

**USE OF GIS FOR INTEGRATED RESOURCE
MANAGEMENT PLANNING IN FORT
PROVIDENCE, NORTHWEST TERRITORIES**

by
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Abstract

Geographic information systems ("GIS") are being adapted for use in a wide variety of activities involving management and analysis of spatial information. In the Canadian north, aboriginal communities engaged in integrated resource management have begun to use these systems. To aid understanding the implications of GIS implementation in aboriginal communities, a conceptual framework of thirteen linked issues grouped into five overlapping areas of concern is proposed. These issues are: capital requirements for GIS; physical infrastructure requirements; interactions of GIS and community social organization and culture; requirements for education and training; availability and maintenance of data; distribution of power within the resource management agency; distribution of power between the community and external interests involved in resource management; distribution of power in the community; legitimation of knowledge through GIS use; the possibility of positivist assumptions affecting forms of knowledge GIS favour; limits imposed on GIS by cartographic theory; limits to representation of knowledge in GIS; and technical limitations to GIS analysis. Field research was carried out in the Incorporated Hamlet of Fort Providence, a community on the Mackenzie River some 75 kilometres downstream from Great Slave Lake in the Northwest Territories in Canada. The study was conducted using unstandardized and semi-structured interviews, analysis of documents, and an unobtrusive research strategy involving technical analysis of computer systems. Interview notes were analysed initially using iterations of open coding with a wide coding approach, with final analysis achieved using systematic axial coding around the categories in the conceptual framework. Analysis of the unobtrusive research was guided using the set of questions developed to shed light upon evidence of intensity of computer use. The research illustrates the practical implications of many of the issues identified in the conceptual framework. A number of recommendations are made for other aboriginal communities considering using GIS as aids for resource management.

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Table of Contents

1.	Introduction.....	1
1.1	Specific Problem Statement.....	4
1.2	Research Objectives.....	5
1.3	Theoretical and Conceptual Background.....	6
1.3.1	The Symbolic Interactionist Perspective On Culture	6
1.3.2	GIS as a Medium.....	8
1.3.3	Planning as a Technical and Normative Exercise.....	10
1.3.4	Social Justice as the Basis for Aboriginal Resource Management Planning	11
1.3.5	Summary: Implications of Theoretical and Conceptual Insights for Aboriginal Resource Management	13
1.4	Thesis Outline	14
2.	Characteristics of Aboriginal Resource Management Planning	16
2.1	Resource Management Planning.....	16
2.2	Aboriginal Resource Management Planning	18
2.3	Integration of Indigenous and Conventional Resource Management.....	19
2.4	Indigenous Knowledge	22
3.	Geographic Information Systems and Resource Management Planning	27
3.1	A Short History of GIS	27
3.2	GIS Definition.....	30
3.3	Using GIS for Resource Management Planning.....	35
3.3.1	Potential Benefits of GIS for Planning	36
3.3.2	Real Experiences and Problems with Planning GIS Use.....	37
3.3.3	Other Concerns with GIS Use for Planning.....	39
3.4	GIS and Aboriginal Resource Management: Questions and Concerns	41
4.	GIS and Aboriginal Resource Management: A Conceptual Framework.....	44
4.1	Access to Technology Concerns and Socio-Cultural Concerns.....	47
4.1.1	Capital Availability	48
4.1.2	Physical Infrastructural Requirements.....	49
4.1.3	Social Organization and Culture.....	51
4.1.4	Knowledge, Education and Local Participation	53
4.1.5	Data Sources and Maintenance.....	55
4.1.6	Connections Between Access to Technology Concerns and Socio- Cultural Concerns	57
4.1.7	Summary: Access to Technology Concerns and Socio-Cultural Concerns	59
4.2	Power Distribution Concerns.....	60
4.2.1	Distribution of Power Within Organization.....	63
4.2.2	Power Balance Between Community and External Interests.....	65
4.2.3	Distribution of Power Within Community.....	67
4.2.4	GIS and Legitimation of Knowledge	68
4.2.5	Connections Between Power Distribution Concerns.....	70

4.2.6	Summary: Power Distribution Concerns	71
4.3	Epistemological and Ontological Concerns and GIS Technical Concerns	72
4.3.1	Positivist Assumptions in GIS	73
4.3.2	Limits to GIS Imposed by their Cartographic Roots	78
4.3.3	Technical Limits to Representation of Knowledge in GIS	81
4.3.4	Technical Limitations to GIS Modelling and Analysis.....	86
4.3.5	Connections Between Epistemological and Ontological Concerns and GIS Technical Concerns.....	88
4.3.6	Summary: Epistemological and Ontological Concerns and GIS Technical Concerns	88
4.4	Summary: A Conceptual Framework For Understanding Aboriginal Community Use of GIS for Resource Management	89
5.	The Case Study: Use of GIS for Resource Management in Fort Providence, Northwest Territories	91
5.1	Background	91
5.2	Community Profiles	91
5.2.1	Locations.....	91
5.2.2	The People	93
5.2.3	History.....	93
5.2.4	Abiotic and Biotic Characteristics of the Land Base.....	94
5.2.5	Community Economy	95
5.3	The Administrative and Planning Context.....	97
5.3.1	Planning Process Initiation and Objectives	97
5.3.2	Stakeholders and Actors	98
5.3.3	Administrative Context and Decision-Making Authority.....	99
5.3.4	Process History and Initiation of GIS Use.....	100
6.	Study Design and Methodologies	102
6.1	Social Science Paradigm and Research Approach.....	102
6.2	Research Strategies	103
6.2.1	Gaining Entry.....	103
6.2.2	Becoming Invisible	105
6.2.3	Research Methodologies.....	106
6.2.4	Disengaging and Getting Out.....	108
6.3	Analytical Methods	109
6.3.1	Interviews.....	109
6.3.2	Technical Analysis of Computer Systems	110
6.4	Summary: Study Design and Methodologies.....	110
7.	Research Findings.....	112
7.1	Capital Availability	112
7.2	Physical Infrastructural Requirements.....	113
7.3	Social Organization and Culture	116
7.4	Knowledge, Education and Local Participation	118
7.5	Data Sources and Maintenance.....	121
7.6	Distribution of Power Within Organization.....	124
7.7	Power Balance Between Community and External Interests.....	125
7.8	Distribution of Power Within Community.....	128

7.9	GIS and Legitimation of Knowledge	128
7.10	Positivist Assumptions of GIS and Limits to GIS Imposed by their Cartographic Roots	129
7.11	Technical Limits to GIS Representation of Knowledge, Modelling and Analysis.....	130
8.	Implications and Recommendations	132
8.1	Recommended Steps for the Fort Providence and Kakisa Resource Management Board to Improve GIS Effectiveness.....	133
8.2	Implications of Findings for Aboriginal Resource Management Exercises	134
8.3	Research Limitations and Areas for Further Study	137
8.4	Conclusion	140
	References	141
	Appendix A: Semi-Standardized Interview Questionnaire.....	159

List of Tables and Illustrations

Figure 1:	Access to Technology and Socio-Cultural Concerns	60
Figure 2:	Distribution of Power Concerns and their Relations to Access to Technology and Socio-Cultural Concerns.....	72
Figure 3:	GIS for Aboriginal Resource Management: A Conceptual Framework	90
Map 1:	Locations of Fort Providence and Kakisa, Northwest Territories	92
Table 1:	Estimated Direct Expenditures for Fort Providence and Kakisa Resource Management Plan GIS Operations, 1993 to 1996	114

List of Abbreviations

AES	Arctic Environmental Strategy
CADD	Computer-assisted design and drafting
CCG	Canadian Centre for Geomatics
CRMP	Northwest Territories Community Resource Management Program
ESRI	Environmental Systems Research Institute
GIS	Geographic information systems
GNWT	Government of the Northwest Territories
IMAG	Information Management Group, Corporate Services Directorate, Indian and Northern Affairs Canada
INAC	Indian and Northern Affairs Canada
IRMP	integrated resource management plan
NCGIA	National Center for Geographic Information and Analysis
NTS	National Topographic Series
NWT	Northwest Territories
SDSS	spatial decision support systems

Chapter One

INTRODUCTION

In the Canadian north, there is an increasing recognition of the importance of involving aboriginal people in control of their own resource bases. Historically, aboriginal communities are known to have managed their land bases and the species on them actively. With increasing government contact and presence, management of resources was changed from a communal cultural practice rooted in long term observation of the land and the creatures on it to one administered by centralized bureaucracies managing on the basis of scientific or quasi-scientific understandings. Traditional practices were dismissed as ill-informed or banned outright. Decisions about what was to happen on the land, where, and when, were made by people far from the land, without consultation with those who lived there and depended on it.

While Canada's aboriginal communities have adopted southern technologies, for many the land base remains at the core of their existence, both for practical economic activities and because of cultural and spiritual ties to the land. After more than a century of erosion of aboriginal control and stewardship over community lands, the last twenty years have seen the beginning of some progress toward allowing aboriginal nations and communities to participate in managing their own land. Associated with aboriginal participation in land management are attempts to use indigenous knowledge to aid decision-making. Scientists and professional resource managers have begun to understand and respect the value of traditional stewardship approaches to the land. For instance, in the lower Mackenzie Valley, the traditional practice of setting small forest fires on an annual basis, dismissed by government officials earlier in the century as the product of misguided superstition and banned, now is understood by professional fire managers to aid the natural forest cycle of renewal and avoid build up of wood in stands that fuels huge, uncontrollable crown fires that devastate areas (Chowns 1995). Furthermore, indigenous knowledge of the land and the creatures on it has been afforded a new respect by botanists and biologists, and is understood as a repository of valuable knowledge that complements scientific learning rather than a motley collection of superstitions and half-truths.

The re-involvement of aboriginal communities in land management is through governments allowing them input into or control of legal processes of resource planning. Although aboriginal resource management can incorporate indigenous knowledge of the land and traditional management practices, communities must frame these in formalized, bureaucratic approaches to understanding and managing land. There are three reasons for this. First, resource management is a responsibility defined in legislative frameworks of the federal and territorial governments. While these levels of government may choose to cede some management responsibility to communities, the legal description of expected processes is unlikely to change. Second, community-based resource management agencies do not have sole jurisdiction over the

land. Federal and territorial areas of jurisdiction, as defined in the Constitution Act and by precedent, continue to exist. Government departments continue to affect the resource base through their own activities and through regulating and licensing land-based activities. Community resource management agencies would be ineffective if they did not interact with these other agencies, which are bureaucratized and require implicitly that such interactions be formalized and adhere to expected practices. Third, community resource managers must foster perceptions of themselves as credible among business interests and other users of the resource base. Without such perceptions, attempts to manage activities on the land may be resisted or ignored. In a societal context that affords respect to formal professional training and practice, aboriginal resource managers must offer indigenous knowledge and management approaches in a formalized professional guise.

Conventional resource management is based upon conservative understandings that planning can be practised as a technical process of accumulating knowledge of an area through scientific means and formally constructing this knowledge into a technical, ahistorical, and value-free framework to be used in a formalized, bureaucratic decision-making process. The essential task of accumulating and organizing an information inventory traditionally has been arduous, time-consuming, and limited in effectiveness by differing information source formats and other factors. In recent years, as capabilities of geographic information systems ("GIS") have increased dramatically while costs have plummeted, resource managers increasingly have made them a core technology for integrating, organizing, and manipulating baseline information about the resource base and activities on it in the formal process of land management. With continuing development of more capable software and hardware, GIS use is likely to continue to increase. Thus, as aboriginal resource managers adopt the approaches used by conventional resource management and synthesize these with indigenous knowledge and management practices, it is increasingly likely that GIS will be used.

Use of GIS brings practical benefits to resource managers. Relative to manual cartographic methods GIS have much greater flexibility for mapping the interrelationships between different landscape features, biotic components, and human activities. As well, new analytical approaches can now be used that either were altogether impossible previously or so time and resource intensive that they were effectively impossible. However, assessing benefits and costs associated with the technology is hampered by the recent advent of GIS. The literature of the field is still fairly sparse concerning many issues around the technology. Although some histories of GIS trace their roots back as early as the 1950's, widespread use and interest in them only began around the mid-1980's with advances in computer processing capabilities, concurrent extreme reduction in their cost, and widespread dissemination of them. The *International Journal of Geographic Information Systems*, the most important academic journal concerned specifically with GIS, began publication only at the beginning of 1987. The number of papers dealing with the technology has increased exponentially in the last ten years, but until recently the content was

concerned with technical issues associated with applications of GIS to specific problems or with means of dealing with software engineering challenges and analytical conundrums.

Proponents of GIS use claim that these new technologies should be central to all spatial inquiry. GIS, the most avid promoters claim, are nothing less than a revolutionary force that will reintegrate geography's fragmentary sub-disciplines (Openshaw 1991, 622; Chrisman *et al.* 1989, 778). GIS are presented as an integrating principle for all information that can be spatially referenced. In this view, while before limitations fundamental to manual cartography made it effectively impossible to examine the interaction of spatial phenomena more than superficially if they were recorded on different maps by different cartographers, GIS provide flexibility and a new spatial *lingua franca* that allow more penetrating comparisons to be made. According to GIS supporters, when these new systems are developed fully, people with diverse understandings of land and all its associated physical, biological, and human processes will be able to share their understandings and synthesize them into a greater whole.

It is only recently that critical examinations of GIS have begun to appear in the literature. Some of these seek to counter the initial euphoria about the possibilities opened up by GIS with assessments of limitations of the systems for representing different forms of knowledge. Some criticize GIS as promoting implicitly quantitative approaches to geographic knowledge and favouring knowledge derived through use of science while discrediting other understandings. Others point out that GIS emphasize the foci and means of communicating used in North American industrial culture, causing problems for those outside of this context who speak different languages or have different ways of doing things. Others examine the impacts of the systems on organizations, asserting that GIS adoption may require a formalisation of roles and responsibilities that promotes increasingly bureaucratic forms of operation. Others are concerned that the level of education and resources required to use the technology may restrict access to knowledge to experts, reducing effectiveness of public involvement in and scrutiny of planning processes and redistributing power to those who have GIS expertise.

Though these are promising beginnings to understanding GIS as social, cultural, cognitive, and political phenomena in addition to technical ones, the infancy of this literature leaves a number of shortcomings for assessing critically the use of GIS for aboriginal resource management planning. There is little published work concerning implementation of GIS outside of the industrialized world. What little does exist concerns GIS issues in developing world contexts, and treats cross-cultural issues in a superficial manner if at all. There is almost no published work on the use of GIS in aboriginal contexts, and none at all of which I am aware that examines critically the issues that might be raised by such application. However, there are a number of reasons for anticipating that problems will exist. First, the literature of indigenous knowledge systems describes these as markedly different from scientific knowledge systems. If GIS favour use of quantitative, scientifically-derived knowledge, they may reduce the perceived value and use of indigenous knowledge, or force those who use it to change it to fit a scientific mould. Second, the

North American industrial society focus of current GIS, emphasising the English language and management of urban areas, may be a stumbling block for indigenous knowledge use because indigenous knowledge systems are most often embodied in an oral tradition in non-Romance languages. Third, if GIS use promotes a more formalized and hierarchical organizational structure, it will tend to support the conventional means of organizing resource management over indigenous approaches, which the literature describes as egalitarian and involving all community members. Fourth, if using GIS requires that educated experts mediate between the systems and non-experts or the public, use of the technology for recording indigenous knowledge, which is a community heritage, may be problematic.

This thesis revolves around a number of basic questions regarding the use of GIS in aboriginal resource management. At the core, it seeks to answer the question: what difficulties may be encountered by aboriginal communities when using GIS as aids for resource management, and what practical steps may be taken to deal with these difficulties? Difficulties may arise in cultural, social, cognitive and political realms, as well as in the better studied technical one. Thus, several other questions arise from the core concern. What resources need to be allocated to ensure that GIS implementation is effective? What technical problems may be encountered by aboriginal groups using GIS? What forms of understanding are promoted and what forms discouraged by use of GIS? What shortcomings do GIS have for organizing and presenting indigenous knowledge, and what steps may be taken to deal with the problems? How will using a complex technology like GIS affect distribution of power in the resource management agency and the community at large?

Adoption of GIS as aids for resource management in aboriginal communities is likely to become increasingly common in the Canadian north as aboriginal groups negotiate greater degrees of self-control. Unless remedied, the lack of clear understandings of the potential weaknesses of these systems in aboriginal contexts may pose obstacles that hamper aboriginal resource management. The current lack of knowledge requires communities to move forward into unknown territory and learn of pitfalls through hard experience. With foresight, some of the hazards posed by the technology can be anticipated and considered in advance.

1.1 Specific Problem Statement

Community-based aboriginal resource management planning is being promoted by the federal and territorial governments in the Northwest Territories through programmes such as the Community Resource Management Programme ("CRMP"), resolution of land claims, and development of aboriginal institutions of self-government. A larger role in resource management will give communities the opportunity to use indigenous knowledge to aid management decision-making. Because of the increasing importance of GIS to resource managers as tools for organizing, analysing, and presenting baseline information for resource management, it is likely that communities

will consider the use of GIS in these exercises. The implications of GIS as tools for storing, organizing, and presenting indigenous knowledge have not been studied, nor have consequences of GIS use in aboriginal communities. It is important to predict problems that aboriginal resource management programmes may encounter when using GIS, and to determine what approaches will address potential difficulties. This will make it easier for communities undertaking resource management to use the technology to their best advantage, taking maximum benefit from the technology while avoiding problems associated with it.

1.2 Research Objectives

In order to achieve the thesis goal of identifying and responding to the implications of use of GIS in aboriginal resource management programmes, several objectives were defined:

1. Synthesize critical discussions of GIS into a single conceptual framework. The fragmentary nature of the critical literature on GIS makes it difficult to assess the technology critically without a long and involved study. A synthesis will aid people working with GIS to understand its potential implications at a generic level.
2. Extend the critical discussions of GIS to examine specific concerns they raise in aboriginal community contexts to make the framework more suitable for understanding issues surrounding GIS use in aboriginal communities. This will address the lack of literature examining aboriginal use of GIS.
3. Research the use of GIS for resource management in an aboriginal community. Summarize the characteristics of GIS use in the research community, including steps that have been taken to make it appropriate to incorporation of indigenous knowledge. The experiences of the community can provide an illustration of the more abstract principles detailed in the conceptual framework and how they apply to practical issues.
4. Identify difficulties encountered and practical approaches used by the research community to address shortcomings of GIS. Analyse the findings of the research to learn how they support the conceptual framework and how the understandings contained in it should be refined.
5. Recommend what steps should be considered to improve further the effectiveness of GIS use in the study community.
6. Determine practical issues surrounding use of GIS as a tool for resource management in aboriginal communities.

1.3 Theoretical and Conceptual Background

This thesis is based on a set of core assumptions about the nature of resource management planning, the rationale for including aboriginal input, and the nature of GIS. These understandings have guided the directions of research.

1.3.1 The Symbolic Interactionist Perspective On Culture

When conducting studies involving different cultural groups, it is important to establish working definitions of culture and its role. A useful perspective drawn from the literature of sociology, anthropology, and human geography is symbolic interactionism.

Earlier in the century, psycho-linguists promoted the thesis that language moulds the way that people think and restricts their modes of thought. This idea is commonly referred to as the “Whorfian hypothesis” because it was developed most completely by Benjamin Whorf,¹ though it was originally expounded by Edward Sapir and Karl Mannheim. In summary, Sapir (1931, 578) wrote, “The relation between language and experience is often misunderstood. . . [Language] actually defines experience for us by reason of its formal completeness and because of our unconscious projection of its implicit expectations into the field of experience.”² Around the same time, Mannheim explored the relationship between individuals and their cultural group, and concluded (1936, 3) that words and their meanings “not only determine to a large extent the avenues of approach to the surrounding world, but they also show at the same time from which angle and in which context of activity objects have hitherto been perceptible and accessible to the group or the individual.” Support was provided to these understandings by the work of some of the early social behaviourists, for instance John Dewey (1930) and George Mead (1934), who investigated networks of shared symbols and meaning in social interaction.

Later, the original concentration on language was expanded by anthropologists such as Edward T. Hall to focus on symbols. The foundation of Hall’s analysis of culture is that culture is communication (1959, 217), and that “people cannot act or interact at all in any meaningful way except through the medium of culture.” (1966, 177). Language is one, but not the only, repository of a body of shared symbols common to members of a culture. Other such repositories include physical artefacts and the meanings vested in them, practices, rituals, and the like. Children born into a particular cultural setting are taught symbols that have been built up over time and means of evoking these symbols in other people through language, gesture, ritualized activity, and other means. The symbols provide a means of organizing undifferentiated sensations into perceptions.

¹See, for instance, *Language, Thought, and Reality* (1956).

² This oft-cited quotation is from the abstract of a paper that Sapir presented to the National Academy of Sciences in 1931. Unfortunately, it appears that the paper itself was never published. The idea expressed here is developed, although succinctly, in Sapir (1933), particularly pages 10-13.

The process of perceiving through these symbols involves focusing attention on some things at the expense of others (Hall 1959, 120). The shared understanding of the common symbols is necessary for communication to occur, because language, understood in a broad sense, “is not (as is commonly thought) a system for transferring thoughts or meaning from one brain to another, but a system for organizing information and for releasing thoughts and responses in other organisms.” (Hall 1976, 49) Without the agreed upon conventions of common symbols provided by culture communication would be impossible because a communicator could not evoke similar thoughts to her own to guide the understanding of the receiver of the communication.

Building on these understandings, Herbert Blumer (1969), who originated the term “symbolic interaction,” built a theory founded on three premises: human action is based on the meanings we ascribe to symbols; these meanings derive from social interaction; and individual understandings of meanings of phenomena change based on the social context in which they are experienced. Echoing some of his intellectual forebears, Blumer (1969, 5) wrote: “The meaning of a thing for a person grows out of the ways in which other persons act toward the person with regard to the thing. Their actions operate to define the thing for the person; thus, symbolic interactionism sees meanings as social products formed through activities of people interacting.”

