inventory operations: (please select one of the choices)

______ Ministry single point of contact help desk/hotline

______ individual Branch or Regional Support

______ individual vendor support/hotline

______ other, please describe. ______________________________
____

20. How would you describe the support that now exists for your:

a) Inventory Program from the Inventory Branch?

______ Poor ______ Fair ______ Good ______ Very good
______ Excellent ______ No opinion

b) Inventory Program from the Regional office?

______ Poor ______ Fair ______ Good ______ Very good
______ Excellent ______ No opinion

Answer questions 20 c) and 20 d) only if your office has no GIS station.

c) GIS operations from the Branch?

______ Poor ______ Fair ______ Good ______ Very good
______ Excellent ______ No opinion

d) GIS operations from the Regional office?

______ Poor ______ Fair ______ Good ______ Very good
______ Excellent ______ No opinion

21. Does the GIS and/or Inventory support you now receive need to be improved?

______ Yes ______ No ______ Don't know

If you answered yes, please describe how this support could be improved.

____
____
____

22. Who do you usually contact when you encounter a problem with:

a) an inventory data question ______________________________________
____

b) an inventory methodology question ________________________________
____

Answer questions 22 c) and 22 d) only if your District has a GIS station

c) your GIS workstation ____
____

d) a GIS project ____
____

23. Please describe your needs and requirements, if any, in regards to producing database reports and maps for routine inventory operations and special projects.

____
____
____

24. Please describe the most common requests for information and data that you receive from the MOF, other Ministries, and the private sector? (eg. area/volume summary reports, gross land base reports, special project maps/inventory reports)

____
____
____

25. Please rank (in descending order from the most frequent to the least), the type of clients that request forest cover maps and database reports, inventory information etc., from your office?

______ Forestry Consultants
______ Forest Companies
______ GIS Consultants
______ Special Interest Groups
______ General Public
______ Native Indian Groups
______ Ministry of Crown Lands
______ Ministry of Environment
______ Federal Government
______ Other: ____

Internal Requests:
______ Planning
______ Inventory
______ Silviculture
______ Protection
______ Range
______ Recreation
______ Timber

26. Are you able to meet all the information/data request that are directed to your office?

______ Yes ______ No ______ Don't know

If you answered no, please explain why.

____
____
____

27. If you had a GIS do you think the development and use of user interfaces or simplified, special application programs will benefit your District's use of a GIS.

____
____
____

28. If you had a GIS, what type of applications and tasks would you like to see automated or simplified by the use of specific GIS application programs?

a) ______ Colour coded or themed map production
b) ______ Area/Volume report generation
c) ______ Other, please describe ______________________________

29. Do you have any questions or concerns regarding forest cover map production standards? (ie. chapters 11 and 12 in the Inventory manual)

______ Yes ______ No ______ Don't know

If you answered yes, please describe.

____
____
____

Section 3 **Inventory Data Requirements**

Part A) Database Structure

30. Does the current Inventory database meet your requirements for the tasks and projects that you work on?

______ Always ______ Most the time ______ Some of the time
______ Seldom ______ Never ______ Don't know

31. Do you think that the structure and format of the inventory database need to be changed?

_____ Yes _____ No _____ Don't know

If you answered yes, please describe any possible changes, improvements or additions to the database.

____
____
____

32. Do you have any concerns or questions regarding inventory data standards?

_____ Yes _____ No _____ Don't know

If you answered yes, please explain your answer.

____
____
____

33. Do you currently integrate other resource information/data (eg. MOE fish and wildlife habitat data) into your inventory database?

_____ Always _____ Most the time _____ Some of the time

_____ Seldom _____ Never _____ Don't know

34. Do you currently use satellite imagery data to complete your District updates?

_____ Always _____ Most of the time _____ Some of the time

_____ Seldom _____ Never _____ Don't know

35. How do you plan to use or integrate TRIM data into your update and or re-inventory projects?

____
____
____

36. How would you describe the linkage between the graphics (ie. map file/data) and the forest cover attributes (ie. the FIP or .SEG file) in the Inventory database?

____
____
____

37. Is there a need to improve the coordination or linkage between these the two components of the Inventory database?
(ie. the graphics file and the forest cover attributes)

______ Yes ______ No ______ Don't know

If you answered yes, please explain your answer.