Social geographers added to this by focusing on how the spatial environment is invested with the symbols and meanings. If culture is defined as shared symbols and their meanings, including ideas about facts, desirable goals, and how people should act and interact, prevailing in any society or parts of society (Hagedorn 1986, 31), the contribution of social geographers is to explore how these shared symbols and meanings relate to space. For instance, Jackson and Smith (1984, 205) state:

[T]he emergent qualities of culture often have a spatial character, not merely because proximity can encourage communication and the sharing of individual life worlds, but also because, from an interactionist perspective, social groups may also create a sense of place, investing the material environment with symbolic qualities such that the very fabric of landscape is permeated by, and caught up in, the active social world.

This projection of culture into landscape is particularly important in cultures in which the economy is tied closely to land-based activities, such as traditional aboriginal communities. Even as these communities move away from exclusively traditional economic activities to mixed economies in which land-based work is less a matter of economic necessity, the cultural significance and spiritual ties to the land engendered by its symbolic significance remain important. For instance, traditional burial grounds, areas where important historical events occurred, and sites of legendary happenings continue to be knit into the cultural fabric.

The symbolic interactionist framework is very useful for understanding the misunderstandings and conflicts that have arisen between northern Canadian aboriginal peoples and people arriving from the south. For instance, southern government officials construct their understandings

of how people should interact with government officials and the social institution of government on the basis of a long cultural history of assent to hierarchical power relations primarily based upon position and only secondarily upon expertise. Traditional northern aboriginal cultures tend to be much less hierarchical, with authority based primarily upon demonstrated expertise and very little upon formal position. These differing understandings can lead to turbulent relations, with officials perceiving Natives as disrespectful, while Natives do not perceive officials as having demonstrated themselves worthy of respect. Southern culture understands the value of land, resources, and animals as primarily being dependent on the benefits they can bring to people, while northern aboriginal cultures vest these with spiritual significance. These different ways of ascribing significance lead to different understandings of appropriate action.³

In summary, the symbolic interactionist perspective focuses on culture as a medium of communication. Culture involves shared understandings of symbols and their meanings that allow people to evoke sequences of thoughts in others through language and other forms of communication. Thus, culture provides a framework that allows interaction between people through shared meaning, and provides a mechanism for humans to adapt to environment.⁴ Symbolic interactionism provides insight into the webs of understanding that underlie apparently simple words and concepts. It indicates how cross-cultural communication may be hampered if these strands of perception are ignored.

1.3.2 GIS as a Medium

Much of the GIS literature focuses on their technical aspects. In this understanding, GIS are tools that facilitate activities involving mapping and spatial information by making manual methods of dealing with information more efficient. Another way of understanding GIS is as social phenomena. In this regard, one way of viewing GIS that has particular value is as a medium in the sense used by Marshall McLuhan in his works on semiotics⁵ and information theory.⁶ A medium, in this definition, is an extension of the capabilities of the human body and nervous system. For instance, television extends the human visual and auditory senses and frees them from the normal constraints imposed by time, since images can be recorded and played back later, and

³ These examples obviously are gross generalizations, and cannot express the complexities and subtleties of symbolic understanding in real situations.

⁴ It should be noted that culture in this sense is dynamic and negotiable, not fixed or immutable (Jackson and Hall 1984, 204).

⁵ A simple definition of semiotics is the study of semiosis, which is "the process by which empirical subjects communicate, communication processes being made possible by the organization of signification systems." (Eco 1976, 316, cited in Head 1991, 240). This study focuses on how *content*, or meaning, is conveyed through *expression*. (Head 1991).

⁶ A short summary cannot do justice to the richness of this work. See Part I of McLuhan's *Understanding Media: The Extensions of Man* (1964) for development of these ideas.

space, since people are able to see and hear happenings that occur far away from them. The printed word extends human memory and verbal communication abilities in space and time, creating a mechanism of memory external to the brain, free from loss over time caused by the frailties of the human body, and allowing communication to occur remotely rather than face to face.

Although an impressive human achievement, media extension of human capabilities does not come without cost. McLuhan's study of media began with the observation, "the medium is the message," now the quintessential McLuhan catch-phrase. McLuhan's thesis is that each medium moulds forms of social interaction involving it and the content that can be conveyed through it (McLuhan 1964, 23-35). For example, an earthquake will produce different impressions and understandings when experienced first-hand, heard on radio, read in a newspaper, or seen on television. Human interactions will change if the dominant form of transportation people use is by foot, oxcart, bicycle, automobile, or some combination thereof.

As new media are invented, some absorb earlier media as their content, partaking of but also altering the characteristics of the original media, enhancing and intensifying some aspects, displacing or rendering obsolete others, and sometimes retrieving some that were previously made obsolete by other media (McLuhan and McLuhan 1988).⁷ For instance, the invention of print absorbed the reproduction of manuscripts in the medium of hand-produced parchment, serving the same function of allowing them to be preserved and distributed, but eliminating the artistic embellishment of the texts and reinforcing uniformity of presentation because of limitations imposed by the printing press. In this view, the microcomputer as a medium began by absorbing the functions of the manual ledger in the first spreadsheet program (Visicalc) and the typewriter in the first word processing program (Electronic Pencil), again while changing the nature of these activities. As hardware capabilities have increased, a mania has developed for absorbing an increasingly large variety of media into the computer realm. A prime example of this is the movement to multimedia computing, where the computer encapsulates the published word, still photographs, television, audio recording, video recording, etc.

These conceptions of media may be combined readily with the perspectives of symbolic interactionists. Symbolic interactionism informs us that even the most basic means of communication rely on culturally-based sets of symbols that shape the thoughts and perceptions of those using them. Similarly, semiotics tells us that media shape the forms of information that can be conveyed within them. While symbolic interactionism indicates that culture is the fountainhead of human perception, thought, and interaction, and moulds these, semiotics demonstrates that these

⁷ This list is derived from a heuristic device for understanding human artefacts called a "tetrad". A tetrad is composed of four general characteristics of all media; these are expressed in the questions: what does the artefact enhance or intensify?: what does the artefact render obsolete or displace?: what does the artefact retrieve that was previously obsolesced?: what does the artefact produce or become when pressed to an extreme? (McLuhan and McLuhan 1988, 7)

perceptions and interactions will be moulded and transformed further when mediated by media extensions. Thus, media can be understood as extensions of cultural systems of understanding and doing. The media characteristic of re-shaping content and human interactions is of particular importance in cross-cultural settings, because if media are extensions of culture, cross-cultural use of a medium can lead to an extremely subtle cultural imperialism by reordering symbols and discarding those not amenable to representation in it.

Treated as a medium, GIS are founded on computer absorption of the products of cartography, including maps and three dimensional representations of the landscape.⁸ To this is added the tabular database, which arose from the recording of information on paper ledgers, again absorbed and altered by the computer. Several questions are raised by looking at GIS from this perspective: How do the original media that have been absorbed into the computer constrain the information that can be conveyed? With the introduction of GIS which of these constraints remain constant in their effects, which are relaxed and in what ways, and what new constraints mould further the information recorded and presented? Combining this perspective with the symbolic interactionist perspective on culture provokes further questions: What forms does symbolic knowledge of culturally-important landscape features take in the aboriginal community using GIS? Which of these forms are amenable to representation in the GIS medium and which are not?

1.3.3 Planning as a Technical and Normative Exercise

Resource management is one of the broad group of activities claimed as the territory of planning. At the most basic level, planning has been defined as the guidance of future action (Forester 1989, 3). Complementing this definition, John Friedmann (1987, 38) defines planning as transforming knowledge into action; by extension, the basic activity of planners is linking scientific and technical knowledge to actions in the public domain. Friedmann defines two broad planning traditions, a conservative tradition in which the actions sought are in the realm of societal guidance, and a radical tradition in which they are in the realm of social transformation. In whatever area they practice, planners review the present state of affairs, past trends that have led to it, and associated influences, then attempt to determine actions that will lead to a desired future.

In what Forester (1989, 3) aptly refers to as a “precariously democratic but strongly capitalistic society,” planners immerse themselves in a process of balancing different and often conflicting views of what futures are desirable and what means should be used to reach them. The regulation of activities in the public sphere is not merely a technical exercise, but a political one through and through. Planning as a technical activity involves the analysis of information and policy and the connection of the outcomes of this analysis to technical instruments that promote some actions and discourage others. However, every component of the technical process can be

⁸ Earlier in history, maps themselves were new media, and introduced their own cultural effects.

supported or questioned by interests that stand to gain or lose power or other benefits from its acceptance. Thus, planning is a politically-charged activity. Although some authors who adhere more to Friedmann's conservative planning traditions attempt to split the technical process from normative processes by which communities define desirable futures and the means to reach them (for instance Hodge 1991, 169), this division is artificial. Political disengagement by planners is impossible. Radical planners begin from this foundation and engage in an explicitly political practice; in the conservative traditions the pretence of disengagement involves implicit siding with status quo interests.

If the purpose of planning is to act to move towards an ideal future, even with the knowledge that it is unattainable, planners must found their ideal visions on something other than the mere desires of those with political clout. Though planners can choose to pretend to be politically disengaged and allow desirable futures to be brokered as compromises between interests, the futures will waver like a distant oasis in the desert heat, ever shifting and as likely as not a mirage. There is a need to have reference to guiding principles that remain constant. One commonly cited normative goal is to improve the lives of people by attempting to rectify social inequities and inequalities.⁹ With the history of social inequity and inequality experienced by aboriginal communities in Canada, it seems important that redressing these when possible be adopted as a guiding principle in resource management activities involving aboriginals, along with the more common but nebulous "sustainable development" resource management principle of fostering the public good through allowing maximum economic benefit to be derived while preserving resources for future generations. The broadness of the social inequity and inequality concepts, however, leaves the operational characteristics of that to be confronted as vague as the sustainable development principle. A very useful development of the specific qualities of social equity and equality is provided by Iris Marion Young (1990) in her thoroughgoing discussion of the concept of social justice and its meaning.

1.3.4 Social Justice as the Basis for Aboriginal Resource Management Planning

In *Justice and the Politics of Difference*, Iris Marion Young examines in detail shortcomings of conventional understandings of the meaning of social justice. Young argues that political philosophers from diverse ideological positions have defined justice using a distributive paradigm. In this view, social justice is:

...the morally proper distribution of social benefits and burdens among society's members. Paramount among these are wealth, income, and other material re-

⁹ For instance, Kraushaar (1988) differentiates between planning as social reform and radical reform on the basis that the former recognizes inequities and inequalities but attempts to rectify them from within the existing sets of institutional and economic mechanisms, whereas the latter attempts to address these problems by altering the institutions and economy. The fundamental rationale for acting remains constant for both.

sources. The distributive definition of justice often includes, however, nonmaterial social goods such as rights, opportunity, power, and self-respect. (Young 1990, 16)

This distributive approach is problematic for a number of reasons. First, it ignores or presupposes the institutional contexts that determine material distribution, implicitly putting aside questioning of the roles of these institutions in promoting justice (Young 1990, 22). For instance, questions about just principles for allocating jobs assume a hierarchical division of labour and unequal access to power, income, and other desirable assets, disregarding questions about whether this form is inherently unjust. Second, the extension of the logic of distribution from material to non-material goods obscures differences between the two and subsumes the latter under the question of economic distribution (Young 1990, 18-22). For instance, social positions are understood in terms of their associated economic status but without regard for other aspects of them that make them desirable to people. Third, by reifying non-material goods, the distributive approach focuses on end state patterns while ignoring social processes (Young 1990, 24-25). Fourth, it adopts an atomistic social ontology that ignores or obscures the importance of social groups (Young 1990, 42-48).

In the place of distributive approaches, Young (1990, 39) argues compellingly for an enabling concept of justice that, instead of distribution of material and social goods, concerns itself with creating institutional conditions that allow development and exercise of individual capacities and collective communication and co-operation. In this conception, social justice is understood as the battle against oppression, which is defined as a combination of exploitation, marginalization, powerlessness, cultural imperialism, and violence (Young 1990, 48-65).¹⁰ Exploitation refers to a structural relation in which the results of the labour of one social group benefits another. Marginalization involves the expulsion of people from the system of labour and useful participation in social life. Powerlessness is the lack of autonomy, authority, creativity, opportunity to develop skills and exercise judgement, and respect of others. Cultural imperialism is the universalisation of a dominant culture as the norm and the rendering of the perspectives of other groups invisible. Violence includes physical attack, harassment, intimidation, or ridicule. By combating these, social justice will improve conditions for people to develop and express their capacities and experiences, and to participate in determining their actions and the conditions of actions (Young 1990, 37).

Though it is apparent that resource managers would be overly ambitious to attempt to confront all the faces of oppression in their activities, social justice is a useful guiding principle for assessing planning activities. The management of resources affects economic activities that use

¹⁰ Young's argument, although it rejects a concept of justice based upon distribution of material and social goods, still is steeped in Marxist understandings of alienation of the products of labour, so it relates indirectly back to production of these goods. However, although framed in terms of labour, the analysis applies more broadly than to labour relations alone.

them. In aboriginal communities that rely on the land base for significant economic benefit, the balance of different activities may afford greater or lesser degrees of power and autonomy. As well, since traditional economic activities in aboriginal communities are tied to culture, resource management can have profound effects on culture. For instance, a management regime that favours resource extraction activities such as mining and logging over wildlife harvesting and tourism may force those who participate in the latter to accept more exploited and powerless roles in the former as their opportunities to engage in their former activities are reduced. At the same time, the cultural ties to the land fostered by the wildlife harvesting activities will be cut. However, the complete rejection of resource extraction may marginalize members of the community who desire employment in these activities. Social justice provides a framework for analysis that makes the implications of decisions such as these clearer.

In resource management involving aboriginal communities, defending against cultural imperialism is of particular importance. The political nature of determining compromises among different interests is obvious, but even a seemingly thoroughly technical activity like collecting baseline information has a political component that becomes very apparent in aboriginal communities if, for example, it encourages economic and technical modes favoured by the dominant southern culture at the cost of different economic, social, and cultural modes used by Natives. The definition of what information is worthy of inclusion in baseline studies, the means that will be used to record and analyse it, and the relative valuation of different information sets all can be used to afford some parties increased power in the resource management process while denying power to others. If knowledge is power, the definition of what knowledge is valid is an exercise of meting out power to those who hold the valid knowledge while denying power to those whose knowledge is considered unimportant. Thus, a resource management approach in which only scientifically-collected information is considered while the indigenous knowledge of the community is given no heed will be culturally imperialistic. Furthermore, given the symbolic interactionist understandings of the cultural significance of landscape, changes to the land may have cultural meaning. This is not to argue that no change should occur, but that it matters who directs change, and with what motivations, cultural blinders, and results. Resource management without input of the community in forms acceptable to the community will be an exercise in cultural imperialism.

1.3.5 Summary: Implications of Theoretical and Conceptual Insights for Aboriginal Resource Management

The theoretical and conceptual insights described shed more light on the research questions detailed earlier. In summary, knowledge is a cultural product built up through sharing of symbols. GIS, as a medium, moulds the content of information that can be conveyed through them and affects social interactions that occur when they are used. Since this medium is a social phenomenon, this moulding of content and social interactions is a product of their designers from

the North American south and the symbolic understandings they bring to GIS. Thus, when used by aboriginal people who have different symbolic understandings, GIS may require foreign ways of interacting and that information content be altered to fit the assumptions of the GIS designers. Clearly, in this way GIS have the potential to be culturally imperialistic. If resource managers operating in aboriginal contexts wish to promote social justice, they must understand and deal with these potential effects of GIS. To do this, how GIS promote and discourage different ways of understanding must be explored, particularly with regard to indigenous knowledge. As well, the changes they may require to social interactions and the resultant redistribution of power need to be grasped. Of course, these understandings will be for naught if less fundamental practical concerns such as resources required to use the technology effectively and technical problems that may be encountered when using it are not known; these too must be studied.

1.4 Thesis Outline

As stated earlier, the research objectives of this thesis were to synthesize critical discussions of GIS into a critical framework, extend this framework to examine aboriginal implications and issues, then research actual GIS use in an aboriginal community to test and refine the framework, discover means through which GIS were made more appropriate to the community's needs, and draw conclusions on the implications of GIS use for indigenous knowledge and steps that other aboriginal communities can take to use GIS for this purpose. Before a conceptual framework may be presented, the fundamental concepts being dealt with must be defined and explored. To this end, chapter two considers the qualities of conventional resource management and the knowledge it uses to understand the area managed. These are contrasted with traditional aboriginal resource management approaches, and approaches to integrating these two very different ways of managing land and resources are reviewed. As well, the forms and characteristics of indigenous knowledge used for aboriginal resource management are discussed. Chapter three defines the meaning of "geographic information systems" and how planning literature sees this technology being used for resource management. As well, some of the concerns raised in this literature about possible problems with GIS use for planning are reviewed. These basic characteristics of resource management planning, and understandings of how the two interact found in planning literature lead to some initial apprehensions about possible difficulties with using the technology for aboriginal resource management.

With these definitions established, chapter four reviews the critical literature on GIS. Various areas of criticism of the technology covered in the literature are presented and summarized. Areas of criticism not treated in the literature to date are suggested. Particular reference is made to ways that the areas of criticism relate to aboriginal community contexts. A classification of the critical concerns is developed to produce a conceptual framework by which areas of concern about GIS use in aboriginal resource management may be understood.

In chapter five, Fort Providence, the community researched to test and refine the conceptual framework, is described, and the initiation, characteristics, and current state of the resource management planning process are detailed. In chapter six, the methodology employed to investigate the community use of GIS for resource management is described, as are the analytical methods used to organize and understand the research findings. Chapter seven details the findings of the research and indicates where these support and illustrate the conceptual framework. As well, it summarizes ways the community has attempted to use GIS for organizing indigenous knowledge and comments on the effectiveness of these steps. Finally, chapter eight summarizes the concerns raised for aboriginal resource managers in the thesis, makes recommendations for Fort Providence and other communities based on the findings of the case study, and points to areas for further research.

Chapter Two

CHARACTERISTICS OF ABORIGINAL RESOURCE MANAGEMENT PLANNING

Resource management normally has been carried out as a highly formalized technical exercise, linking baseline information derived from scientific examination of a resource area to a hierarchical, bureaucratic management system. When used in northern areas where Native populations engage in traditional hunting and trapping activities, conventional resource managers have assumed that they are entering a resource management vacuum. Recently, however, there has been an increasing attention to and acceptance of the idea that aboriginal people have their own traditional management systems, embodied in cultural practices, and that indigenous knowledge and practices may surpass conventional scientific management in some respects. As Native communities have struggled to re-assert control of their land bases, they have begun to demand that their traditional knowledge and management practices be incorporated into land management.

In this chapter, the characteristics of conventional resource management are discussed, including its use of scientifically-derived knowledge to understand the resource base and its formalized and bureaucratized approach to decision-making. Conventional resource management is contrasted with traditional aboriginal resource management, in which authority is derived from accumulation of knowledge and demonstrated ability to use it, and all community members are involved in resource management practices, which are inseparable from harvesting activities. Then, approaches to integrating the two are considered, including co-management arrangements and devolution of authority. Finally, the use of indigenous knowledge as a basis for managing resources in aboriginal systems is highlighted, and understandings of the nature of this knowledge are sketched out.

2.1 Resource Management Planning

The field of planning is laid claim to by a number of different professions, complicating its definition. Civil engineers, geographers, land managers, and architects all may describe themselves as planners. As well, within the academic literature of planning, a number of divergent activities are described as planning. For instance, in his well-known and exhaustive review of the history of the field, *Planning in the Public Domain*, John Friedmann (1987, 38) defines planning as linking scientific and technical knowledge to actions in the public domain. This definition encompasses activities ranging from conventional policy analysis and public administration to various efforts that reform society and improve social justice to radical and even revolutionary efforts that mobilize people to confront and change conditions of structural inequality.

Even Friedmann's definition, which delineates an extremely broad territory, is not adequate to encompass all views of planning. Recently, it has been suggested that the transition between modernist and postmodernist outlooks may represent a profound re-orientation of the profession (Beauregard 1991; Moore-Milroy 1991; Lake 1992). Since postmodernism is a revolt against a modernist foundational epistemology and ontology which relies on rationality to search for universal truth and meaning (Dear 1988, 265), postmodernist planning would draw into question the validity of the scientific and technical knowledge to be linked to action. Accepting this critique, the definition of planning would be left as "linking knowledge to actions in the public domain," an impossibly broad and useless demarcation of the term. It is not surprising that discussions of general characteristics of planning almost always deal with a subset of the field as a whole, most often implicitly.

The literature of resource management planning largely derives from conservative understandings of planning. Resource management documents normally conceive of planning in the policy analysis tradition. In this, it is believed that objective methods of science should be used to make rational policy decisions to solve problems (Friedmann 1987, 139). As well, some documents appear to be based upon the belief that resource management can fit into the social reform planning tradition, in which it is understood that rationality and technical reason can be used to moderate the excesses of free market activity to increase the social good (pp. 87-105). In either of these conceptions, discussions of conventional resource management are based on the notion that it involves the scientific management of renewable and non-renewable resources (see, for instance, Nelson 1991; Slocombe 1993).

Hodge (1991, 169) differentiates between normative planning processes, which determine the ideal approach(es) through which or framework(s) in which planning should occur, and technical planning processes, which are methods used to undertake planning. Although both are present in any planning exercise, some planners, particularly in the conservative traditions into which resource management falls, focus on planning as a technical process and treat the normative processes as preconditions that are to be accepted and not challenged.¹¹ Faludi (1973, 4) differentiates similarly between normative theories of planning, which deal with how planners ought to proceed rationally, and positive theories of planning, which focus on limitations to acting. Using this division of normative and technical processes, the literature of resource management conceives of resource management as strictly technical. Authors have varying conceptions of the rationale for managing resources, ranging from very conventional attempts to moderate land use conflict among stakeholders in an area to laudable goals of sustaining ecosystem diversity and

¹¹ This position of value-neutrality in planning has been criticized roundly and convincingly by many authors (e.g. Klosterman 1978; Harper and Stein 1992; Healey 1992; Howe 1992) on the basis that value neutrality is impossible. Lake (1993, 404) points out that the critique has gained such widespread currency that it now is taken as common knowledge. However, this theoretical recognition apparently has yet to have percolated through to many resource management planning practitioners.

promoting social equity. However, they understand the process itself as remaining constant and untainted by objectives determined politically in a separate normative process. This contributes to resistance to integration of aboriginal resource management approaches, as it requires changes to normative planning processes as well as the addition of new technical ones.

2.2 Aboriginal Resource Management Planning

Usher (1986; 1987) and Feit (1988a; 1988b) contrast the modernist conventional understandings of resource management, which they term “the state system,” with traditional indigenous systems of resource management. The state system is based upon an arrangement in which the state assumes exclusive responsibility for managing resources. Valid knowledge for management is based on scientific accumulation, organization, and interpretation of data (Usher 1986, 2) using an organismic model, the ecosystem model (Feit 1988b, 78). This knowledge is constructed into a technical, ahistorical, and value-free framework, and used in a bureaucratic, hierarchically organized, and vertically compartmentalized management system (Usher 1986, 2).

Indigenous systems, to the contrary, are founded on communal property arrangements that facilitate harvesting (Usher 1987, 6). Management knowledge is gained from the experience of all aspects of harvesting, accumulated as a cultural heritage as an integrated, non-compartmentalized view of the environment, and understood as part of a social world (Feit 1988b, 78). Management is based on consensus, and “management and harvesting are conceptually and practically inseparable.” (Usher 1986, 3) All members of the community are involved in management, with recognition of authority and leadership based on greatest accumulation of knowledge and demonstrated ability to use it (Usher 1987, 7). This system of management “is a core feature of all northern Native cultures, and is therefore intimately linked with their values, ethics, and cosmology.” (Usher 1986, 3) Management practices are framed as spiritual and value-guided, attempt to provide a balance of life and ensure continuity of all species (Wolfe *et al* 1992, 18-21).

Until recently, the two systems of management at best have not acknowledged the legitimacy of the other and often have been openly hostile. Most often, the state system has not recognized the existence of an indigenous system, assuming that it simply is filling a void (Usher 1987, 7). Feit (1988a, 44) points out that traditional management practices have often been overlooked, because they depend on social institutions and practices unfamiliar in southern society. These are “fundamentally different from forms of bureaucratic decision-making and highly specialized fields of responsibility which characterize state-mandated wildlife management systems.” Sometimes traditional resource management techniques have been denigrated as destructive superstitions and actively proscribed. For instance, a system of annual fire-setting practised by the Dene residents of the lower Mackenzie River was outlawed in the early part of the twentieth century, driving the practice underground and eventually ending it (Chowns 1995).

As Feit indicates, the traditional hostility of the state system to the indigenous system may be traced to their different ways of conceiving valid knowledge and management actions. The knowledge used to guide management actions in conventional resource management is gained through use of scientific approaches. Resource management texts refer to the need to accumulate sufficient baseline information about the resource base, often providing lists of biophysical characteristics that should be known framed in ways that make them most comprehensible natural scientists. Many of these texts adhere to the positivist conception that sound knowledge can be derived only from the practice of science grounded in observation (see Halfpenny 1982, 13-16). Wolfe *et al* (1992, 5-18) contrast this approach to knowledge with that of indigenous knowledge systems, stating that the former is analytical, objective, reductionist, and positivist, while the latter is intuitive, subjective, holistic, and experiential.

As well as its emphasis of scientific means of understanding the land, the intellectual and cultural setting that supports the conventional planning process affects conventional resource managers' conceptions of valid management actions (Feit 1988a, 44; Jacobs 1988, 54). For instance, Jacobs (1988, 54) points out that the southern view of space assumes that land can be divided and sub-divided, and that different spaces can and should be used for different activities. Based on this conception, conventional resource management planning seeks to delineate areas where different activities should occur. In contrast, northern aboriginal understandings emphasize land extent and continuity, an approach appropriate to an environment where the distinction between land and water varies seasonally and locations for traditional harvesting activities rely on the movements of mobile animal populations. Traditional management actions arising from this view revolve around controls on resource use practices that are not fixed to specific areas or apply to different areas on short and long term cycles.

2.3 Integration of Indigenous and Conventional Resource Management

In recent years there has been slow but increasing recognition that traditional management systems and knowledge systems can be a valuable complement to scientific resource management. This move has begun through a dual process of recognizing limitations to scientific resource management approaches and acknowledging the merits of traditional systems. The re-examination of the limits of scientific resource management has come about in part because of increasing interest in integrated resource management, which considers human activities and how these affect the land. Integrated management exercises have added the need to complement natural science methods of gaining information used in traditional resource management with social science methods. The application of natural science approaches to social science research has been

criticized by many social scientists as being laden with theory that biases results.¹² Thus, the introduction of social science research elements into resource management has drawn into question the ascendancy of natural science methods in resource management. As well, independent of the field of resource management, the assumption that scientific methods of gathering and analysing information yield objective understandings has come under increasing criticism. Authors such as Thomas Kuhn (1970) have argued convincingly that scientific knowledge is founded on accepted but unprovable base understandings rather than being a pure exercise in phenomenological observation and recording, and that these understandings are subject to cycles of change. Others have observed that fundamental aspects of the scientific mode of understanding such as reductionism and positivism restrict its ability to deal with environmental systems holistically and in terms of long cycles (for instance Wolfe *et al* 1992, 11-16).

While the idea that scientific approaches to resource management have limitations has grown, a re-examination of the value of traditional knowledge and management practices has taken place.¹³ A literature has developed around documenting traditional skills and knowledge (for instance Brokensha, Warren and Werner 1980; Freeman and Carbyn 1988; Inglis 1993), often indicating that these are superior to scientific approaches for understanding and dealing with environmental problems. Slowly, the growth of the study of indigenous management approaches has gained them a respect among conventional resource managers. For instance, the report of the World Commission on Environment and Development (1987, 114-115) acknowledges that indigenous communities “are the repositories of vast accumulations of traditional knowledge and experience that links humanity with its ancient origins” and that larger society “could learn a great deal from their traditional skills in sustainably managing very complex ecological systems.” In addition, there is a growing acceptance of the idea that in order to assure an adequate understanding of both the human and natural resources of a region, communities must be encouraged to articulate their social, economic, and cultural aspirations (Redclift 1987, 151-158).

With the new-found respect for traditional resource management, front-line resource managers in aboriginal contexts have begun to experiment with different means of integrating indigenous resource management knowledge and practices with conventional scientific approaches. The divergent natures of these has made this challenging to operationalize. Usher

¹² Sayer (1979, 1-5) provides a succinct summary of this position from the critical Marxist perspective, while Guba and Lincoln (1983, 3-70), and Yeich and Levine (1992, 1896-1897) provide summaries from the constructionist perspective.

¹³ Initially, this arose as a polar response to the conventional resource management disdain of traditional practices, with proponents recasting Native benighted heathens as noble savages and rejecting scientific management approaches. The initial polarity remains to some extent, though most current proponents would agree with Johannes (1989, 7) that uncritical acceptance of traditional indigenous ecological knowledge and resource management practices is equally unfortunate to dismissing them. Toward the opposite pole, some conventional resource managers who acknowledge indigenous knowledge will only accept it after applying scientific methods to verify and validate it (Wolfe *et al* 1992, 5).

(1986, 81-92) notes, in addition to the differences in conceiving property arrangements and management authority described in section 2.2, two other important differences:

- The traditional cultural dependence of northern aboriginals on hunting causes them to consider the land and creatures on it as the basis of their collective lives, social organization, and identities, while non-aboriginal systems regard the land as of recreational, aesthetic, and ethical significance, but without cultural significance.
- Indigenous resource management has the maintenance and reproduction of the social system as its primary objective, and includes the socialization of youth, the maintenance of social solidarity through sharing and mutual aid, and reinforcement of land tenure and stewardship systems. Conventional resource management, to the contrary, is based on abstracted goals of resource conservation and economic development.

Both of these make normative management goals and processes different for the two systems. Producing a system in which compromises on these goals are acceptable to all parties is very challenging.

The most common approach for combining the two approaches to resource management has been to set up co-management arrangements. Osherenko (1988, 94) defines co-management as:

an institutional arrangement in which government agencies with jurisdiction over resources and user groups enter into an agreement covering a specific geographic region and make explicit (1) a system of rights and obligations for those interested in the resource, (2) a collection of rules indicating actions that subjects are expected to take under various circumstances, and (3) procedures for making collective decisions affecting the interests of government actors, user organizations, and individual users.

An important aspect of co-management is that it does not require the level of government that has legal authority to relinquish or transfer this. This has the advantage of making it more palatable to administrators, since “government officials often jealously guard their authority against encroachment by other agencies, and they are not in the habit of sharing power with those they have authority to regulate.” (Osherenko 1988, 103) The disadvantage, of course, is that if a stake in decision-making is given only at the pleasure of the government agencies and without any legal foundation, there is a danger that co-management will be just window-dressing for the old normative processes and will seek to co-opt those in favour of effective indigenous input (Wolfe *et al* 1992, 28). Without real power sharing, co-management regimes have a reduced chance of developing mutual respect between the different parties.

A second, less common approach to integrating the two systems has come about through the devolution and decentralization of management authority from federal and provincial agencies to more local concerns. Devolution has occurred as a result of transfer of authority and

responsibility for management from higher to lower levels of government, and, much less frequently, in response to aboriginal land claims and self-government negotiations (Usher 1986, 117). A difficulty in both cases is that normative and technical processes may remain unchanged, although responsibility for administration has changed. Even when authority is transferred to aboriginal agencies, the previous power-holders will have a significant stake in the forms that management take.

In summary, aboriginal groups that are afforded a stake in resource management activities, either through co-management or devolution of authority, do not start with a normative *tabula rasa* upon which they can chalk a new set of arrangements. Rather, at best, they are afforded the opportunity to revise the existing arrangements to incorporate indigenous systems. However, while change must be accommodated to conventional resource management systems and assumptions, the increasing questioning of the value of conventional approaches and the increasing respect for indigenous resource management has meant that conventional systems are more open to change. There is an opportunity for positive change in which aboriginals can re-assume management responsibilities, adapted to a changing management environment (Riewe and Gamble 1988, 35-36).

2.4 Indigenous Knowledge

As indicated above, one of the key differences between conventional and indigenous resource management is that the former relies on information derived from scientific methods while the latter relies on knowledge distilled from first hand experiences and intuition that is accumulated over time as a cultural heritage. A literature has grown up around this second type of knowledge, which is called, variously, traditional ecological knowledge (Berkes 1993; Ruddle 1993), traditional environmental knowledge (Johnson 1992), indigenous technical knowledge (Howes and Chambers 1980), indigenous ecological knowledge (Gombay 1995), or indigenous knowledge (Warren 1989; Wolfe *et al* 1992). Gombay (1995) points out that the use of the word “traditional” causes some to understand the knowledge as being a thing of the bygone past, and favours the use of “indigenous” to emphasize that the understandings still continue to exist in and apply to the present. Although this knowledge is related intimately to the environment and ecology, as indicated in the previous section and discussed below it includes human activities and actions. To avoid the baggage carried by southern vernacular understandings of environment and ecology as separate from humanity, this paper follows the examples of Warren (1989) and Wolfe *et al* (1992) and uses “indigenous knowledge”.

There is no universally accepted definition of indigenous knowledge in the literature (Berkes 1993, 3). Few authors attempt to describe this form of knowing without reference to contrasts with conventional modern science. Certainly the few definitions of indigenous knowledge as a thing in itself still leave the concept vague and demand clarification most

effectively achieved by reference to the familiar notion of scientific knowledge. Even so, it is best to begin a description of the precise nature of a thing with a positive statement of its characteristics, rather than relying solely on a series of contrasts with another thing or things that in turn begs positive definition of the things contrasted. Two authors provide good definitions of indigenous knowledge as a thing in itself. Johnson (1992, 4) describes indigenous knowledge as:

a body of knowledge built up by a group of people through generations of living in close contact with nature. It includes a system of classification, a set of empirical observations about the local environment, and a system of self-management that governs resource use. . . . [It] is both cumulative and dynamic, building upon the experience of earlier generations and adapting to the new technological and socio-economic changes of the present.

Berkes (1993, 3) defines indigenous knowledge as:

a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Further, [indigenous knowledge] is an attribute of societies with historical continuity in resource use practices; by and large, these are non-industrial or less technologically advanced societies, many of them indigenous or tribal.

Commonalities in these definitions are apparent. Both emphasize that indigenous knowledge is derived from empirical observation of the environment and the living beings in it during resource use activities. It is accumulated as a cultural heritage over generations of close contact with the land, and is dynamic and responsive to changing circumstances and additional observations.

As noted above, most authors prefer to delimit the concept by contrasting it with scientific knowledge. Though these characterizations risk encouraging viewing the two as elements of a dichotomy rather than different approaches to understanding the same world, they aid understanding the strengths of each approach.¹⁴ Generally, several areas of difference may be distilled from papers on the subject:¹⁵

- **Modes of Observation and Understanding:** Indigenous knowledge is a product of ongoing collective concrete observation and experience, which are understood using intuitive approaches, while scientific observations are abstracted and separated from experience and understood using deductive and inductive reasoning based on theory.

¹⁴ One element of similarity noted by some authors (for instance Bronowski 1978, 9-10; Howes and Chambers 1980, 329-330) is that the empirical basis of both types of knowledge should be emphasized. This observation probably arises in reaction to conventional understandings of indigenous knowledge as being inferior to scientific knowledge, an unfortunate extension of viewing the two types of knowledge as dichotomous.

¹⁵ This list is derived from several sources, including Usher (1986), Osherenko (1988), Wolfe *et al* (1992), Johnson (1992), and Berkes (1993).

- **Measurement Approach:** Indigenous knowledge focuses on qualitative understandings more than quantitative ones,¹⁶ while scientific knowledge is mainly quantitative, with qualitative understandings largely built from mathematical models.
- **Temporality, Prediction, and Contextual Specificity:** Indigenous knowledge is diachronic, based on a long series of observations in a specific locale, while scientific knowledge is synchronic, based on short term observations in a large number of different locales. As a result, indigenous knowledge is superior for recognizing long-term cycles for a particular area,¹⁷ while scientific knowledge is superior for short-term prediction on a more generic basis.
- **Recording and Communication:** Indigenous knowledge is accumulated as a cultural heritage and transmitted through an oral tradition through story-telling and teaching through doing, while scientific knowledge is recorded in writing, understood as being acultural, and transmitted by didactic methods.
- **Connection of Elements of Knowledge:** Indigenous knowledge is holistic, understanding all elements of the environment and human activities as interconnected, while scientific knowledge is reductionist and seeks to understand each element in isolation.
- **Cultural and Social Context of Knowledge:** Indigenous knowledge is understood in a social context that includes obligations and relations of reciprocity, grounded in spiritual understandings that emphasize the unity of humanity and the natural world (Booth and Jacobs 1990), while scientific knowledge is understood to be isolated from human actions, ethical considerations, and spirituality.

It is useful, for the purpose of this paper, to note that elements of indigenous knowledge may have greater or lesser degrees of spatial location. Some indigenous understandings deal with characteristics of the land and living organisms on it that cannot be located spatially, for instance the behaviours of lynx during mating season or the specific medicinal qualities of a certain plant. Some deal with elements with an indistinct spatial component, for instance the general movements of bison from one seasonal range to another, or the microclimatic characteristics of good areas for picking berries. Finally, some deal with elements with fairly specific spatial locations, such as wintering areas for deer or location of spawning beds for salmon.

It is evident even from these examples that the holistic and synthetic nature of the knowledge described above makes it difficult to attempt to break down the knowledge into

¹⁶ Johnson (1992, 9) notes, however, that Feit's (1986) work with subarctic beaver trappers indicates that indigenous knowledge can be quantitative. It is clear that this differentiation between indigenous knowledge and scientific knowledge should be taken as relative rather than a polar absolute.

¹⁷ Wolfe *et al* (1992, 13) summarize, succinctly, that "there is no single Native science or knowledge system; each group has a system specific to their locale."

components and classify each component in this manner. However, methodologies used to document indigenous knowledge sometimes focus more on spatial or non-spatial elements. For instance, traditional land use and occupancy studies emphasize spatial location of hunting, trapping, and fishing activities, while paying less attention to biotic and landscape characteristics that influence why these locations are suited to the activities. Traditional ecological knowledge studies, on the other hand, may stress animal behaviours and plant characteristics while not focusing on where these animals and plants are located. As will be seen in chapter four, the spatial emphasis of GIS may direct attention away from indigenous knowledge elements that cannot be represented or are difficult to represent spatially.

Although indigenous knowledge has received growing mainstream acceptance as valid and useful, this review would not be complete without noting criticism of it. Negative views of indigenous knowledge are expressed most openly in earlier works, written from the perspective of conventional modern natural science. In these, contrasts between indigenous knowledge and scientific knowledge involve subtle or not so subtle denigration of the former fostered by a idolatrous worship of the latter blind to its own weaknesses. A typical example is provided by Howes and Chambers (1980, 330), who state that indigenous knowledge systems are closed systems, characterized by a lack of awareness that there may be other ways of regarding the world, while “science is an open system whose adherents are always aware of the possibility of alternative perspectives to those adopted.” In the same paragraph they cite Thomas Kuhn’s (1970) *The Structure of Scientific Revolutions* to support this contention, stating that indigenous knowledge is comparable to Kuhn’s “normal science” within an established paradigm, while “science, in contrast, constantly carries with it the possibility of ‘revolutionary change’ in which one paradigm would be destroyed and replaced by another.” In a terrific irony, the core of Kuhn’s discussion of this revolutionary change, which he terms paradigm shift, emphasizes that it comes after a paradigm crisis, in which empirical evidence demonstrates the inadequacy of the existing paradigm to explain reality so compellingly that it forces a few visionaries to seek a new paradigm (1970, 79-90). Kuhn emphasizes that almost all scientists in a given paradigm will never be able to remove their blinders and step into a new paradigm. In other words, Kuhn’s work asserts that science compels its adherents to close their minds to empirical evidence contrary to their theoretical constructs, a way of thinking arguably more close-minded than supposedly closed indigenous knowledge systems, which at least have a pragmatic regard for empirical evidence.

As detailed in the previous section, there has been growing discussion of and attempts to integrate indigenous knowledge and associated management practices and conventional resource management. One important concern about these efforts is that if not carefully handled, this integration may involve forcing indigenous knowledge into the scientific knowledge frameworks favoured in conventional resource management. Because it is transmitted orally, often through the praxis of shared activities, indigenous knowledge already is vulnerable to loss as a result of culturally inappropriate approaches to knowledgeable elders (Wolfe *et al* 1992, 17-18). Furthermore, when not handled with great sensitivity, embodiment of indigenous knowledge in

formal management structures may transform it from a dynamic entity to a static one, a collection of facts and figures isolated from its physical and cultural sources and detached from its true meaning (Gombay 1995, 178).

Since GIS are being used increasingly in conventional resource management to compile, analyse, and present information on the land base, and because efforts to include indigenous resource management approaches must be accommodated to this form of resource management, the differences between indigenous and scientific knowledge are a particular concern in aboriginal resource management exercises. In the next chapter, the basis of GIS in quantitative geography and other scientific disciplines concerned with land is detailed. These roots of GIS raise the question of how GIS use in resource management will affect indigenous knowledge. Knowledge systems that have adapted to centuries of biotic, abiotic, cultural, and technological change must have a measure of resiliency that will allow them to accommodate some changes, and perhaps benefit from access to other ways of knowing. At the same time, because of the differences between these ways of knowing, the combination of the two management approaches demands creative and thoughtful approaches.

Chapter Three

GEOGRAPHIC INFORMATION SYSTEMS AND RESOURCE MANAGEMENT PLANNING

Although *prima facie* one would expect that defining a seemingly concrete technology like geographic information systems would pose little difficulty and that broad agreements would exist in the literature, a review of the literature reveals that this is not the case. There are fundamental disagreements on how broadly the term should be applied, requiring that readers of texts that do not define the term explicitly decide how broadly the net is being cast. This fuzziness of definition does nothing to improve the rigour of discussions on the technology. In this chapter, a capsule history of the development of GIS is presented to indicate the roots of some of the differences between definitions. Competing definitions are reviewed, and an explicit definition of the term in the context of this thesis is developed. Then, some of the basic discussions of GIS use in planning practice and resource management are reviewed. These grapple with how this spatial information technology should be incorporated into resource management planning. The discussions anticipate, in a general way, some of the critical concerns about GIS use in aboriginal resource management that are discussed in detail in chapter four.

3.1 A Short History of GIS

A useful starting point for defining GIS is to examine the history of their development and the antecedents that contributed to their advent. Though there is some truth to the assertion of Coppock and Rhind (1991, 22) that the definition of GIS adopted will determine in large measure the content of a history of GIS, competing historical claims also help to clarify how some of the understandings of how GIS should be defined come about. As well, understanding the history of the technology aids grasping some of the issues and limitations discussed in chapter three.