____
____
____

Part B) Database Quality/Distribution

39. How would you describe the accuracy of the inventory database (ie. FIP file) for use in the following:

a) TSA Plans

______ Very poor ______ Poor ______ Fair ______ Good
______ Very Good ______ Excellent ______ No opinion

b) Regional Plans;

______ Very poor ______ Poor ______ Fair ______ Good
______ Very Good ______ Excellent ______ No opinion

c) Local Resource Use Plans;

______ Very poor ______ Poor ______ Fair ______ Good
______ Very Good ______ Excellent ______ No opinion

d) Watershed Plans;

______ Very poor ______ Poor ______ Fair ______ Good
______ Very Good ______ Excellent ______ No opinion

e) Development Plans;

______ Very poor ______ Poor ______ Fair ______ Good
______ Very Good ______ Excellent ______ No opinion

f) Other; ____

40. Does the accuracy of Inventory data need to be improved?

______ Yes ______ No ______ Don't know

If you answered yes, please describe any suggestions you have for improving the accuracy of the database.

____
____
____

Thank you for taking the time to complete this questionnaire.

APPENDIX B

DESCRIPTION AND JUSTIFICATION FOR INDIVIDUAL QUESTIONS

Section 1. Regional/District Inventory Program

Question 1. In your opinion what are the most pressing forest management issue that face your office (given 13 choices to rank in order of importance)?

- General "opener" type question.
- Ranks the importance of various prominent resource management issues.
- Identifies the nature or type of resource management issues that are prevalent to help determine how GIS technology could be employed to enhance current forest management practices.

Question 2. Please describe any responsibilities, concerns and issues that are prominent or unique to your office in regards to forest management (in order of importance).

- Inquires about and ranks legislated and non-legislated mandates, responsibilities, concerns, issues, etc.
- Catches responses that question 1 may have missed.

Question 3. To what degree do you feel that your office is meeting/handling these responsibilities, concerns and issues that are prominent or unique to your office (given a range of choices and space for comments)?

- Determines the level of effectiveness that each office is perceived to have regarding the issues identified in questions 1 and 2 for offices that have and do not have GIS capabilities.
- Provides another opportunity to identify concerns and issues not covered by questions 1 and 2.

Question 12. Please outline how inventory projects such as area/volume reports or summaries and colour coded maps are currently performed in your office.

- Determines how various key IRM and GIS related tasks are currently completed.
- Directly applies to GIS use as all of these tasks can be automated and enhanced with GIS.

Question 13. How do you currently complete these phases of inventory updates: (given choices on 3 main phases)

- Determines how various phases of inventory update are currently completed.
- Applies to GIS use as each phase can be performed on an in-house GIS.

Question 14. What map scale would be most appropriate to meet the majority of your needs in providing information for staff and private sector clients (ie. for planning projects, reports, etc.)? (given a range of choices)

- Asks what map scale is appropriate for various mapping needs.
- Applies to GIS use as you can easily change map scales within a GIS

Section 2. Impact of GIS on Regional/District Operations

Question 15. Have you had **any** experience with GIS?

- Introductory "opener" type question for section two of the survey.
- Determines the respondents level of experience and background with GIS.

Question 16. What kind of impact would/has the use of GIS have/had on your office's ability to manage the forest resources in your Region/District?

- A "opener" introduction type question that investigates the overall utility of GIS in forest management.
- Inquires into the actual and/or perceived impact of GIS use on Regional and District forest management abilities.
- Gathers information on how GIS technology can be applied or benefit various operational tasks and planning procedures.
- Identifies any concerns or issues surrounding the Ministry's implementation and use of GIS.

Question 17. Would/Has the use of GIS assist/ed in your office to meet its mandates and duties more effectively and efficiently (ie. assuming that all your hardware/software, staffing and training needs, etc. were met)?

- Investigates both actual and perceived impacts and effects of GIS use on organizational mandates and duties.

- Inquires as to what kind of tasks and applications GIS would be used for.
- Identifies any concerns or issues surrounding the Ministry's implementation and use of GIS.

Question 18. Would/Has a GIS help/ed you in conducting your Inventory Program (ie. re-inventory and inventory updates) more effectively or efficiently? (ie. assuming that all your hardware/software, staffing and training needs, etc. were met)?

- Investigates the actual and perceived impacts and effects of GIS use on the forest inventory program and for database management tasks.
- Identifies any concerns or issues surrounding the Ministry's implementation and use of GIS.

Question 19. How would/have you use/d a GIS station if you had/have one at your disposal (ie. list the priority of the uses for the GIS in order of importance eg. analysis projects,inventory updates, etc.)?