One of the historical roots of GIS often mentioned in the literature is the development of computer-assisted cartography. The possibility of using computers as aids to manual mapping exercises was considered as early as 1959 (see Tobler 1959). However, for many years computer-automated cartography could only be accomplished on large mainframe computers (Marble and Amundson 1988, 309). Even these were severely restricted in capabilities because of market focus on numerically intensive scientific applications for universities and transaction and inventory management applications for large businesses, neither of which required computer graphics (Goodchild 1988, 313; Coppock and Rhind 1991, 26). Pioneering experiments with adopting mainframe computers for mapping purposes occurred through the 1960's. In general, during this time achievements were the product of individual personalities operating largely in isolation (Rhind 1988) in large government organizations such as the Canada Department of Energy, Mines and

Resources, the Topographic Division of the U.S. Geological Survey (Tomlinson 1988, 250-251), and the British Experimental Cartography Unit (Rhind 1988), and in universities, most notably at the Harvard Laboratory for Computer Graphics and Spatial Analysis (see Chrisman 1988).

A second important antecedent of GIS is the field of remote sensing. Image processing software was developed from the late 1960's onwards to analyse increasingly available digital satellite images. As early as 1972 the potential for use of remote sensing data in GIS was discussed by Roger Tomlinson (1972, cited in Nyerges 1993, 76). Linkages between image processing and GIS developed for digital cartography remained nascent until the 1980's. However, as digital image processing software developed, rudimentary map generation capabilities were added and attribute manipulation abilities were improved, incrementally producing raster-based GIS (Marble and Peuquet 1983). Since the 1980's some considerable effort has been made to improve links between GIS software developed to aid cartography and spatial analysis and these image processing systems.

A third contributor to the development of GIS is the field of spatial statistics. Mathematical approaches were developed by quantitative geographers in the 1950's and 1960's to approach such problems as statistical measures of central tendency, gravity potential modelling, application of regression analysis to spatial data, shift-share analysis, discriminant analysis, nearest-neighbour analysis, and spatial autocorrelation¹⁸. Application of these techniques to anything except trivial problems requires an exceedingly large amount of calculation that is feasible only using computers. Programs to automate processing of these analyses were usually non-graphical, falling under the rubric of the numerically intensive scientific applications that the computer hardware and software of the 1960's addressed. As graphical hardware and software capabilities increased through the 1970's and onward, a number of spatial statisticians¹⁹ migrated to applying their quantitative approaches using GIS.

A fourth precursor to GIS development is the development of database software. As mentioned previously, one of the major foci of computer systems application during the 1960's was the automation of transaction and inventory management applications for large businesses. The original, rudimentary forms that software addressing this need took was based on computer representation of paper ledgers and filing systems. Gradually, computer database software supplemented this approach with hierarchical representations of inventory items as entities related to each other by key fields. As well, they were transformed into more generic software engines applicable to a broader range of problems than the manual systems they replaced. During the

¹⁸ See Berry and Marble (1968), Pounds (1970), Cole and King (1968), and Taylor (1977) for discussions of these techniques.

¹⁹ The most notable is Duane Marble, who has developed a considerable regard for his GIS work under the auspices of the NCGIA.

development of GIS, the approaches used by database software were adopted by GIS designers to associate textual and numeric attributes to graphically represented information.

A number of other professions also are cited as having contributed to the pioneering efforts that led to the development of GIS. These include civil engineering (Nyerges 1993, 76), surveying, computer science, and mathematics (Coppock and Rhind 1991, 22). Many different professions concerned with understanding and manipulating spatial information were inspired by new data processing capabilities to evolve computer methods of representing and manipulating space, most often in isolation to each other. The field of GIS developed "from a melting pot of concepts, ideas, practice, terminology and prejudice brought together by people from many different backgrounds, interacting with each other often on a chance and bilateral basis in the early days and normally proceeding in blissful ignorance of what was going on elsewhere." (Coppock and Rhind 1991, 22)

During the 1970's and early 1980's, the seminal experiments began to be replaced with more regularized practices and experiments, particularly in large national agencies. During this time local experiments and actions continued, often duplicating efforts (Coppock and Rhind 1991). Disjunct approaches to managing geographic information in computers common in the 1960's systems (Clarke 1986, 175) began to be integrated into models, both in university contexts and in nascent commercial enterprises. For instance, a prototype vector-based geographic information system called the Odyssey system was developed at the Harvard Laboratory for Computer Graphics and Spatial Analysis (see Morehouse 1978; Chrisman 1988). One of the chief designers of this system later moved to the Environmental Systems Research Institute ("ESRI"), a commercial company, founded by another Harvard Laboratory alumnus, that provided professional consulting services to support geographic studies and has since become one of the largest commercial GIS firms. ESRI developed a number of software packages to automate mapping and geographic analysis (Dangermond and Smith 1988, 301-303). The experiences gained through this development later formed the basis for programming ARC/INFO, a geographic information system that has enjoyed great success during the 1980's and 1990's. A number of other commercial GIS enterprises, including Intergraph, ComputerVision, and Synercom, entered the market during the 1970's, mostly from the CAD/CAM sector (Coppock and Rhind 1991, 32). These drew from the pool of people who had experimented with precursors to GIS.

The explosion of interest in, use of, and academic discussion of GIS that has occurred in the last ten years has been linked to the development of microcomputers of sufficient power to move GIS into smaller agencies and to individual users from the large government bodies and universities in which they were concentrated. This development has occurred since the mid-1980's. Even as late as 1988, Marble and Amundson (1988, 309-310) noted that problems with the simple operating systems and lack of memory and disk storage capacity imposed significant limits to microcomputer GIS. Since that time, for an average system the processing speed has improved at least 20 fold, memory capacity at least 4 to 8 fold, and disk storage capacity about 30

fold while the total system cost has fallen even without accounting for inflation.²⁰ As well, graphics hardware, output devices, and operating systems have improved. As this development has occurred, new commercial GIS vendors such as Mapinfo Corporation and Strategic Mapping Incorporated have entered the market, providing inexpensive software with reduced functionality relative to the older, mainframe and minicomputer based GIS vendors that evolved in the 1970's and 1980's. In the 1990's, the commercial GIS data, software, and hardware market is estimated to be in the billions of dollars (Nyerges 1993, 76).

The increase in the installed base of GIS software and interest in its use has raised anew the question of what constitutes a geographic information system. Representatives of the older, more established GIS software concerns sniff that the newcomers do not sell "real" GIS. Meanwhile, a new generation of academic researchers writes about the technology using a number of definitions that, while they resemble each other, do not agree on what the fundamental qualities that define GIS are or where the line should be drawn between the hardware and software components and related data and activities. As Cowen (1988, 1551) observes, "vague definitions are doing a great disservice to the field by allowing the label of GIS to be applied to almost any software system that can display a map or map-like image on a computer output device." Furthermore, vague definitions cloud discussion of the qualities of GIS. Before GIS are discussed, what is meant by "geographic information systems" should be clarified.

3.2 GIS Definition

Maguire (1991) points out that several facets of GIS converge to make it difficult to define what is meant by the term "geographic information systems". First, as detailed above, although the field can trace its roots back as far as the 1950's, widespread use of the technology has only occurred in the last ten years. Combined with the recent intense activity in the field, the rapid rate of GIS theoretical and practical development throughout its history has not been conducive to analysis and definition. Second, the commercial interests involved in GIS have produced a great deal of hyperbole and rhetoric, often contradictory, about the technology. Third, GIS are integrating systems with a great diversity of applications. These "bring together ideas developed in many areas, including the fields of agriculture, botany, computing, economics, mathematics, photogrammetry, surveying, zoology and, of course, geography, to name but a few. Inevitably, it is difficult to distinguish between the competing claims of different organizations and individuals all of whom wish to be represented in a vibrant and profitable field." (Maguire 1991, 9) Fourth, GIS are difficult to define because there are many ways of defining and classifying their subjects and objects. For instance, definitions have been proposed based on processes (Carter 1989), functionality (Burrough 1986), applications, database characteristics (Smith *et al* 1987), and

²⁰ The statistics provided in this paragraph were current as of April of 1996. Price-performance movements are so rapid that they are unlikely to remain valid for more than three months.

taxonomy (Obermeyer 1989), among others. Fifth, there is academic disagreement about the focus and scope of GIS.

One issue of definition springs from how much the word “system” is understood to include. Recent academic discussion of GIS has shown an increasing focus on the characteristics and challenges posed by implementing the technology to achieve various objectives, for instance as aids for environmental problem-solving, developing world tourism development, municipal land management, and the like. Studies of this nature would fail if they treated the technology in isolation to the capital, infrastructural, personnel, and organizational contexts into which it was introduced. A response of some authors writing on GIS implementation issues is to define GIS as systems in the broadest sense, where GIS encompasses the human operators and processes, organizational structure, socio-cultural context, and physical infrastructure as well as the computer hardware, software, and data (for instance Carter 1989; Frank, Egenhofer and Kuhn 1991; Burrough 1992).

The rationale behind these broad definitions of GIS is laudable, and the inclusion of all important system aspects is in keeping with the use of “system” in the systems design field. Certainly, when examining the implementation of GIS, treating technical issues in isolation to the context in which they occur would be short-sighted. As well, those with a systems design background and training will wince at the colloquial, narrow use of “system” to refer to a computer system and associated software only.²¹ However, the broadening of the definition of GIS to include elements other than the computer hardware and software runs counter to the vernacular use of the term and its use in most academic literature. Furthermore, the broad definition demands, for the sake of precision, that a new term be coined to refer to the computer-related components of the system. Little of the discussion of GIS in papers defining them broadly actually refers to systems in their entirety when using the term GIS. Often, these papers use GIS to refer to the more narrowly defined computer components as well as the broad system, relying on context to indicate to what the term applies. The result of these problems is that the intentions of the proponents of broad definitions to retain the pure definition of “system” and remind readers that the software technologies do not exist in isolation to their systems contexts are not realised, and instead the meaning of an already imprecise term is muddled further.

Based upon a thoroughgoing review of the literature, Cowen (1988, 1551-1552) states that there are four general approaches to defining GIS. First, process-oriented definitions describe GIS as comprising several integrated subsystems dealing with geographic data. These include software that handles input, storage, retrieval, analysis, and output. Second, application approaches categorize GIS by type of information handled. For instance, these definitions would list natural resource inventory systems, urban systems, and planning and evaluation systems all as being GIS. Third,

²¹ Some authors use other terminology to describe the computer hardware and software itself. For instance, one conference referred to “geographic information technology” (see Masser and Onsrud 1993).

toolbox approaches describe operational software functions and algorithms used in GIS for handling spatial data. These are similar to process-oriented definitions but provide explicit delineation of software sub-functions. Fourth, database approaches describe how geographical information is organized in computer databases. These on their own mainly deal with questions of representation of geographic co-ordinate information and its linkage to attributes or variables, problems that are more important to system performance than to system functionality. Because of this, most often they are linked to toolbox approaches.²²

Cowen points out that each approach on its own fails to provide a viable definition of the field, either by being too inclusive to distinguish GIS from other types of automated geographical data processing in the first two cases, or by failing to provide viable definitions of the field by concentrating on specifics in the last two. For a formal definition, the application approach is not appropriate, as the definition should be independent of subject matter, while application approaches rely on producing exhaustive lists of uses of the technology. Likewise, the toolbox approach relies on forming a check-list of system functions, failing to provide a viable definition of the field as a whole. As well, both of these approaches are weak because the discipline or disciplines a list writer emerges from will affect the list content. Despite their shortcomings for defining GIS on their own, the database and functional approaches provide some guidance as to components of a definition.

To the database and functional approaches detailed by Cowen, it is necessary to add a physical characteristics approach to deal with a problem that arises from the broadening of the term "system" described above. Some definitions of GIS insist that these systems do not need to be computer-based at all and can include manual systems.²³ This leads to similar problems to the broad systems definitions described above in that despite having merit from a pure definition of "system", defining manual information systems as GIS runs counter to normal usage. Even Maguire (1991, 10), who introduces this concept into his definition, admits that "all contemporary information systems are computer based." There seems to be as little value to this extension of the term as including abaci and slide rules in a definition of computers; it serves only to reduce precision and introduce a potential for confusion. Therefore, the first element of the definition of GIS used in this thesis is that they are computer-based systems and associated software.

A second element of a GIS definition is suggested by Clarke (1986, 176), who asserts that GIS must provide a "unity of sorts", an integrated environment for dealing with geographical

²² A taxonomical approach detailed in Obermeyer (1989) can be added to these as a fifth approach. This relies on formal approaches to taxonomic classification developed in the natural sciences, and promises much greater rigour than most definitional approaches in the literature. However, effectively this approach is a combination of the application and toolbox approaches underpinned by much better theoretical understandings, and suffers from the weaknesses described for those approaches.

²³ For instance Maguire (1991, 10), Dickinson and Calkins (1988), and Aronoff (1989, 39: cited in Maguire 1991, 10).

information. As the description of the early history of GIS development indicates, seminal experiments with spatial information processing software during the 1960's were often fragmentary products of inspired individuals or groups of individuals. Early programs most often were written to achieve specific ends. For instance, individuals at a university laboratory like the Harvard Laboratory for Computer Graphics and Spatial Analysis might have developed one program to convert spatial co-ordinates to digital form, another to establish topological relationships between spatial entities, another to conduct proximity analysis, and yet another to produce paper outputs. Without an umbrella of program, user interface, and database standards to link these, spatial information processing was not so much a toolbox of methods as a workshop with various tools intended for roughly related purposes scattered about haphazardly. A GIS definition must differentiate between such fragmentary approaches, where different geographical processing software components are loosely-linked or stand-alone, and the integrated environments for dealing with geographical information that GIS provide.

The database approach that Cowen describes leads to another set of elements necessary for defining GIS. Parker (1988, 1547) summarizes succinctly that GIS databases deal with geographic features and must specify three things for each feature: where it is; what it is; what its relationship to other features is. GIS include geographical information, which is represented as features with two data elements: locational information and attribute information. The locational element to each feature describes its geographical location in two, or less frequently three, dimensions. Most current GIS use one or both of two systems, raster and vector, for representing location.²⁴ The raster system divides land areas using a grid, and represents each object with by one or more grid cells. The vector system represents objects using the cartographic fundamentals points, lines, and areas (or "polygons").²⁵ Maguire (1991, 12) rightly notes that "spatial" and "geographical" often are used interchangeably to describe geographical features, but that the term spatial refers to any type of information about location, while geographical "refers only to locational information about the surface or near surface of the earth at real-world scales and in real world space."

The attribute element or elements of each feature contain non-spatial information describing the feature. Traditionally, attributes have included numeric information such as surface area, number of occupants, and land classifications, or textual information such as place names and descriptions. More recently, incorporation of object-oriented database approaches into GIS have allowed some systems to include a wide variety of other attributes, such as sounds, pictures, and

²⁴ Some authors (for instance Newkirk and Yang 1990) define only vector systems as GIS, with raster systems defined as remote sensing software. The roots of GIS in remote sensing described in the GIS history and the close linkages between current cartographic spatial information systems, which tend to favour vector models, and remote sensing spatial information systems, which tend to favour raster ones, suggest that this differentiation is artificial and should be eschewed.

²⁵ A third system, which is a superset the vector system, allows objects to be represented as objects, where an object can be a combination of points, lines, and polygons. This is used by the McDonnell Douglas GIS extensions to its GDS product. As well, in theory, raster elements might be added as part of an object.

video clips. Software with the ability to store geographical but not attribute information may assist users with producing maps, but it must be classified as automated cartography software and not as GIS. Tomlinson Associates (1987, 204) differentiate these on the basis that automated cartography is the use of computer-based systems for more efficient production of maps, while GIS focus on analysis and manipulation of geographical data.

As well as including information about geographical features represented with geographical location and attribute data, GIS databases must include descriptions of the relations between the features. In GIS, all objects have a set of explicit topological relations with other objects. For instance, in vector GIS, lines with end-points co-occupying the same location will have explicit connections to one another, while abutting areas will be stored as explicitly adjacent. This characteristic of GIS databases often is used to differentiate GIS from CADD systems. Although both may be used to represent geographical features with attributes, the CADD systems do not contain any explicit topological information. This characteristic of CADD systems makes computer-based analysis of data difficult or impossible.

Cowen's functional approach points toward a final set of elements for defining GIS. GIS must include a set of basic functions for manipulating the geographical data their databases contain.²⁶ First, GIS software must include functions for creating and editing both geographical and attribute information in data sets. Normally data set creation in GIS is handled through table digitization of paper maps or use of co-ordinate geometry approaches derived from surveying techniques. As well, data sets may be created by capture of digital satellite signals or conversion of aerial photographs to digital orthogonal format. Insisting on this functionality excludes a relatively new class of GIS related "viewer" software, for instance ESRI's ArcView versions 1 through 2.1 and Tydac's SPANS Explorer version 1.x, that allows people to query information in and change the output appearance of existing data sets, but does not allow new information to be added. Without the ability to produce new data sets and make changes to existing ones, users of viewer software can have only ephemeral influence on information provided by others. This violates Clarke's (1986) rule, described above, that GIS provide a unity rather than be fragmentary. Necessarily associated with this database creation and modification characteristic, a second GIS necessity is that they must allow created data sets to be stored and retrieved at will.

A third necessary function of GIS software is that it includes the capability to allow computer-based analysis of geographical data based upon locational and attribute information. Examples of analytical operations include distance and area measurement, buffer generation around features, reclassification, and overlaying of data layers. The lack of this type of functionality normally is cited in literature that differentiates between computer-based cartography and GIS (see, for instance Goodchild 1988). The dynamic nature of GIS and development of

²⁶ These elements are derived from Clarke (1986, 176) and Burrough (1986, 6), though they are not unique to these authors.

functionality, along with the lack of viability of GIS definitions that rely on specifics discussed above makes it unprofitable to list specific analytical operations that must be included, but without the ability to undertake computer-based analysis, software cannot be classed as GIS but only as facilitating computer-based cartography.

A fourth essential GIS software function is that the systems must include the capacity to allow graphical and tabular display of data sets and production of output maps and tables. Simple versions of viewer software restrict output generation to capturing and reproducing screen images. Without the ability to produce formally annotated and formatted maps with the expected features such as scale, north arrow, title, and legends, pseudo-GIS software removes itself from its cartographic roots described in the history section above. Although the history makes it clear that GIS do not derive from cartography alone, the ability to produce maps is an essential component of them.

In summary, GIS may be defined as follows: GIS are computer-based systems and software that: (a) provide an integrated environment for dealing with geographical information; (b) include databases that represent geographical information as features with locational and attribute information, and include topological information describing the spatial relations between features; and (c) provide functions that allow creation and editing of data sets, storage and retrieval of these, analysis of them based on location and attributes, graphical and tabular display of information, and production of output maps and tables.

3.3 Using GIS for Resource Management Planning

Because a significant part of planning exercises involves reviewing, analysing, and synthesizing spatial information, it is to be expected that planners would look to GIS with considerable interest as aids to their activities. Interestingly, although the history of GIS includes many people from professions related to planning, and the seminal experiments in applying the technology include planning operations from early on, documentation of GIS use in the planning literature was very sparse until the mid-1980's. Widespread interest in planning applications of GIS has appeared only with the explosive development of computing power described earlier. A not insignificant literature documenting planning and resource management uses of the technology has been published recently, but it is still exploratory in nature. Articles either deal in theoretical generalities with little or no reference to practical examples, or describe specific experiences with GIS but with little reference to theory. A review of articles in the theoretical camp reveals two general planning application themes: information inventory maintenance and spatial information analysis. As well, some of the work describing inventory functions indicates that a third theme, information presentation, should be included, although this is not defined explicitly. Though there is agreement that GIS have great potential as planning aids in the theoretical papers, descriptions of real implementation and papers critically examining planning implications of the technology

indicate a number of problem areas that may affect use for aboriginal resource management planning.

3.3.1 Potential Benefits of GIS for Planning

In the literature of GIS use in planning, one frequently observed point is that GIS are very useful for enhancing information inventory functions previously handled manually. Two major benefits for planners are noted. First, the process of maintaining information records is made more efficient. There is a great enthusiasm for efficiencies gained over use of manual records and paper maps, which “were expensive to prepare, hard to store, and very difficult to maintain, update, and analyse.” (Klosterman 1995, 1) Second, storage of planning information in GIS encourages representation of different data sets in a common format, easing comparison. In the past, information important to planning often has been maintained and stored in diverse jurisdictions and formats, making it hard to gain access to and compare components. GIS information inventory capabilities provide a “superior filing system” for land information, allowing this information to be assembled into a single database (Marble and Amundson 1988, 306). Coherent representation of information allows decision-makers to gain a sophisticated polyvalent picture in a concise form (Douven *et al* 1993, 318). Thus, planners may spend time considering strategic policy issues that would have been used extracting data and generating relationships between them and other data. Both information inventory benefits do not alter planning activities using manual methods, but rather reduce the allocation of resources to routine record keeping and manual information processing for comparison, allowing planners to gain more thorough understandings that benefit decision-making.

A second planning application of GIS is the use of spatial analysis functions to improve understandings beyond manual spatial analysis methods. Simple analyses, such as spatial overlay and buffer operations, already are used in manual planning practices. The concerns expressed about the time-consuming nature of manual methods for managing information inventories and the enthusiasm about improved efficiencies to be gained through use of GIS are echoed in discussions of comparative advantages between manual and GIS analyses of this sort. For instance, capacity and constraint analysis previously handled by arduous manual transfer of different constraining and capacity factors to mylar overlay maps is made much faster by GIS (Marble and Amundson 1988, 307). This is a benefit that results, in part, from the common format discipline that GIS impose upon data sets entered into them. Previously, maps of different scales, projections, and symbolic conventions had to be converted into common ones to allow these analyses; GIS, to the contrary, allow a degree of after-the-fact manipulation of these map attributes.

In addition to overlay analysis functions previously accomplished manually, GIS permit analyses that were previously too time-consuming to perform without computers. For instance, these systems allow the easy construction of statistical breakdowns of land classification and other attributes (Marble and Amundson 1988, 307-309) such as density of school aged children in a

school catchment area or district average price for land by land use. For transportation planners and civil engineers, the behaviour of flows through networks may be analysed to predict capacities of roadways or storm sewer shortcomings. As well, GIS have the potential to allow more complex numerical analyses and construction of predictive spatial models. Particular attention has been paid to developing these models by GIS researchers in the field of resource management planning.

A third general area of use for GIS in planning is touched upon by some authors who discuss the utility of GIS information inventory capabilities. A key associated function of managing information for planning is presenting it, both in public fora and privately to stakeholders in plans. Large planning departments are able to employ technical cartographers or draftsmen to synthesize important information into comprehensible summaries, but even with such staff manual cartographic output is time-consuming and inflexible to after-the-fact requests for changes or additions. GIS improve the quantity and quality of cartographic products that may be produced in a reasonable time frame. Harris (1989, 86-87) notes that because many planners are visually oriented the mapping and display characteristics of GIS are of great psychological and operational importance as aids to visualization. Furthermore, the flexibility of GIS for producing cartographic and non-cartographic summaries of information allows these to be tailored to the interests and levels of expertise of knowledge users.

3.3.2 Real Experiences and Problems with Planning GIS Use

While they provide good insights into potential planning applications of GIS, most of the articles cited in the previous section are speculative rather than based upon field experiences. The optimistic ideal visions they present are not borne out in descriptions of actual GIS use for planning. In general, articles report significant problems with integrating the technology into planning that result from software design, organizational, and administrative problems; successes are reported only in implementing strictly technical and quantitative analyses.

One set of difficulties associated with GIS use for planning arises from shortcomings of the software. Some problems described are not inherent to GIS, but rather require additional programming or changes to program designs that are still being made in a developing industry. For instance, as documented in the earlier GIS history, GIS were spawned largely in North America. Even today, all major GIS software firms are based in North America; systems developed outside the continent are small endeavours of inspired non-governmental organization departments, the United Nations, or universities. With these roots, the primary software development focus has been the English-speaking industrial world. Planners operating outside this context may find that the software is not amenable to local conditions. For instance, Wegener and Hartwig (1993) state that lack of GIS support for local language caused problems for German planners. As well, the transversal Mercator projection used for German base maps was not supported. A more fundamental GIS software criticism is that the software is difficult to use, both because the

complexity of operations requires specialized technical knowledge and because user interfaces are not conducive to easy use. For instance, Robinson, Frank, and Karimi (1989, 156) state that the main obstruction for GIS use in resource management is that current resource management GIS are not easy to use, and that it is not realistic to expect resource managers to become GIS experts. Though most articles describing use in specific circumstances do not mention this problem explicitly, frequent mention of the need for expert personnel and staff training (e.g. Yapa 1988; Yeh 1991, 15-16; Cartwright 1993, 266-267; Rumor 1993, 232) supports the idea that technical problems result at least in part from software complexity.

A common theme in many articles describing specific implementations of GIS for planning is that organizational and administrative difficulties associated with the technology keep it from being used effectively. Organizationally, GIS may change internal power balances in planning agencies, with older, less technically literate individuals losing power to newcomers with GIS knowledge.²⁷ As well, compiling an information base in one location and format may require that control of information shift and that related planning agencies with different practices standardize these as well as agreeing on common GIS formats and software. Potentially, this involves a multi-organization bureaucratic formalisation of roles, responsibilities, and reporting relationships. Not surprisingly, such changes are not easily effected. For instance, Arnaud (1993) describes planning use of GIS in Portugal as a Tower of Babel of unco-ordinated effort, with individual planning efforts driven by consultants and vendors, and a lack of standards stymieing information sharing. Rumor (1993) outlines GIS use for urban planning in Padova, Italy, describes several technical difficulties encountered, but concludes that organizational and political issues were even more critical than technical ones.

With reports of GIS use for planning emphasising pitfalls of introducing the technology into planning contexts, it is not surprising that a study of use of GIS by planning agencies in California found that real applications of GIS to planning and resource management usually are restricted to automating routine repetitive tasks such as permit tracking, vacant land inventory, automated cartography, and the like, while complex analytical techniques to determine land impact, environmental impact assessment, and suitability analyses are not usually attempted (French and Wiggins 1990). The inventory management and information presentation capabilities used represent incremental, though not trivial, changes to pre-existing manual planning practices; these may be accommodated in planning agencies without great organizational upheaval. However, complex spatial analysis and modelling functions derive from quantitative approaches promoted by scientific planning. For many planners, this will require not only changes to technical planning processes, but acceptance of normative planning understandings from the conservative planning traditions described in the last chapter.

²⁷ This problem is described in more detail in the next chapter.

Most literature describing GIS use for resource management is considerably more positive than that describing use for other forms of planning. This literature emphasizes the technical processes undertaken to implement GIS, for instance identification of data sources and data entry methods, data manipulation, and model development (for example, Logan *et al* 1982; Hart, Wherry, and Bain 1985; Walsh 1985; Williams 1985; Tomlin, Berwick, and Tomlin 1987). As well, like other planners, resource managers display enthusiasm for the automated information inventory capabilities of the systems. With the emphasis that GIS implementation causes organizational and administrative difficulties in other planning literature, it seems likely that these problems are encountered to some degree in resource management contexts. However, organizational difficulties rarely are discussed in the literature of GIS use specific to resource management. It is possible that, as discussed in the last chapter, because conventional resource management already conceives of planning as a scientific technical exercise, implementation of the technology produces less angst than in other contexts.

3.3.3 Other Concerns with GIS Use for Planning

Aside from the software design, organizational, and administrative problems described in papers on specific implementation of GIS for planning, a number of concerns are raised in the theoretical literature. Although there is no documentary evidence supporting these criticisms with specific examples, this may be because some are extremely difficult to demonstrate from a research standpoint. However, as will be discussed in the next chapter, other critical literature regarding GIS supports the contentions of critics of GIS for planning, particularly in aboriginal contexts.

One important concern relevant to the largely unquestioned information inventory functionality of GIS as well as its analytical functionality is that GIS represent space in a way foreign to some planning functions. Couclelis (1991, 15) contends that GIS have an absolute, "container" view of space, in which all information pertains only to spatial objects contained in space; non-localized spatial qualities such as organization, configuration, pattern, process, and change are omitted. In short, GIS are oriented strongly to site rather than situation. Harris (1989, 86) supports this view, stating that virtually all aspects of urban areas of importance to planners have spatial dimensions defined by interactions, while GIS provide only a snapshot of present conditions and recent trends of operational variables. Couclelis breaks planning into operational, management, strategic, and communication functions, and points out that the missing information is important to urban and regional planning, especially in the strategic function, which normally adopts a relative or relational view of space. While current GIS are suited to some functions and may help planners meet some of their spatial information requirements more efficiently, they bring the danger of "displacing skills and habits of thought that may still be valuable." (p.17) Therefore, before GIS will be suited to planning they must "move beyond the naive view of space implicit in the current designs to something more compatible with the state of the art in spatial theory." (p.17)

If this criticism is valid, the benefit of a common format that allows comparison of information from different sources is purchased by omission of information that cannot be included in current GIS formats.

A second criticism is of the complex analytical functions possible with GIS. A number of authors criticize these as not advanced enough to permit effective prediction and evaluation support for policy-making. Douven *et al* (1993) assert that though GIS have become an important part of regional and urban research, linkage with urban and regional modelling has been weak. Klosterman (1992, 252-253) warns that although a literature has emerged that suggests ways in which computer modelling and expert systems might be used as planning aids, so few have been implemented that it is impossible to evaluate their effectiveness. Scholten and Padding (1990) state that current GIS are not sufficient for support of urban policy making because their analysis and modelling functions are too limited. These critics admit to a possibility that the modelling shortcomings may be rectified through further research and system development.²⁸ A more extreme view is put forward by Harris (1989, 88-89), who contends that most large planning problems are “NP-complete”, a term from computing theory that refers to problems that have so many possible solutions they cannot be solved optimally in a reasonable time without unlimited computing power. If this is the case, modelling of planning situations using GIS is futile.

A third criticism of GIS use for planning is an extension of the observations, reviewed in the previous section, that current GIS are complex and difficult to operate. If effective operation of GIS requires intensive training, their use to store information inventories will reduce access to that information by ordinary citizens who wish to use the information to make informed responses to government policies (Yeh and Batty 1990, 372). Easy access to the information used to make planning decisions by all stakeholders in the planning process is important as a means to providing checks and balances. If GIS storage of planning information makes those who wish access to it dependent on GIS technical experts to advise them on retrieval, and if the complexity of GIS analyses makes the systems black boxes, the workings of which are accessible to GIS analysts alone, one must pose the question, “Quid custodiet consilarius?” This is an issue particularly with a technology new and complex enough that it is easy for those advising (the GIS experts) to make errors or questionable steps in analysis but present the results in plausible and convincing output maps.

A fourth criticism of GIS as planning tools is the contention that GIS are saddled with the epistemological and ontological baggage of positivism. In this view, the criticism that GIS analytical techniques derive from quantitative approaches that support the normative

²⁸ One response that has been offered is to create spatial decision support systems (“SDSS”) as a superstructure for GIS. SDSS are implemented for limited domain problems and facilitate use of analytical and modelling techniques and presentation of the results in a variety of forms through an easy to use user interface (Densham 1991). Even more than GIS, examples of real and effective SDSS implementation are few and far between.

understanding of planning as value-neutral and scientific can be extended to GIS in general. For instance, Lake (1993) argues that GIS are founded on the positivist assumption of subject-object dualism and are unable to comprehend subjective differences amongst the objects of its analysis. Because of this, he asserts that GIS are not appropriate to use by post-positivist planners. Sui (1994) supports this view, and in addition argues that GIS are ontologically inadequate because GIS representation of reality in Cartesian space is too limited to represent socially and culturally constructed space, and that GIS fail to recognize the implicit values embedded in them and extinguish subjective differences between individuals.

A fifth criticism of GIS in planning contexts concerns how the systems may alter the nature of planning processes. Adler (1987, 96-97) posits that GIS may make raw data that have been available only to planners in manual processes readily accessible to other parties. This increased accessibility may reduce use of professional discretion by planners, since planner control of data access, analysis, and interpretation in manual systems has been used to shape planning conclusions. This may lead to planning processes where comprehensive approaches and coordination are replaced by shorter-range sectoral programming. In addition, when GIS become central tools for storing planning information, the type of information that they are able to hold may alter planning directions. Klosterman (1995, 9) points out that in planning exercises “increased use of computer-aided tools like GIS tends to focus public attention on policy questions that can be more readily incorporated into a GIS database and away from those that cannot be easily measured, counted, or mapped.” Both of these possibilities would reduce the efficacy of planning exercises.

3.4 GIS and Aboriginal Resource Management: Questions and Concerns

In the last chapter, indigenous resource management systems were contrasted with conventional resource management. In summary, it was noted that in conventional resource management knowledge is constructed into a technical, ahistorical, and value-free framework, and used in a bureaucratic, hierarchically organized, and vertically compartmentalized management system. In indigenous resource management all members of the community are involved, with leadership based on accumulation of management and harvest knowledge and demonstrated ability to use it, and management activities inseparable from harvesting. While conventional resource management relies on scientific approaches to deriving knowledge used for planning, indigenous resource management is based on a system of indigenous knowledge. Indigenous knowledge focuses on qualitative and holistic understandings of the environment derived from diachronic observation of a specific locale and intuitive comprehension of the processes operating in it. It is accumulated as a cultural heritage, transmitted through oral traditions and learning through doing, and understood in a social context that recognizes the unity of humanity and the natural world. At best, the combination of the two systems through co-management or devolution of authority may allow each system to complement the other with its strengths while alleviating its own weaknesses. At worst,

because resource management authority is vested in the conventional system, integration of the two systems can lead to co-optation of indigenous systems while conventional systems remain dominant.

Several concerns raised by the literature concerning GIS use for planning and theoretical criticisms of them are of considerable importance if GIS are to be considered for a role in integrating indigenous and conventional resource management systems:

First, criticisms that GIS representation of knowledge cannot handle non-localized spatial qualities such as organization, configuration, pattern, process, and change, and view spatial information as concerning objects contained in absolute space raise concerns about the amenability of GIS to handling indigenous knowledge. This is a particular concern in light of the criticism that GIS are based on positivist epistemology and ontology, since one of the fundamental contrasts between indigenous resource management and conventional resource management is that the latter bases itself on reductionist scientific understandings of the world while the former is based upon holistic understandings. If GIS necessarily support positivist normative views, they are likely to devalue indigenous knowledge.

Second, even if these arguments are not supported upon more thoroughgoing examination, the concern that the North American industrial focus of the software and its resulting lack of support for languages other than English will cause difficulties for recording indigenous knowledge is still important. As well, the oral nature of transmission of indigenous knowledge may cause difficulties by requiring transcription if the software does not support embedding of sound recordings.

Third, if GIS require a considerable amount of education and training to use properly, this may impose a barrier to direct involvement of aboriginal community members as resource managers. In addition, concerns that GIS may restrict access to knowledge by requiring that expert GIS advisors aid others to use it is of great concern when applied to indigenous knowledge. Indigenous knowledge is a social and cultural product, held and disseminated by community members of experience and wisdom (generally elders and respected hunters). If this information can be recorded in GIS control of it may shift to computer technicians able to use the software. The potential impact of this is unclear, but possibly significant.

Fourth, associated with this third concern, organizational and administrative changes required by use of the technology are doubly important. Aboriginal resource management organizations will have to deal with the same kinds of problems detailed in the general literature of planning GIS use. As well, the bureaucratic formalisation of roles and responsibilities, already a challenge for resource management planning bodies that are already bureaucratic, hierarchically-organized, and compartmentalized, may be even more difficult for indigenous managers who are used to less structured organizations. Again, this may reinforce conventional resource management at the expense of indigenous approaches.

All these concerns make it clear that the implications of GIS use in aboriginal resource management planning should be studied closely and understood. Because of the increasing use of these systems in conventional resource management, it is very likely that exercises integrating conventional approaches with indigenous management approaches increasingly will bring indigenous management systems in contact with GIS. This contact should be managed to maximize the technology's benefit and minimize negative effects for both systems.

Chapter Four

GIS AND ABORIGINAL RESOURCE MANAGEMENT: A CONCEPTUAL FRAMEWORK

The enlargement of the literature of GIS in the field of planning and geographic inquiry in the last few years described in the last chapter makes it clear that they are being adopted in an increasingly broad range of planning exercises and contexts. Though GIS use in aboriginal communities in the Canadian north is still in its genesis, as computer hardware continues to advance in processing capability and drop in price, while planners become more familiar with GIS and their application to planning problems, the technology will be used in more aboriginal planning exercises. As yet, the growth in the technical literature of GIS has not yet spawned a wide body of critical thought that examines the practical implications and impacts of their use in Canadian aboriginal communities. However, despite the scarcity of articles on aboriginal GIS use and the trivial nature of the few that do exist,²⁹ there are reasons to anticipate that GIS use will raise issues and present challenges when used in Canadian aboriginal communities.

First, though there is next to no literature regarding aboriginal GIS use, the small body of literature summarized in chapter three that examines critically GIS use for planning gives an initial indication that areas of concern exist. As well, a related literature exists that examines implications of use of this technology in cross-cultural contexts in the developing world. This body of work deals with two general types of problems. One set of problems it discusses is practical requirements that may be lacking in the developing world contexts without which implementing GIS will be difficult or impossible. These include such things as capital resources necessary to purchase computer hardware and software, physical infrastructure without which computers cannot be run or may become damaged, and baseline data sets for the areas being studied. The other set of problems mentioned is socio-cultural issues that will affect operation of the systems. These include basic aspects of GIS software such as the software not supporting use of aboriginal languages. They discuss human issues important to GIS implementation such as the availability of people with the high levels of formal education and training necessary to use the systems, or at least people with educational backgrounds that suit them to undertaking the highly technical training. As well, they include the need for social organization suitable to GIS use, either microscopically within agencies, or macroscopically within the broader culture. Though there are differences between the Third World contexts discussed in this literature and Fourth World contexts such as many northern Canadian aboriginal communities, the parallels between some of

²⁹ A lengthy literature search turned up only a single article on GIS use in Canadian aboriginal contexts outside of conference proceedings – Rishchynski and Telawski 1995 – and this was not published in a refereed journal. The 500 word piece is little more than advertising for the consulting company that employs the authors.

the conditions in these and their relations with the industrial and urban contexts out of which GIS have emerged suggest that some of the issues raised in the developing world literature will apply to aboriginal communities.

Second, a literature exists that examines GIS critically. A number of authors have raised a range of epistemological and ontological considerations about the beliefs at the foundation of the technology. Some critics state that the models of knowledge used in GIS enforce implicitly positivist understandings that make the ontological assumption of an independent reality of which knowledge can be gained through phenomenological approaches (e.g. Lake 1993; Sui 1994). Others are concerned that the cartographic roots of the technology impose limits on how information can be represented that affect profoundly the information's accuracy and meanings, but that GIS disguise these problems, particularly when used by people without a knowledge of cartographic theory (e.g. Chrisman 1989; Nyerges 1991a; Goodchild 1993). Still others remark on the potential of GIS to modify power relations between people, for instance by making access to information contingent on the co-operation of people with GIS technical expertise. Even the unabashedly positivistic and technical National Center for Geographic Information and Analysis ("NCGIA"), an important umbrella for research established in 1988 by the United States National Science Foundation to advance GIS theory, methods, and techniques, to improve levels of GIS expertise and diffusion throughout the scientific community, and to disseminate GIS information (Abler 1987, 303), recognizes that there is an important unfilled need for research on social, economic, and institutional issues surrounding the adoption and implementation of GIS (Abler 1987, 310-311). As well, a strictly technical literature reinforces the idea that technical characteristics of GIS limit their representational and analytical capabilities. Though the research and criticism described are mostly generic in nature, *prima facie* they appear to apply to GIS use in aboriginal communities. In particular, the epistemological and ontological concerns deserve particular consideration if GIS are to be used to record and manipulate culturally-based systems of understanding such as indigenous knowledge.

Third, GIS may be examined as social artefacts of industrial culture using the understandings of cultural anthropology and semiotics. The idea that tools embody the ways of understanding of those who make them is well documented in the literature of cultural anthropology.³⁰ It is supported further by McLuhan's (1964) development of the notion that media shape the information that can be conveyed through them. By extension, taking tools created in one cultural setting and using them in another is likely to require adoption of cultural modes of thinking of the tool makers by the tool users in the new cultural setting. Depending on the nature of the accommodation and the compatibility of the new modes with the old forms of knowledge, this may lead to a form of cultural imperialism in which the perspectives of southern culture

³⁰ This is covered lucidly in the discussions of extensions in Hall (1976), of proximal versus distal knowledge in Polanyi (1966), and of material culture in Hall (1959).

deprecate indigenous understandings (see Young 1990, 58-61 and section 1.3.4). This is a particularly insidious potential of technologies like GIS that deal with the recording, manipulation, and retrieval of information, particularly if the criticism that GIS force adoption of positivist ontology and natural science understandings are correct, since these consider socially-constructed intersubjective understandings of reality to be invalid.³¹ These perspectives reinforce the epistemological and ontological discussions.

Because these initial indications suggest that GIS use will raise issues and challenges in aboriginal communities, it seems best advised that their practical effects be examined in advance of implementation of the technology in a community. However, at present, consideration of problem areas is stymied by critical discussions being scattered thinly and widely through a literature encompassing the fields of geography, cartography, planning, sociology, psychology, anthropology, and pure GIS research. As yet, no attempt has been made to synthesize critical understandings. Participants in practical projects involving GIS in aboriginal communities are highly unlikely to have the time and resources to undertake an arduous thoroughgoing examination of critical issues and how to address them. A summary of issues and considerations would be useful for permitting a quick review of them and allowing plans for dealing with them to be made at the outset of projects.

This chapter summarizes areas of concern about GIS raised in the literature that may be of importance in aboriginal resource management efforts that use the technology. Thirteen issues are discussed: capital availability; physical infrastructure requirements; impacts of GIS on social organization and culture, and social organization requirements for GIS; requirements for education and training; availability and maintenance of data; distribution of power within the resource management agency; distribution of power between the community and external interests involved in resource management; distribution of power in the community; legitimation of knowledge through GIS use; the possibility of positivist assumptions affecting forms of knowledge GIS favour; limits imposed on GIS by cartographic theory; limits to representation of knowledge in GIS; and technical limitations to GIS analysis. Each issue is described, and particular implications for aboriginal GIS use for resource management are suggested. Since issues are not isolated from one another; linkages between them are indicated. The issues are grouped into five overlapping areas of concern: socio-cultural concerns; access to technology concerns; distribution of power concerns; epistemological and ontological concerns; and GIS technical concerns. All of these, taken together, form a conceptual framework to aid understanding GIS use for aboriginal resource management.

³¹ For an insightful discussion of the sociological perspective that reality is a social construct see Berger and Luckmann (1966).

4.1 Access to Technology Concerns and Socio-Cultural Concerns

One set of issues about possible problems with GIS implementation in northern aboriginal communities is raised in literature that examines issues of implementation outside of the industrialized nations in which they arose. A small but useful body of literature exists that scrutinizes GIS applications in developing countries; this is complemented by literature discussing generic concerns in GIS implementation. Most issues arise from pragmatic concerns about basic requirements without which access to the technology will not be possible. Also treated are issues related to the socio-cultural environment in which GIS is implemented.