- Ranks in order of importance the actual and perceived use and applications of a GIS station if such a station is available.
- Will assist in determining the level of importance of various forest management tasks in relation to GIS.
- Identifies any concerns or issues surrounding the Ministry's implementation and use of GIS.

Question 20. What would be the best option for providing support for GIS.

- Inquires as to what would be the best method for providing end user support for GIS and inventory operations.
- Indicates how the respondents perceives the effectiveness of support for various support centres.
- Will help determine how important end user support is to the respondent to the success of the GIS implementation.

Question 21. How would you describe the support that now exists for your GIS: (given 4 categories to respond to).

- Rates the end user support for both GIS and inventory operations.
- Like question 19 indicates how the respondents perceives or rates the effectiveness of support operations for the two support centres.

- Will determine the importance of end user support as seen by the respondent to the success of the GIS implementation.

Question 22. Does the GIS and/or Inventory support you now receive need to be improved?

- Asks whether end-user support needs to improve and if so, how and in what way(s).
- Like questions 19-20 this question will help determine the importance the respondent places on the issue of end-user support in light of the Ministry's GIS implementation initiative.

Question 25. Please describe your needs and requirements, (ie. hardware/software, training, etc.) if any in regards to producing database reports and maps for routine operations and special projects

- Inquires as to what kind of, if any, needs and requirements the respondent has in regards to specific inventory and forest management functions.
- Relates to GIS in that many of these functions can be automated and enhanced with the use of GIS.

Question 26. Please describe the most common requests for information and data that you receive from the MOF, other ministries, and the private sector (eg. area/volume summary reports, gross land base reports, special projects maps/inventory reports)?

- Inquires as to what kind of information and data requests are directed to Regional and District offices by various clients.
- Relates to GIS use as many of these information and data requests can be produced, automated and enhanced with use of GIS.

Question 28. Are you able to meet **all** the information/data requests that are directed to your office?

- Inquires whether Regional and District offices are able to meet the information and data requests directed to them.
- Relates to GIS in that many of the data and information requests can be automated and enhanced with the use of GIS.
- Inquires as to whether the use of a GIS would enable forest offices to enhance their ability to meet information requests (depending on the type of the request).

Question 29. If you have/had a GIS do you think that the development and use of user interfaces or simplified, special "canned" application programs would benefit the use of GIS in your office?

- Asks the respondent if the development and use of special application programs would benefit the use of GIS.

Question 30. If you have/had a GIS, what type of applications and tasks would you like to see automated or simplified by the use of specific GIS applications programs? (given 3 choices)

- Inquires as to what kind of forest management and GIS applications and functions would benefit from the development special applications programs.

Section 3. Inventory Data Requirements

Question 32. Does the current Inventory database meet your requirements for the tasks and projects you work on?

- Asks whether the current inventory database meets operational requirements.
- Gathers information of the adequacy of the database for forest management and GIS use.

Question 33. Do you think that the structure and format of the inventory database needs to be changed (ie. the Forest Inventory Planning (FIP) file format)?

- Asks the respondent if the structure of the inventory database needs to be changed.
- Provides information on the adequacy of the inventory database for overall forest management.

Question 34. Do you have any concerns or questions regarding the inventory data standards (ie. both the forest cover map files and the inventory attribute files)?

- Asks if there are any concerns regarding inventory data standards.
- Provides information on the adequacy of the inventory database for overall forest management.

Question 35. Do you currently integrate other resource information/data (eg. MOE fish and wildlife habitat data) into your inventory database?

- Asks if other resource information and data is added to the inventory database at the field level.
- Provides information on the adequacy of the inventory database for overall forest management.

Question 36. Do you currently use satellite imagery data to complete your District updates?

- Inquires if satellite imagery is used in completing District forest cover map updates.
- Relates to GIS use as one can integrate satellite data with a GIS.

Question 39. Is there a need to improve the coordination or linkage between these two components of the Inventory database (ie. the graphics file and the forest cover attributes)?

- Inquires as to whether the linkage between the two main components of the inventory database needs to be improved.
- Inquires as to whether the inventory database needs to be re-structured into a "true" GIS database.

Question 40. How would you describe the accuracy and resolution of the forest inventory database (ie. FIP file for use in the following:

- Asks the respondent to rate the level of accuracy of the inventory database for use in various levels of forest management and planning.
- Inquires as to what levels of planning that the database is best suited in supporting.
- Determines if the database is suitable for small scale planning purposes. (ie. adequacy of data resolution).
- Relates to GIS use in that the greatest identified need for GIS is for small scale planning scenarios, can the current database support this level of planning?