One of the root questions behind these inquiries has been phrased, "Are GIS appropriate technologies?" (Yapa 1991) This question refers to the concept of appropriate technology first promoted by E. F. Schumacher (1973) in his landmark book *Small Is Beautiful*. Schumacher observed that modern industrial technology in the developed world is immense and complex not only in its manifestations in machinery, but more importantly in the prerequisite linkages and knowledge necessary to sustain it. Industrial technology is the end stage of evolution of many systems: advanced education and research; management activities; planning activities; financial and capital systems; and infrastructural linkages to allow supplies of raw materials to be received and processed products to be packaged, labelled, and distributed. Schumacher observed that without the "invisible" prerequisites the industry cannot function. He postulated that the failure of advanced technological aid to the developing world results from transplanting advanced technology alone into situations where the supporting underpinnings do not exist (Schumacher, 1973, 153-155). In its place, he proposed the use of "intermediate" or "appropriate" technologies that can be used where people reside, are cheap enough so they can be created without an unattainable level of capital formation and imports, are simple enough so that demands for high skill levels are minimized in matters of use, organization, financing, marketing, etc., and are oriented to the use of local materials for local use (Schumacher 1973, 163).

Though the concept of appropriate technology was put forward originally to apply to productive technologies that meet basic needs, its critique of advanced technology requirements for capital, knowledge, and organization that cannot be met in developing world contexts sheds light on transfer of GIS into such contexts. Several issues are raised.³² First, like productive industrial technologies, GIS require that capital be available for their purchase and maintenance. Second, they require that physical infrastructure exists to support the systems, for instance a reliable supply of electricity, constantly climate controlled conditions for the equipment, and transportation systems to allow necessary supplies to arrive in a timely manner. Third, they require socio-cultural

³² This list is derived from van Teeffelen, van Grunsven, and Verkoren (1992) and Burrough (1992), who are concerned with GIS use in developing nations, though they do not use an appropriate technology framework explicitly. Yapa (1991) was the first author of whom I am aware who used this framework explicitly for examining GIS, but his discussion is esoteric and theoretical.

organization associated with industrialized nations, for instance systems of record keeping and storage and formalized relations between individuals using them based on specialization. Fourth, they require a level of advanced education and training to operate. Finally, they require that data sets describing the area of interest be compiled and updated on a timely basis, a requirement that includes elements of all the other issues.³³

Although differences exist, a number of commonalities between Third World contexts and northern aboriginal communities living on the fringes of the industrial south make discussions in the developing world literature of GIS applicable to them. First, like the Third World, northern aboriginal communities do not have large capital resources, and largely are reliant upon transfers of capital from governments. Second, inhabitants of northern aboriginal communities are raised in a cultural setting different from the technical-industrial culture of the south. Like inhabitants of developing countries, their experience of southern culture is through its caricatured representation on television and other indirect forms of contact, but not through day-to-day immersion in it. Their own cultural background may lead to different values, forms of organization, and ways of interacting. Third, to pursue advanced education people must leave their communities and travel to the industrial south, while primary education often is not of sufficient quality to prepare students for more advanced levels. As well, local economies mostly do not require people with advanced education, encouraging those who pursue it not to return. These factors tend to reduce the pool of available people with advanced education. Though conditions are not as extreme as some developing world contexts, these parallels make consideration of the developing world concerns worthwhile in aboriginal contexts.

4.1.1 Capital Availability

One important basic requirement without which use of GIS is impossible is a supply of capital with which to purchase the technology and associated essential adjuncts and services. Even as recently as the early 1990's, most commercial GIS required, at minimum, the purchase of mini- or workstation-computer equipment worth tens of thousands of dollars. GIS software to install on these systems easily could add another twenty to thirty thousand dollars, with support fees for upgrades and technical assistance amounting to several thousand dollars per annum. Microcomputer software, when available, was limited in capabilities and still required an investment of around \$30,000 for it and suitable computer equipment and peripherals on which to run it. This large capital outlay (easily over \$50,000) was one of the factors that caused Burrough (1992) to observe that GIS had remained an inappropriate technology in developing countries.

³³ Interestingly though not surprisingly, these concerns are mirrored by the literature of GIS implementation in the industrial world. For instance, Yeh and Batty (1990, 373) point out that there are many non-technical problems with GIS, including "lack of staff and staff training, lack of management support, problems with data input and conversion, maintenance of databases, and difficulties with system implementation."

Outlay of capital for a GIS installation can be underestimated easily when use of the technology is considered. The precipitous drop in microcomputer hardware prices in the last few years and the low cost of mass-marketed office automation software such as word processors and spreadsheets encourage a perception that a capable computer system with software installed may be purchased for under \$5,000. While more capable GIS software for microcomputers (for instance Atlas GIS and Mapinfo) has become available and continues to be developed, the more narrow market for this means that it is priced at upwards of \$2,000, considerably higher than mass-market software. As well, the base cost of this software may disguise the real cost; optional program modules or supporting software often are required to provide essential functionality such as import and export of data. Microcomputer GIS software from the industry-leading companies is still priced at \$7,500 to over \$10,000.³⁴ In addition, GIS require unusual and relatively expensive peripheral devices such as digitizing tablets and large-size plotters, while unreliable electrical power systems found in northern communities require that backup units and uninterruptable power supplies be added to the cost.

In total, an aboriginal resource management agency is likely to require a budget of at least \$20,000 for microcomputer-based GIS hardware and software. Once this is purchased, considerable additional costs may be incurred for meeting other requirements described below. For instance, digital versions of the Canadian National Topographic Series maps cost about \$3,000 per map; a large resource management area easily can require several of these. As well, attendance of resource managers at special educational seminars offered by GIS vendors and data may be very costly.³⁵

4.1.2 Physical Infrastructural Requirements

Another basic requirement for use of GIS is the availability of basic physical infrastructure needed to ensure that computer systems can be run and will not be damaged (Burrough 1992). As well, other physical infrastructure is essential for receiving support and supplies from service providers. Areas of concern are the local climatic conditions and security conditions at the site for the computer equipment, and reliable transportation and communication facilities.

Although in the last 20 years common computers have become considerably less fragile, no longer requiring special rooms with finely controlled temperature, humidity, and electrical static, they still require certain basic conditions to be met so that they are not damaged. In general,

³⁴ For instance, ESRI's PC ARC/INFO is priced at \$7,500, while Tydac Technology's SPANS GIS costs a minimum of \$12,500. Since territorial and federal government agencies that produce GIS data tend to use software from industry-leading companies, aboriginal resource managers may be forced to spend the additional funds necessary to acquire this software in the interest of maintaining compatibility with associated agencies and potential data sources.

³⁵ This point is supported by Rumor (1993, 232), who concludes that GIS require long term investment plans for education, data creation, and data maintenance.

average microcomputer equipment and peripherals require protection from extremes in temperature and humidity at all times.³⁶ In addition, they must be sheltered from dust and moisture. The electrical supply must be free of irregularities such as power surges, spikes, brownouts, or blackouts. Finally, since the high quality computer equipment generally required for GIS is very attractive for off-hours use for games and other activities, and hardware and associated software and data are vulnerable to damage by viruses, system reconfiguration, mistaken deletion and the like, GIS sites must be secure from unauthorized users.

A second level of physical infrastructure important for use of GIS is transportation and communication facilities. Transportation infrastructure is necessary to allow equipment to be shipped to repair outlets if it breaks down, or to allow service personnel to travel to the site. Communication infrastructure such as reliable voice, facsimile, and modem capable telephone lines is required to gain assistance from software and other technical support personnel to resolve problems that crop up inevitably from time to time when using GIS.

Physical infrastructural requirements for GIS are linked intimately to capital availability. Site conditions will not be a concern where money already has been invested in a building with reliable heating and cooling equipment, insulation and the like. Electrical power supplies are a product of investment in electrical transmission grids or local generating facilities. It is apparent that in this respect infrastructure requirements issues are one of the areas in which aboriginal communities in the Canadian north are likely to differ significantly from the developing world. A remote community in the developing world is far less likely to have had money made available to invest in infrastructure that allows the pre-requisite conditions to be met than a Canadian aboriginal community. At the same time, use and upgrading of infrastructure in the north are likely to add to the capital costs of implementing GIS much more than in the south. For instance, northern Canadian electrical supplies are notoriously unreliable for reasons as diverse as the much greater distances that electricity must be transmitted, impact of solar flares on transmission grids, and reliability of local generating stations in remote communities. These problems may be addressed by investment in an uninterruptable power supply of sufficient capacity, but this additional cost will not be borne in a southern installation. Telephone systems normally are available in northern communities, but the cost of calls to distant technical support personnel is increased greatly over those of the south. Repair of broken equipment requires expensive and time-consuming shipment of it to repair depots outside the community while these could be achieved more cheaply and rapidly in the urban south. Thus, infrastructure issues may add additional capital costs to northern aboriginal GIS installations, while causing delays when equipment needs repairs or supplies need to be shipped.

³⁶ When it expresses this explicitly, technical information tends to specify a range of operating temperatures between 12 and 30°C, and relative humidity between 25 and 75 percent. In general, any conditions very much different from those in a climate controlled office fall outside these ranges.

4.1.3 Social Organization and Culture

One requirement for GIS implementation emphasized frequently in both the literature of developing world GIS and that concerning general issues surrounding GIS implementation is social organization amenable to their introduction (e.g. Frank, Egenhofer, and Kuhn 1991; Burrough 1992; Klosterman 1992; Rumor 1993). Discussions of this perspective arise from a criticism that there has been a tendency for GIS designers and innovators to over-simplify the problems of technology adoption, and that understandings of social and institutional factors affecting use and value of geographic information are far from complete (Onsrud 1989). When issues of social organization are explored, most papers focus on the social context within the agency in which GIS are being implemented. All of these presume that the organization is structured along the bureaucratic and hierarchical lines normal to industrial contexts. Given the contrasts drawn between this sort of structure as used in conventional resource management and alternative forms of organization favoured in traditional aboriginal management approaches (see section 2.2), it is apparent that forms of organization that derive from broader culture also may have a great impact on the GIS implementation, although these are not discussed in the literature.

Within a bureaucratically-structured organization, GIS implementation may require significant changes to reporting relationships and communication networks based upon position in formal and informal hierarchies. Timothy Cartwright (1987, 204) points out that information systems can shape public administration, alter individual roles, change institutional responsibilities, and even alter the balance of bureaucratic power. Since bureaucratic organizations tend to be inherently conservative about accepting changes to these relationships and hierarchies, computer adoption tends to be favoured only if it extends and reinforces the prevailing structures and processes (Kraemer and Dutton 1982; Danziger *et al* 1982, 229-230). Because information management and analysis are so central to planning activities, introduction of a technology like GIS may change radically practices surrounding these, clashing with these conservative tendencies. To counteract these, Klosterman (1995) states that there is a need for the sustained efforts of an advocate and active support of senior management to ensure that financial and personnel resources are made available for GIS implementation in planning organizations. As well, different groups within the organization each lack information. While management establishes system goals, GIS technicians poll system users on their needs and implement the system to suit these, and planners and other analysts use the system, each of these groups lacks the information needed to understand the system as a whole. "Senior management has a sense of political and organizational realities but does not know what is technically realistic or operationally feasible. Technicians understand the technical possibilities but do not know what is politically desirable or operationally necessary. Planners may not know what is technically feasible or politically desirable; however, they are the only ones who are familiar with planning issues and the details of their work." (p. 8) To address this difficulty, unfettered communication and mutual learning involving all parties must occur.

In aboriginal resource management contexts, the implications of the internal organizational changes described in the literature are uncertain. Authors who discuss these changes consider axiomatic the idea that GIS will be implemented in bureaucratically-organized agencies. It is unclear whether the authors mean to assert that GIS implementation *requires* formal bureaucratic organization or that they merely have not considered its effects on practices and relationships in agencies that are not structured bureaucratically. It is apparent that the larger and older a planning agency is, the more bureaucratic vested interests and inertia will have had a chance to develop. Because aboriginal input into resource management through co-management or devolution is quite recent and still being developed, in the case of community-based aboriginal resource management, the implementing agency is unlikely to be either large or old. It seems likely that a smaller, newer body will be more flexible and able to accommodate the kinds of changes described. As well, situations of co-management already require significant changes be accepted by existing planning bodies involved in them. Because of this, these agencies will have been forced to accept significant changes, and therefore could be more open to additional change. Finally, aboriginal resource management agencies may not be structured with the same degree of bureaucratic formality as is prevalent in the south. Introduction of GIS to such agencies is still likely to cause some change, but there is no consideration in the literature as to what the qualities of this change will be.

The broader issue of how differences in social organization that arise from culture will affect and be affected by GIS implementation is not discussed in GIS literature. There is some recognition that the larger societal context is important to GIS efforts, but this is framed in terms of the roles of formal political institutions. For instance, Burrough and Jones (1993, 211) point out that long-term political and institutional stability is essential to allow programmes of training, application development, and data collection. Arnaud (1993) asserts that deficiencies in these areas were disruptive to Portuguese GIS implementation. Certainly in aboriginal GIS implementation the roles of larger formal political bodies in producing baseline data and setting standards are likely to have an impact (see section 4.1.5 below). However, in addition, culture may interact with GIS informally. Social organization at a cultural level will affect formal organization at an agency level if northern aboriginal cultures favour non-hierarchical forms of authority and leadership based on knowledge and ability (as is discussed in section 2.2). This in turn will affect GIS implementation if these systems in fact favour or require formalized hierarchical relationships based on position. Research on the role of technology in society has reveals that although it is understood commonly to be value neutral, technology reflects and transmits values and modes of acting and interacting (see, in particular, Ellul 1964). Some particular values that it carries are rationality, efficiency understood in terms of productivity, and a predilection for problem-solving through reduction of problems into component parts³⁷ (Goulet 1975, 13-15). As a consequence, technology may conflict with other values and conceptions of

³⁷ See section 4.3.

appropriate problem solving approaches (pp. 15-19). If traditional resource management practices involve participation of the community as a whole and indigenous knowledge systems that are part of an oral tradition learned through praxis, the intervention of a technology that requires specialization and separates knowledge from doing will require significant changes to organization.

4.1.4 Knowledge, Education and Local Participation

The literature of GIS implementation both inside and outside the developing world emphasizes that using the technology requires trained personnel or education programmes to train people. Current GIS are technically complex to operate and demand specialized technical knowledge to understand and use properly. As specialized computer databases, they require a background in database technical issues. As mapping tools, they require a background in the basics of cartography. Furthermore, some basic cartographic operations that are facile when executed manually become perplexing technical quandaries when handled using GIS. For instance, McMaster (1991) details five separate models of map generalization, operating at different conceptual levels, that were used to develop a formalized and comprehensive set of rules by the U.S. Defence Mapping Agency. As a manual operation, though, much of map generalization is based upon a loose set of rules and operations understood intuitively by cartographers. Herzog (1989) describes an extremely detailed technical method for generating relatively straightforward simple choropleth classifications. Chrisman (1989) shows how estimating errors generated by overlay, one of the most basic GIS analytical operations, is statistically complex. Similarly, other basic operations using GIS require formalisation where manual methods could rely on tacit knowledge. Introduction of them into planning contexts poses challenges both to the planners who will use them as aids for decision-making and to interested members of the public who wish to be involved in the planning process.

For planners, benefiting from GIS poses educational challenges. GIS use promotes demand for retraining in techniques that computers can facilitate. Cartwright, Brown, and Seaforth (1988, 1990) observe that this retraining need often is understood primarily in terms of computer skills. However, they point out that the methods that computers can facilitate often either have not been taught in planning curricula or have been taught but not used. For instance, a spatial statistical approach like gravity modelling may have been understood once but never attempted because it is so daunting to apply it even with standard computer spreadsheets or database programs. Therefore, planners must learn or re-learn the techniques that GIS can facilitate in addition to the computer skills required to use these approaches. They must grasp the internal workings of GIS data models to be able to manipulate these and understand their limitations. They must understand the cartographic basics necessary to avoid misrepresenting the meanings of information.

At the same time, though, as Timothy Cartwright (1987, 203) points out, ideally planners want to be able to manipulate and interact with data without having to become computer specialists. Though some steps toward this ideal have been made in the last few years with the development of GIS viewer software that packages common operations into straightforward user interfaces that can be learned in a fairly short time, these still require substantial technical knowledge to use properly. Furthermore, the ease with which the functionality is used makes it extremely easy to make gross errors that are not readily apparent. For instance,³⁸ one of the most basic functions in GIS viewers is classification of areas by attribute into colour-shaded or choropleth maps. By cartographic convention, the former generally are used to represent differences in kind, while the latter are used to represent differences in intensity (Monmonier 1991, 149-150). However, GIS software does nothing to prevent this convention from being broken, misrepresenting the meaning of the information being presented. Furthermore, the scale of output maps may be altered instantaneously without regard to the source scale of the data, and information with different source scales and collection methods may be mixed effortlessly. Again, the GIS software will not warn users about the problems associated with taking these actions. In sum, at the current level of development of GIS, planners may not have to become computer specialists, but they must become knowledgeable enough to converse intelligently with these specialists, and they must know and respect basic principles from disciplines like cartography.

Planners who wish to use GIS can become conversant in technical and non-technical disciplines associated with the technology; however, members of the public who wish input into decisions will be at a disadvantage without similar knowledge. As one paper notes, "For use by the ordinary citizen who would like to use their data in making informed responses to government policies, [GIS] can positively terrify." (Yeh and Batty 1990, 372) Manual planning information analysis processes discussed in chapter three make gaining access to all information pertinent to a decision potentially arduous and time consuming for resource managers and more likely than not more so for the public at large. GIS may make access to information easier by consolidating it in one location in a form that is easy to duplicate, but they add additional barriers of requiring technical knowledge to operate and other non-technical information to assess strengths and weaknesses. Klosterman (1995, 9) points out that "GIS and related computer-assisted analysis tools can be used to provide a technological form of 'mystification through automation,' burying inherently political choices within technical analyses unfathomable to outsiders." This danger caused Godschalk and McMahon (1992, 217-218) to note that, at their worst, GIS could be used to shut out citizens from decision-making. More positively, they note, GIS may open up technical planning processes to public scrutiny and input if designed to encourage public participation. If planners wish to encourage the latter, some effort must be devoted to passing the knowledge and

³⁸ These examples are drawn from section 4.3.1, below, which details limitations to GIS imposed by their cartographic roots. Limitations explored in section 4.3 indicate general areas that can lead to problems for hapless unknowledgeable GIS users, but are by no means exhaustive.

training required by planners to interested members of the public. If resource managers adopt the normative goal of promoting social justice discussed in the first chapter, this will be necessary to foster a democratic decision-making process; without it, the potential will be high for GIS to increase marginalization and powerlessness among groups without the skills to operate them and scrutinize information used to make decisions.

The discussion above makes it clear that the need for a combination of educated people and training to enhance the skills of people using GIS for planning are generic issues in the critical literature of GIS. As well, they are discussed frequently in the literature of the developing world (e.g. Yeh 1991; Burrough 1992; van Teeffelen, van Grunsven, and Verkoren 1992; Cartwright 1993). This body of work indicates that their importance in contexts outside the industrial south is increased mainly by the additional need to build foundation skills that may not have been covered. As well, the longer, more fragile, and more expensive lines of communication infrastructure require an added degree of self-reliance best attained by gaining expertise in advance. In northern aboriginal resource management, these matters also are likely to have some bearing, but like issues of physical infrastructure they are likely to be more moderate. For instance, since GIS implementation is likely to be carried out in association with territorial or federal agencies that already use GIS, a network of people with practical expertise to provide support will be more available than in developing world contexts.

The second facet of education, the need for fostering knowledge of GIS among citizens interested in contributing to the resource management process, may pose additional challenges. At this early stage in the development of GIS, there is no literature of which I am aware that builds upon the observation that GIS may obstruct or augment public participation and documents practical examples of or theoretical approaches to addressing the public participation issue. Encouraging public participation in planning processes always has been a great challenge. One suspects that because most planners are still struggling with how GIS should be incorporated into their own roles and activities, little consideration has been given to how GIS may and should affect public involvement. A premise of the literature discussing the need for education – that this education is built upon post-secondary and graduate course work – points to challenges for aboriginal communities in which members of the public, although potentially very intelligent and knowledgeable, have not progressed to higher levels of formal education. The difficulty to be addressed probably has more to do with the lack of examples of how GIS education may be implemented outside of post-secondary academic contexts and professional seminars than with inherent problems with actually doing this.

4.1.5 Data Sources and Maintenance

Lack of data sources to be used in GIS is an important constraint to use of the systems in all contexts. Frank, Egenhofer, and Kuhn (1991) argue that because without timely and complete

data to feed them, GIS are useless no matter how functional, the creation and updating of data are more important to GIS than computer software and hardware. In developed nations, national or regional governments take a lead role in producing and maintaining baseline data sets that may be acquired and used as a complement for locally-created data sets. As well, private sector firms may generate and market useful data sets. In both instances, these can require a very large amount of skilled personnel and capital. Depending upon the nature of the information, this may have to be updated on a regular basis through ground survey or aerial and satellite image analysis, again requiring substantial resources. Without the national or private sector data, GIS implementation can be derailed or limited significantly.

Outside the core of the developed world, availability of data sets developed by outside agencies is likely to be severely limited (Burrough 1992). In developing countries, national governments are unlikely to have programmes in place to produce quality baseline digital information. Often, even manual information collection processes generate information of inconsistent quality, making its translation into GIS of questionable value. As one paper notes, "There is little point in developing sophisticated vehicles for adding value to data through generating information in [GIS] if these data are problematic in the first instance." (Yeh and Batty 1990, 370-371) Furthermore, private sector interests have little impetus to make available digital data sets to small markets with limited need for them and capital to purchase them. Local production of basic physiographic and socio-economic information for requires educated personnel, facilities and equipment for them to use, a combination of equipment and infrastructure to allow surveys to take place, money to pay for these,³⁹ and adherence to social organization structured around formal economic activities. As discussed above, these may not be present in northern aboriginal communities to the same degree as the industrial south.

In the Canadian north, relative to developing world contexts, these problems are moderated but still of some importance. The national and territorial levels of government have in place programmes to produce and update GIS data sets for a variety of topics. Nevertheless, quality and availability may be limited for some areas. For instance, the Canadian National Topographic Series maps – which contain a wide variety of useful baseline physiographic information – are being converted to digital format. However, priority is placed on areas of large urban concentration or resource extraction potential. An aboriginal community may find that digital data for its area have not been generated. Particularly for integrated resource management, which needs to take into account a very large variety of information, lack of available digital information may make use of GIS much more expensive and time-consuming.

³⁹ The expenditure for construction of GIS databases commonly is five to ten times greater than the cost of hardware and software (Klosterman 1995, 4).

4.1.6 Connections Between Access to Technology Concerns and Socio-Cultural Concerns

It is apparent that the issues investigated do not stand in isolation but act in concert. The discussion above makes reference to some of the most intimate connections between issues, but not to all links. This section summarizes ways in which the issues interact.

Availability of capital is important to all access to technology concerns, and also may affect institutional and social organization:

- As discussed in section 4.1.2, availability of physical infrastructure necessary for GIS is related intimately to capital availability. Development and maintenance of the facilities, utilities, transportation networks, and communication systems desirable for a GIS installation require ongoing and large-scale capital investment. As well, when infrastructure is inadequate or unreliable, these problems often can be addressed through additional expenditures. Untrustworthy electrical supplies can be augmented by uninterruptable power supplies or, in extreme instances, backup generators. Secure offices to house GIS can be built. Communications with southern GIS companies and consultants can be maintained with sufficient phone and fax budgets.
- To some degree, the education and training issue also may be understood as a capital availability issue. Almost all GIS training courses are offered through colleges and universities or by GIS vendors. These are situated mainly in southern urban centres. For northern aboriginal communities engaged in resource management, there are three options for taking advantage of these training opportunities. First, resource managers may be sent to the training institutions for courses or seminars. Since these will be remote, travel and accommodation costs must be paid as well as tuition. Second, the training institutions may be paid to conduct seminars on site. Again, this will involve relatively costly travel and accommodation charges if they may be arranged at all. Third, the services of skilled persons who have the necessary expertise already may be contracted; contracts may be in the form of hiring outside experts full-time, arranging intensive short-term visits by consultants, or arranging some form of ongoing expert technical support. In all these cases, the remote locations of the northern communities to the southern centres in which these experts are likely to reside requires a premium be paid on top of already high fees in a field with a limited number of experts.
- Acquiring data for resource management, even if these have been generated by a government agency, may require payment to the responsible government ministry or company. If required data sets are out of date or not available, money may be required to have these updated or created.
- The level of capital formation in a community may affect social organization. A wealthy community will have increased opportunities for larger scale endeavours in the formal economy. These promote formalisation of roles and responsibilities that is in keeping with

bureaucratic organization and specialization discussed in GIS implementation literature. As well, capital formation tends to bring with it creation of corporate legal entities; the legal and administrative requirements for controlling these are highly formalized.

Physical infrastructure, particularly large scale utilities, transportation, and communication facilities, has particular implications for capital formation and for data generation and maintenance. As well, it may affect social organization and culture:

- Capital flows in northern aboriginal communities largely are derived from external sources. Opportunities to promote growth in the formal economy in such fields as tourism benefit from linkages to the urban south. Transportation and communication infrastructure facilitates formal economic activity by making communities more accessible.
- Availability of physical infrastructure such as transportation networks and facilities will affect the cost of compiling and updating GIS data. For instance, if fish counts must be taken on rivers, it may be much more costly if the count sites are accessible by float plane but not by road.
- Physical infrastructure affects social organization that arises from culture. For instance, government programs implemented in the 1950's to encourage the resettlement of Inuit from widely dispersed transient communities into larger, more fixed communities disrupted traditional activities and resulted in an increased reliance of those resettled on formal economic activity (Brody 1975, 166-168; Merritt *et al* 1989, 2). It seems impossible that this would not affect the matrix of mutually understood and shared roles, practices, experiences, rituals, and symbols that are culture. In particular, from the standpoint of social geography discussed in section 1.3.1, infrastructure can alter the arrangement and experience of space.

The social organization and cultures of northern aboriginal communities may have effects on all the other issues discussed in this section. These effects will arise from understandings about authority and leadership, economic activity, appropriate action, and the like.⁴⁰ As mentioned in section 4.1.4, aboriginal cultures may place a lower value on the post-secondary educational background normally required for GIS operators. As well, culturally-favoured modes of economic activity may affect other issues. For instance, in many northern aboriginal communities people favour mixing economic activities in the formal and informal economies, taking extended breaks during prime hunting times to spend time on the land. This may require that data collection and updating processes be altered significantly from those used in southern settings to account for

⁴⁰ Obviously the effects of culture are many and varied. Examples are provided for illustration only.

availability of people to provide information and people to collect it. As well, effects on the level of activity in the formal economy could affect capital availability.⁴¹

Finally, education and training may have impacts on social organization and culture. As suggested above, cultural attitudes toward the post-secondary education and training needed to use GIS will affect opportunities to pursue these. Reciprocally, post-secondary education exposes students to other cultural traditions, both formally through academic study of them and informally because students must venture into the urban south to receive this education. This exposure may alter understandings of social organization and culture among individuals who undertake post-secondary education.

4.1.7 Summary: Access to Technology Concerns and Socio-Cultural Concerns

The five issues above may be grouped into two broad areas of concern. First, four of the issues – capital requirements, physical infrastructure requirements, education and training requirements, and data availability and maintenance – relate to requirements without which access to GIS technology will be made impossible or constrained. The discussion above makes it clear that a lack of capital, supporting physical infrastructure, educated people, or data will be a stumbling block for GIS implementation. Second, two of the issues – institutional and social organization, and education and training requirements – relate to the socio-cultural environment in which GIS are implemented. The education and training issue is classified under both concerns because while education and training are essential to access to GIS, as well, as indicated in the discussion above, the socio-cultural environment affects the potential of people in aboriginal communities to pursue education. The issues, areas of concern, and linkages between them are summarized in Figure 1.

⁴¹ For instance, by reducing the tax base in municipally-structured communities. However, lack of formal economic opportunities that are consequences of the power of outside economic interests by far supersede in importance any cultural disposition towards the formal economy.

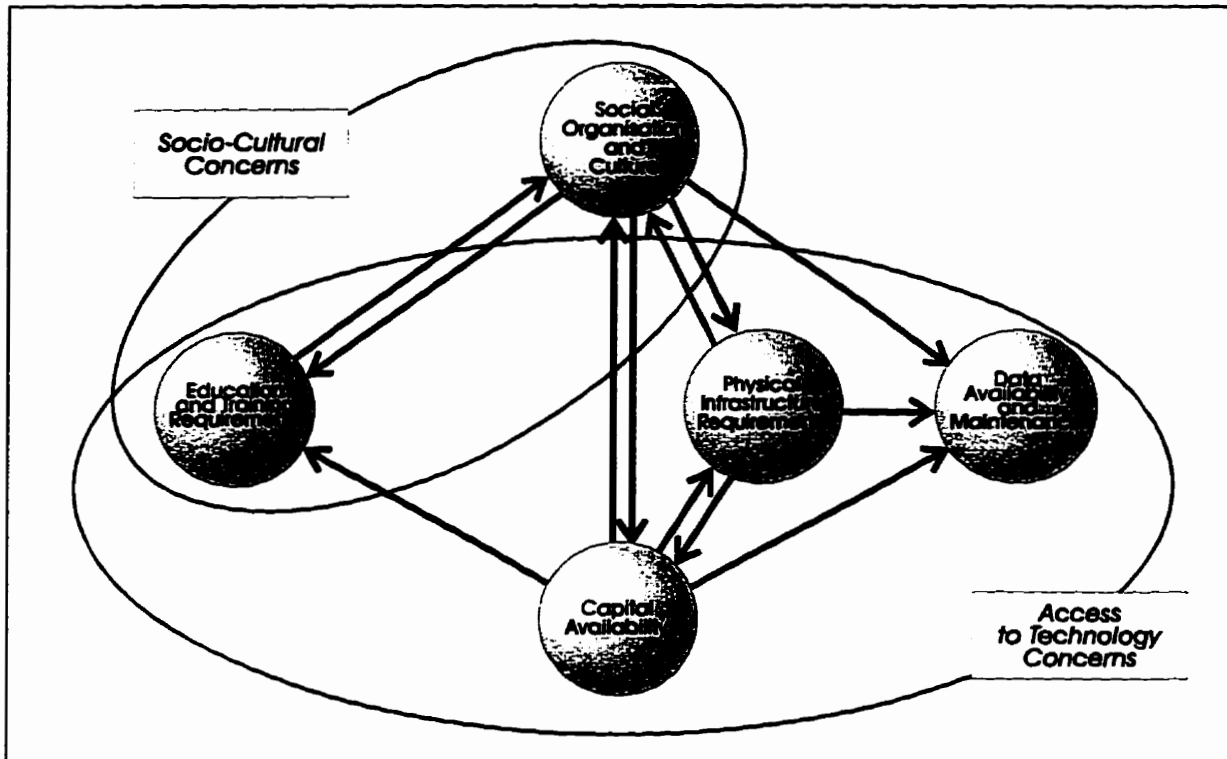


Figure 1: Access to Technology and Socio-Cultural Concerns

4.2 Power Distribution Concerns

A second set of concerns about GIS implementation in northern aboriginal communities revolves around possible impacts of implementation of the technology on the distribution of power. Though the body of literature examining GIS critically offers little concrete research into how this technology alters power relations, a number of papers point to this possibility on a theoretical basis. Most commonly, discussions focus on changes to the power of individuals within organizations in which GIS are implemented. As well, some attention is paid to possible changes to power relations between an organization in which GIS is installed and other government agencies and bodies. In addition, a few point out that when GIS are used by a planning office this may bring about changes in access to knowledge and associated decision-making power for members of the community it serves (Yeh and Batty 1990; Godschalk and McMahon 1992; Lake 1993). In general, no matter what the particular concern of the author, discussions of GIS and power focus on the relationship of GIS to knowledge, and on the power that this knowledge can bring to participants in the planning process. As Kraemer and Dutton (1982, 171) point out, since computers can change the speed, direction, content, and pattern of circulation of information flows, they may change the relative decision-making effectiveness of different people. Certainly, in resource management, which, like all planning, seeks to link technical knowledge to action, a complex computer technology like GIS that is used to record and

manipulate knowledge is likely to change relative accessibility of that knowledge to different actors. This may change the abilities of the actors to influence decisions that are made. Thus there is a good initial case for the idea that implementation of GIS will affect distribution of power in resource management contexts.

One immediate difficulty in discussing the effects of GIS implementation on power distribution is definition of the term “power”. Traditionally, there have been two main social science approaches to research into power. One classic social science approach to the definition of power is the decision-making position. Proponents of this position assert that the only valid evidence of power is derived from the study of action in the decision-making arena. Power, in this view, is defined in terms of action outcomes and without regard to the socially-constructed roles that are associated with them. Robert Dahl (1957, 202-203), one of the fathers of this school of thought, provides the following definition of power: “A has power over B to the extent that [s/]he can get B to do something that B would not otherwise do.” The decision-making position may be understood as a response to the complexity of tracing the myriad factors that come into play when people estimate their own and others’ power, and the difficulty research subjects have understanding and explaining these. Explication of operational variables is set aside and research attention is focused on the actual evidence of the operation of power. Research focuses on actions and attempts to make the case that different actions would have taken place in the absence of the exercise of power.

Although from a research standpoint this approach and definition simplify inquiry because they set aside questions about the nature of power and why it manifests itself in whatever ways that it does in favour of questions about how it operates, the decision-making approach necessarily abdicates responsibility for explaining the operation of power in a way that allows predictive insight. In response to this shortcoming, a second basic approach for defining power bases itself on the idea that power is socially structured. In this view, the “reputational” or “elitist” position, in order to study power one must start from a statement of the nature of its structure. A classic definition from this position was laid out by Floyd Hunter (1963). Hunter (1963, 2) stated that power “describe[s] the acts of [people] going about the business of moving other [people] to act in relation to themselves or in relation to organic or inorganic things.” Unlike the decision-making position, the reputational approach attempts to understand the roles of actors in a social arena, how these are perceived by others, and how these understandings contribute to the influence each individual has.

The traditional reputational position has been criticized for shortcomings in a number of areas, including its inability to deal with the power of collectivities and problems it has handling the role of subjective, non-rational perceptions in dealings of power. Later proponents of the position (for instance, Bachrach 1967; Bachrach and Baratz 1970; Lukes 1987) have responded to these by modifying and extending the original position. Some of the literature refers to the approach used by these later proponents of the position as “neo-elitist” to differentiate it from the

more nascent original thought. The neo-elitist position focuses less exclusively on the relationships of power among individuals than the traditional reputational one and uses more hermeneutic research approaches when examining perceptions of power. Although these changes address the shortcomings mentioned above, two other criticisms of a more fundamental nature are made of both the traditional reputational and neo-elitist approaches. First, reputational approaches are criticized for postulating a stratified pyramidal social power structure (Bell and Newby 1972, 222-243). To address this difficulty, some authors propose alternatives to concentrating on social structure, such as focusing on issues and decisions, that may deal more effectively with power distribution among factions and coalitions in an amorphous and/or pluralist social framework. Second, the elitist position is criticized for being unable to analyse indirect power relations that often may have profound implications. One proposal to deal with this problem is to use an ecological model of power as well as a reputational one. For instance, Dorwin Cartwright (1965, 142) defines ecological power as follows: "When O influences P by ecological control, [s/]he takes some action that modifies P's social or physical environment on the assumption that the new environment will subsequently bring about the desired change in P." Proponents of ecological understandings of power of course do not propose to set aside the study of direct power relations, but rather to add a significant additional field of study to it. When discussing GIS and power, including an ecological approach helps to deal with such issues as the power government manifests through programs that encourage actions without requiring them legislatively.

In a compelling review of the literature of power, Geoffrey Debnam (1984, 2) points out that none of the decision-making, reputational, and neo-elitist approaches defines the nature of power rigorously.⁴² Instead, each position focuses on determining the location of power. After a review of a wide cross-section of writings on power from both perspectives described above and some of the popular sub-perspectives such as conflict theory⁴³ in which he classifies the key elements discussed, he isolates four core elements that may be used to analyse the working of power: actors; action; intention; and outcome (1984, 15-73). His discussion of even these four elements makes the difficulty of understanding and studying power apparent. Actors can include both individuals and collectivities. Collectivities may have power both as actors, such as an army whose actions cannot be broken down into the individual actions of its component soldiers, and as images that act as motives in the minds of others, for instance a union group that causes workers to refuse overtime work because the workers understand that the union disapproves of such work. Action includes the possibility of acting or not acting to achieve some outcome.⁴⁴ In organizations,

⁴² This criticism applies equally to the decision/issue analysis and ecological approaches, though Debnam does not make reference to them.

⁴³ Debnam rejects conflict as a heterogeneous extension to his core elements, citing Collingwood's (1942, 153-154) example of the consensual power of two men moving a piano, a relationship not of conflict but of joint control in which elements of tension, threat, strategy, bargaining, and manipulation may come into effect.

⁴⁴ Debnam (1984, 28) notes that no satisfactory way has been developed to study the role of inaction in power.

political objectives may be achieved through the very way in which interactions are structured⁴⁵ as well as explicit formulation and enactment of policy objectives. As well, actions of power may be unconscious in that the actor may be unaware of one or more of the motives to act, the interpretation of the action, or its consequences. Intention to achieve an outcome is necessary in relations of power, but intention may not be consciously formulated. Finally, outcome provides a critical focusing device for the study of power, but in-process outcomes such as conflict, sanction, or decisions must be considered as well as end-process ones such as furthering of interests.

As the discussion above indicates, the formal study of power in social science is an involved affair. As one author puts it, "The analysis of power relations is one of the most complicated problems in political science and in economics, sociology, and psychology as well." (Petersen 1968, 131) In any approach that attempts to demonstrate that power is being exercised, there are great research challenges in establishing convincing counterfactuals, assertions that outcomes would not have occurred without the exercise of power (Lukes 1974, 41). It is impossible to ignore the idea that GIS, like all computing, are political tools that influence the relative power and autonomy of particular actors and interest by redistributing resources such as information, prestige, and legitimacy that affect decision-making effectiveness (Kraemer and Dutton 1982, 170). However, it is difficult to draw any definite conclusions on the effects of GIS on power distribution because of the current paucity of research directed toward shedding light on this subject. Therefore, discussion in this section is limited to sketching out issues to which the literature points and drawing some relations between them. Three arenas in which implementation of GIS may change distribution of power are discussed: within the organization in which GIS are implemented; within the community in which GIS are implemented; and between the organization – and community that it represents – and external interests concerned with resource management. These are all united by the issue of how GIS are understood to legitimize knowledge and the resultant increased regard and associated decision-making authority afforded to those who use them.

4.2.1 Distribution of Power Within Organization

The discussion of possible GIS requirements for particular forms of social organization in section 4.1.3 reviewed the work of a number of authors (Frank, Egenhofer, and Kuhn 1991; Burrough 1992; Klosterman 1992; Arnaud 1993; Burrough and Jones 1993; Rumor 1993) who assert that the characteristics of organizations may make them fertile ground in which to sew GIS seeds or, alternatively, stunt the growth of these systems. To extend the metaphor, as GIS take root they will change the nature of the soil from which they spring, possibly depleting it of some re-

⁴⁵ This idea is referred to in the literature of power as "mobilization of bias". This term was originated by E. E. Schattschneider (1960, 71), who wrote that "all forms of political organization have a bias in favour of the exploitation of some kinds of conflicts and the suppression of others because organization is the mobilization of bias."

sources while enriching it with others, stabilising some areas while heaving up others. As Timothy Cartwright (1987, 204) puts it, because GIS alter the basic public administration process of production and distribution of knowledge, they “can alter individual roles and change institutional responsibilities; they can even alter the balance of bureaucratic power. In so doing, information systems may do good or they may cause harm.” (Cartwright 1987, 204)

Aangeenbrug (1991, 105-106) details several modifications to information flows and associated power relations within urban governments in which GIS are implemented. Because both are bureaucratic bodies engaged in large scale planning activities, similar changes are likely to take place as well in resource management bodies which use GIS. Aangeenbrug states that GIS facilitate transfer of information about events directly to top-level officials, reducing the opportunity for lower- and intermediate-level personnel to screen information and add interpretation. Adler (1987, 96-97) argues that increased information accessibility such as that described by Aangeenbrug may reduce use of professional discretion by planners, since planner control of access to and analysis and interpretation of data has been used in manual systems to shape planning conclusions. At the same time, the systems free lower echelon staff from routine recording and information processing tasks, but at the same time give them less pivotal roles in controlling information and thus reduce their power. In sum, Aangeenbrug argues that these factors contribute to transferring the power of planning analysts to higher level officials and politicians. Discretionary influence of the former on decision-making is severely curtailed, reducing their ability to act to achieve desired outcomes.⁴⁶

A second important power shift results from the ability of GIS to provide superior information about environmental factors, but only to officials capable of understanding and using them. Although lower ranking personnel engaged in routine data processing tasks lose power as GIS make information directly accessible to others in the agency, the complexity of GIS technology substitutes the need for mediated access to information through technically-educated officials who are able to command the new technologies for mediated access via data processing personnel. Technically adept members of an organization thus tend to gain power while technically less-educated ones lose it. In this way, the shift of power to higher level officials and politicians that Aangeenbrug asserts will result from GIS implementation may be illusory if the latter do not have the technical background to use the technology effectively. Instead, technical decision-makers and programmers may gain power to shape the flow of information under the veneer of supposed objective technical constraints to programming user access functions. As Klosterman (1995, 8) points out, since they most often lack technical training in GIS, senior managers often do not know what is technically realistic or operationally feasible. Thus, although they may benefit from the reduced barriers to information flows that GIS may bring about, they

⁴⁶ This power shift, combined with the tendency of GIS shift decision-making emphasis toward easily-quantifiable information and away from qualitative concerns (Aangeenbrug 1991, 105), may lead to the replacement of comprehensive planning processes and co-ordination with shorter-range sectoral programming.

must rely on technical advice of GIS-trained personnel regarding the feasibility of having particular information made available to them and on its interpretation.

Since community-based aboriginal resource management processes in northern Canada are unlikely to involve very large organizations, the power shifts described in this section will be somewhat different in scope and magnitude than those in larger organizations implementing GIS. On one hand, as discussed in section 2.2, less bureaucratic and formalized organizational structures may arise in aboriginal community agencies. Along with this, the lack of large numbers of specialists in smaller organizations tends to make role definitions looser. These factors might reduce the impact of GIS on power relations in aboriginal resource management, since the influence of the structural power attributes of organizations such as formal authority and reputation may be much diminished.⁴⁷ On the other hand, in small organizations, expertise in the new technology is likely to reside with one or two people. If GIS have a central role in organizing the information base used for resource management decision-making, these individuals may gain the potential of having an inordinate amount of sway. This is a particular issue if GIS use affects the power balance between the resource management organization and external agencies involved in resource management by increasing the respect the outside bodies have for the organization. In southern culture, perceived technical prowess can garner great admiration. If, as the next section discusses, GIS foster such perceptions in people outside the organization, the power of the individuals in the organization who are able to use the technology may benefit additionally.

4.2.2 Power Balance Between Community and External Interests

The previous section describes ways in which implementation of GIS may alter the balance of power within an agency into which it is introduced by changing how information circulates and the relative abilities of different individuals to influence decisions. If the exercise of power involves different actors acting to influence outcomes, the process of community-based resource management can be understood as an exercise of power in a context that includes a large number of interests, only some of which are in the community. If resource management involves applying technical knowledge to making decisions about actions that affect the land, one way that aboriginal efforts to manage resources on a community level may be conceived of is as attempts to effect information flow changes that improve the community influence on those decisions. Changes to the production and distribution of knowledge brought about by GIS affect the power and influence of government units at the expense of others (Cartwright 1987, 204). Thus, in addition to the power relations between individuals in the agency into which they are introduced,

⁴⁷ See Pfeffer (1992, 72-77) for a discussion of such structural characteristics of power within organizations. This author describes two basic sources of power in an organization: structural qualities and personality traits. As well as formal authority and reputation, other structural aspects of power include performance, location in communication networks, and control over resource allocation and use. Evidently, in small, intimate agencies these will be predominated personality and personal attributes.