Question 41. Does the accuracy and resolution of the forest inventory data need to be improved?

- Asks whether the accuracy of inventory data needs to be improved.

- Assists in determining whether inventory data is accurate enough for operational uses.
- Inquires as to whether inventory data contains a level of precision high enough for use with GIS for planning purposes.

Question 42 - Inquires whether the respondent has any other comments to make

Questions not reported on in this study - that is questions collected for the Ministry of Forests' interests only

Question 4. What is the annual budget for the Inventory Program in your office (exclusive of salaries)?

- Determines the annual inventory budget.
- Used to determine the resource base and importance and stature of regional and district inventory programs.

Question 5. How many persons/FTE's do you have working in the Inventory Program in your office?

- Determines the current staffing levels and resource base for inventory, as well the importance and stature of regional and district inventory programs.

Question 6. Please list the job title/classification of those persons that work in the Inventory Program and the percentage of time that they spend working on inventory tasks.

- Determines the job titles and classification levels of inventory staff, the importance and stature of regional and district inventory programs and the percentage amount of time spent on inventory work.

Question 7. Is the current level of staffing and budget sufficient to run the Inventory Program in your office?

- Inquires whether additional resources are needed to run the inventory program, and if so for what reasons and purposes (ie. in comments section).

Question 8. Does your office require additional budget and/or staff to run the Inventory Program?

- Inquires regarding whether additional staffing or budgeting resources are required to run the Inventory Program and if so what how much more staff and budget is required.

Question 9. Please list the jobs or tasks that you spend most of your time working on in a percentage basis in descending order

- Inquires about what type of work is currently being preformed by the respondent ranked in descending order.
- Examine to see if this work is inventory related or GIS related at present or in potential.

Question 10. How would you describe the quality of the documentation and manuals that are provided by the Inventory Branch such as the Inventory Manual, etc.?

- Inquires about the quality and utility of documentation from the Inventory Branch.

Question 11. Are there any subjects or processes that the Inventory Branch should provide documentation and information on?

- Asks if there is a requirement for additional documentation on Inventory related processes and tasks.

Question 23. How good of a job is the Inventory Branch doing in keeping Regional and District staff informed as to new programs, policies and procedures?

- Asks how good of a job the Inventory Branch is doing in keeping its staff informed and up to date.

Question 24. Who do you usually contact when you encounter a problem with: (includes inventory program and GIS support)

- Inquires as to who the respondent contacts when he or she requires Inventory Program and GIS support.
- Determines whether Regional and District staff know who to contact for certain types of support and if the Inventory Branch and MOF as a whole is doing a good job in communicating and

selling the support services it offers and if these services are adequate.

Question 27. Please rank (in descending order from the most frequent to the least), the type of clients that requests forest cover maps and database reports, inventory information etc., from your office (given a range of choices)

- Identifies and ranks MOF clients with data and information requests.
- Relates to Inventory Program and GIS for same reason as question 24.

Question 31. Do you have any questions or concerns regarding forest cover map production standards (ie. chapter 11 and 12 in the Inventory Manual)?

- Asks whether there are any questions or concerns regarding forest cover map production standards.

Question 37. How do you plan to use or integrate TRIM data into your update or re-inventory projects?

- Asks the respondents how TRIM data/maps will be integrated into map update and re-inventory projects.

Question 38. How would you describe the linkage between the graphics (ie. map file/data) and the forest cover attributes (ie. the FIP or SEG file) in the Inventory database?

- Asks the respondent to describe the linkage between the two principal components of the inventory database.
- Inquires as to whether the inventory database needs to re-structured into a "true" GIS relational database.

VITA

Surname: Miller

Given Names: Christopher, Robert

Place of Birth: Gold Beach, Oregon, U.S.A.

Birthdate: 24-03-1963

Educational Institutions Attended:

University of Victoria	1981-1987
Camosun College	1983-1984

Degree Awarded:

B.A. University of Victoria	1987

Honours and Awards:

Federal Job-Trac T/A Scholarship	1988, 1989
Mark A. Green Scholarship	1986
B.C. Post Secondary Scholarship	1986, 1987

Publications:

Sullivan, Shelley and Miller, Christopher (1991) "GIS Training and Education - The Need for a New Approach", in Heit, M. and Shortreid, A. (eds.) GIS Applications in Natural Resources, Fort Collins, CO., GIS World, Inc., pp. 65-70.