GIS are likely to affect power relations between the agency – and community interests that it represents – and outside interests in the resource management process.

Currently, two aspects of GIS use for resource management may affect distribution of power between an aboriginal community implementing GIS for this purpose and outside interests. First, these systems are being adopted to an increasing degree by resource managers in territorial and federal government units. Improvements in computer performance, increases in software capabilities, reductions in computer and software prices, and growth in availability of GIS data sets through ongoing government digital mapping programs and development of remote sensing technology have all contributed to the trend of changing GIS from an esoteric technology to a common tool for resource management. Although this change is by no means complete, the technology is much more commonplace than it was even a few years ago. As the change has occurred, ability to use GIS has become more an expected attribute of people involved in resource management, at least among agencies that are using it already. Having a working GIS is becoming one of the initiation fees for joining the resource management club. Agencies that command the technology gain professional respect of others that have implemented it. In turn, their perceived legitimacy and resultant influence on resource management decisions is improved.

A second, more insidious aspect of how use of GIS for resource management may affect power relations arises from the fact that GIS still is a technology in transition from an esoteric to a commonplace status. The technology is new and complicated enough that even for those agencies that have secured it, doubts may exist as to how it should be used. As suggested above, the upper level managers who have the greatest formal decision-making authority may have little notion of how the GIS should be applied. Because of this, even among agencies involved in a resource management process that have acquired GIS, agencies that make *effective use* of the systems will garner respect and influence among those who have them but are unsure of their use. To the contrary, those organizations that acquire GIS but do not ascertain how they should be used may find it necessary to defer to those that are clear on how they are using the systems. As the technology continues to evolve, this quality of GIS and power will dissipate, but currently it may have some importance.

A third concern relates to the facilitation of access to information through GIS and the potential for information abuse or misuse. Aronoff (1989, 269-277) suggests that the mere automation of previously manual records may lead to circumstances in which information may be used to promote some interests at the cost of others. For instance, a geographic database that contains records of large game habitats and animal harvest records could be used by a resort operator to determine the best hunting areas for resort clientele, leading to over-hunting of the areas and reduced harvests for the individuals who provided the harvest information. A map of old village and grave sites could be used by unprincipled profiteers to strip these of artefacts. In ways such as this, if not used with care GIS could reduce the power of the community to protect its interests.

The implications, for aboriginal communities undertaking resource management, of GIS effects on power distribution between resource management agencies are straightforward:

- If major actors in the resource management arena already have installed GIS, the community resource managers may seize more influence by implementing the systems themselves.
- If the community resource management body does install GIS and makes use of them effectively, its power will increase relative to other actors that do not use the technology and to actors that have the technology but do not make use of it effectively.
- If the community resource managers acquire the technology but do not undertake a program of using it to achieve clear objectives, they will reduce their power relative to other actors that have clearly defined programmes of GIS use.
- Community resource managers should be careful to consider how GIS data sets could be abused contrary to community interests. Access to those with a realistic potential of damaging community interests should be guarded diligently.

4.2.3 Distribution of Power Within Community

If implementation of GIS may cause notable shifts of power within an organization that uses them and may change the power of the organization and the community that it represents relative to outside agencies and interests, it is not surprising that there are some concerns raised in the literature of GIS and planning about how use of these systems may redistribute power within a community.

One particular concern raised concerns GIS impacts on processes of public input into planning. In most planning textbooks, the merit of structuring planning processes to allow significant and informed public input is emphasized (see, for instance Hodge 1991, 347-368). On one hand, one might suspect that the increased accessibility of information used for resource management facilitated by GIS would lead to increased citizen input opportunities. However, Yeh and Batty (1990, 372) argue that because operating GIS requires substantial training that most members of the public do not have, if GIS are used for planning they may actually reduce public access to information. Thus, GIS have the potential to either increase or reduce the power of members of the public interested in having input into resource decisions (Godschalk and McMahon 1992, 217-218), but since use of GIS favours technically sophisticated individuals at the expense of the less technically proficient, it is likely that the systems will further unbalance already unequal power relations. Furthermore, since the technically proficient users are usually employed by those with political and economic power, GIS will support the status quo and reinforce existing power relations (Lake 1993, 405-406). These potentials have particular importance in northern aboriginal communities in which use of the land is a central facet of both economic and cultural life. If, as

asserted in section 1.3.4, resource management should be based on the social justice principle of increasing power and autonomy of community residents over their own circumstances, effective and consequential public input into decision-making processes is essential. Therefore, means of mitigating the disempowering aspects and promoting the empowering aspects of GIS for community members must be considered.

One concern regarding distribution of power within aboriginal communities to which no reference is made in the tiny literature of aboriginal GIS use is the impact these systems might have on social systems of power and respect. As detailed in sections 2.2 and 2.4, indigenous knowledge used for traditional resource management is knit into the cultural and social fabric of aboriginal communities. Recognition of authority and leadership in traditional communities is based on greatest accumulation of knowledge and demonstrated ability to use it (Usher 1987, 7), and indigenous knowledge used for traditional resource management is accumulated and transmitted through an oral tradition. Some anthropological research on knowledge and power in indigenous culture demonstrates that knowledge and power are inseparably fused, and that respect for the knowledge of elders is what makes them powerful (Salmond 1982, cited in Parkin 1985, 49). Section 2.3 points out the recent trend toward integrating indigenous knowledge with scientific knowledge to allow for more effective resource management. If GIS are used as a central technology for recording and transmitting resource management information, resource managers will be tempted to include elements of indigenous knowledge as part of the GIS information base. This raises the question of how GIS may shift power distribution in aboriginal communities as they are used in this way. Although there is no literature of which I am aware that poses the question or investigates it, it seems, *prima facie*, that GIS could affect the power of community elders who hold the knowledge. If, for instance, an effort is made to collect locations most favourable for fishing so that these may be considered for protection, the people who provide this information lose some of their control to whom and under what circumstances their knowledge is imparted. At the same time, recording the knowledge in GIS may give it more standing when decisions are made about land use, increasing the elders' influence.

4.2.4 GIS and Legitimation of Knowledge

Most of the literature regarding GIS impacts on power distribution detailed in the sections above derive from the understanding that this technology alters the distribution of information used to make planning decisions. The observation of Kraemer and Dutton (1982, 171) that computers may change the decision-making influence of different people by altering the speed, direction, content, and pattern of circulation of information flows bears repeating. That GIS will bring about such changes to an information-driven process like resource management is certain inasmuch as GIS are becoming central to information storage, retrieval, transfer, and analysis in these processes. Changes to power distribution that may be brought about by alteration of

information flows may be anticipated and encouraged, managed, or mitigated depending on the positive or negative natures of their impacts.

A second, more subtle way in which GIS may change the power of actors in a resource management process is through how their very use may alter perceptions of the value of the information they contain. These changed perceptions result from some of the fundamental popular beliefs about knowledge in southern culture. First, in popular belief, reductionist science and positivist thinking approaches are revered and understood to produce unbiased, objective knowledge, which is understood to have great value. Second, computer systems are associated with the production of this scientific knowledge. Extending McLuhan's observation that each medium shapes the content that can be conveyed through it (McLuhan 1964, 23-35), from a sociology of knowledge perspective the use of different media to convey the same information can alter perceptions of the content not only because of changes wrought to it by the instruments used to transmit the content but also because of the way that the instruments themselves are valued. For instance, several years ago when cellular telephones were introduced, stock brokers used them in part to promote feelings in their clients that they were important and that the brokerage house using them was successful and forward-thinking, even though the content of any conversation was indistinguishable from one placed on a regular telephone; in this case, the perception of the clients that the medium was associated with innovation and success coloured their perceptions of the value of the buy and sell recommendations made using them. Similarly, if computer processing of information is associated with science and objectivity, which are understood to have great value, use of GIS may increase the perceived value of information stored in them even if their use adds no value to the information over other means of storing it.⁴⁸

In aboriginal communities undertaking resource management, this GIS potential provides an impetus for adopting the technology to give community knowledge of the resource base a greater impact on decisions. The discussion of epistemological and ontological concerns below lays out characteristics of GIS that may subtract from information recorded in them, characteristics that are of particular concern when dealing with richly qualitative information such as indigenous knowledge of the land. However, the trade-off of omitting some aspects of the information may be acceptable if the information that is conveyed gains greater ability to influence resource management decisions.

4.2.5 Connections Between Power Distribution Concerns

Like the issues in the access to technology and socio-cultural areas of concern above, the power distribution issues interact with and reinforce one another. Some of the linkages between

⁴⁸ In fact, GIS may increase the perceived value of information even if their use strips the information of some of its content, as discussed in sections 4.3.2 and 4.3.4.

them are referred to in the sections above. In addition, changes in the distribution of power affect some of the issues described in the other areas of concern:

- The power of interests outside the community may have some bearing on the distribution of power within the aboriginal resource management agency and the community. For instance, external interests may have sway over approval of personnel selection within the agency. As well, they may have connections to powerful members of the community through shared activities in political fora and the like. Certainly, with the network financial assistance programmes government agencies provide to promote various resource management related activities, government interests may have considerable power that is manifested ecologically.
- The distribution of power in the community may be sufficient to have some bearing on the power of external interests. For instance, a particularly politically active and successful Chief may be able to bring pressure to bear on external agencies to undertake desired actions.
- The distribution of power in the community will have a definite effect on the power of individuals within the resource management agency. If powerful members of the community support some agency members more than others, the status and sway of the supported people will improve in the agency.
- Legitimation of knowledge has a bearing on the distribution of power in the aboriginal resource management agency, the community, and external interests. In a knowledge-driven process like resource management, any party who believes that information embodied in GIS has greater value than the same information recorded in other forms will assess their power relative to others partially on the basis of what GIS information they and others control.
- Distribution of power within the aboriginal resource management agency will affect the amount of capital made available to purchase and maintain GIS. If proponents have more power, they will be more able to influence budgetary allocations for the technology and related requirements. As well, they will be able to influence allocation of staff time for GIS education and training.
- Distribution of power within the larger community may affect capital availability for GIS. For instance, if the Band Council has some responsibility for promoting and funding resource management activities, the influence of powerful community members and their opinions of the technology will affect decisions about making efforts to pursue additional funding.

- The opinions of powerful community members of the technology will, in the long term, affect whether people in the community consider it valuable to pursue the education necessary to use it.
- Advanced education and training required to use GIS may affect the power of those who undertake it relative to others in the community. Certainly, if this sort of education is needed for effective public participation, its presence or absence in community members will affect their influence on resource management activities.
- The power of external interests can affect whether capital is made available to the community for GIS and related requirements. As well, because GIS data sets often are produced by territorial or federal government agencies, these can determine whether the GIS data required by the community are produced and made available.

4.2.6 Summary: Power Distribution Concerns

The four issues described in this section are grouped into a broad area of concern, termed power distribution concerns. These issues, the area of concern, and the linkages between them and other issues in the access to technology and socio-cultural concern areas are summarized in Figure 2.

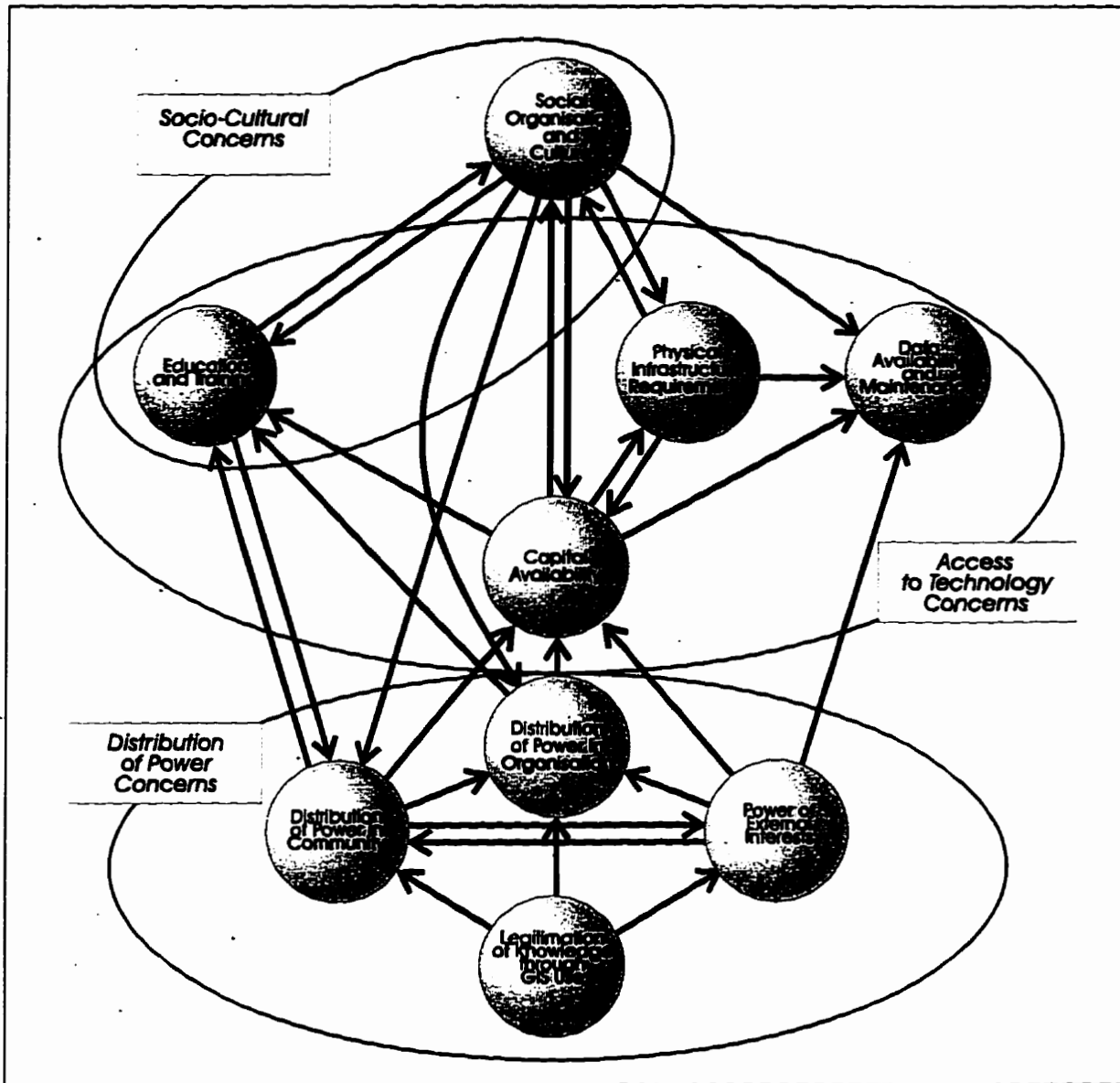


Figure 2: Distribution of Power Concerns and their Relations to Access to Technology and Socio-Cultural Concerns

4.3 Epistemological and Ontological Concerns and GIS Technical Concerns

A third set of issues of importance when implementing GIS for aboriginal integrated resource management concerns the ways in which the technology may limit the knowledge that can be represented in it. Researchers with these concerns argue that the technology will direct users to favour some forms of thinking about space while steering them away from other forms that are not compatible with GIS. A first specific concern is that GIS encourage positivist understandings of valid knowledge that are incompatible with other valid types of knowledge. A second is that GIS as a medium embody limitations to conveying information imposed through inheritance from

maps and mapping. A third is that computer database characteristics of GIS limit types of information that can be represented. In particular, some assert that GIS cannot represent space except in absolute, Cartesian co-ordinates, and that this excludes other ways of perceiving space; associated with this is concern about GIS abilities to represent time. Finally, there is a concern that these computer database roots and other technical limitations of computer logic and operations restrict analyses that can be effected by GIS, and that GIS users will be directed away from forms of analysis that cannot be undertaken.

A particularly worrisome aspect of these areas of concern is that GIS software and manuals give no indication that there may be problematic limitations to the technology. In the view of one author, GIS present an image of complexity, but embody a simple set of practices that limit the ways in which alternative notions of time and space, or narrative and chronology, can be represented (Curry 1994, 442-449). Users of the technology may be deceived by the images and believe that the abilities of the systems to represent knowledge are much greater than they are. Adding to this is a problem arising from the sharing of cognitive responsibility between human operator and computer running GIS software. Optimisation of this split responsibility, a subset of the field of human-computer interaction known as cognitive ergonomics, recognizes that some cognitive tasks are easier for people than computers and vice versa. Factors that vary between people, such as cognitive capacity and style, will affect the optimisation of the split (Turk 1990, 39-43). In current GIS software, this split almost invariably is fixed by system and application programmers in ways that hide the responsibilities of the computer and make them impossible to alter. Since computer programs contain implicitly the assumptions of their creators, the component of cognitive responsibility taken by the computer effectively is taken by the software designers, and, to a lesser degree, by the hardware designers. Glossed over with a sheen of presumed technical objectivity, GIS become prescriptive technologies⁴⁹ that establish an accepted orthodoxy of doing things, technical "best means" that exclude others (see Ellul 1964, 21-22). Because the technology arises from the dominant southern culture and its particular biases of perception and understanding, this baggage of hidden assumptions could lead to GIS becoming instruments of cognitive imperialism when used in cross-cultural settings. In aboriginal resource management endeavours that include indigenous knowledge as part of the information to allow informed decision-making this is an important concern.

4.3.1 Positivist Assumptions in GIS

Section 4.2.4 introduces the idea that GIS may be associated with scientific and positivist thinking approaches, and that this may colour perceptions of the value of the information contained in them. However, it does not address the question of whether there is any truth to these

⁴⁹ See Franklin (1990, 18-24) for a discussion of prescriptive, as opposed to holistic, technologies.

associations. Some commentators on the technology argue that GIS designs and functions favour positivist approaches to knowledge (e.g. Heywood 1990; Taylor 1990; Lake 1993; Sui 1994). Since in the last 25 years positivist approaches have come under fire as being inadequate for treating all knowledge, particularly in the social sciences disciplines,⁵⁰ if GIS do embody positivist principles and discourage use of other types of knowledge, care must be taken in planning processes so that their use does not slant understandings and divert attention from other important aspects of situations being analysed to aid decision-making.⁵¹

Conventional definitions of positivism include several elements. A typical and relatively succinct summary states:

The characteristic theses of positivism are that science is the only valid knowledge and facts the only possible objects of knowledge; that philosophy does not possess a method different from science; and that the task of philosophy is to find the general principles common to all the sciences and to use these principles as guides to human conduct and as the basis of social organization. Positivism, consequently, denies the existence or intelligibility of forces or substances that go beyond facts and the laws ascertained by science. It opposes any kind of metaphysics and, in general, any procedure of investigation that is not reducible to scientific method. (Encyclopedia of Philosophy 1972, 414)

This definition contains several important elements that often are intended when the term is used. In sum, positivism is a theory of valid knowledge and its characteristics, how knowledge should be pursued, and what the objects of knowledge should be used to achieve. As a natural consequence, the dialectical complement to this position is that positivism indicates classes of knowledge that are invalid, means of pursuing knowledge that are incorrect, and agendas for use of knowledge that are inappropriate; critics often use the term as synonymous with these consequent positions.

The broadness of such a definition makes it difficult be clear on what is intended when GIS are characterized as positivist. In a compelling review of definitions of the term in the literature of positivism, Peter Halfpenny (1982) demonstrates that these may be broken down into twelve separate definitions that can be classified into three groups, one dealing with historical development, a second describing a quasi-religion, and the third including epistemological theses. The first two groups of definitions deal with historical meanings that have been superseded by understandings that correspond to the epistemological group. The epistemological group has three classes of definition. First, positivism is a theory of what the valid objects of knowledge are. The positivist approach postulates that the only source of valid knowledge is empirical observation using the scientific method, and that other subjective objects of experience are not worthy of consideration. Second, positivism adheres to a unity of science thesis according to which all areas

⁵⁰ These criticisms are sketched out in section 6.1.

⁵¹ This section is derived in part from an unpublished longer paper by the author entitled "Planning, Geographic Information Systems, Positivism, and Post-Positivism."

of scientific inquiry can be integrated into a single natural system. An extension of this view is that all situation-specific knowledge may be understood in a unified framework. Third, positivism holds that observed elements of knowledge may be related through universal laws, explanation and prediction derived using formal logic. Positivists seek to reduce specific observations to general rules and principles that are universally valid (Keat and Urry 1975, 22-23; Halfpenny 1982, 64). These laws are confirmed or rejected using the Hypothetico-Deductive (“H-D”) method (Miller 1983, 143-151), and applied using a formal logic of deduction, the Deductive-Nomological (“D-N”) approach, or a statistical logic of induction, the Inductive-Statistical (“I-S”) approach (Keat and Urry 1975, 9-13).

Positivism has been criticized for providing incomplete understandings, particularly in the social sciences. As discussed in section 1.3.1, earlier in the century theorists and researchers such as Benjamin Whorf, Edward Sapir, and Karl Mannheim put forward the argument that knowledge is a social product that arises from language. This view was supported by the research of social behaviourists, and later on expanded by cultural anthropologists such as Edward T. Hall to include other elements of communication and used by Herbert Blumer as the basis for the notion of symbolic interactionism. A related branch of this line of reasoning was developed in the 1950’s and 1960’s by post-positivist critics such as Peter Winch (1958) and Berger and Luckmann (1966). These authors argue that for sociologists, studying knowledge as a social product is more important than attempting to gain empirical understandings of people through positivist methods. As these ideas have gained currency in planning and the social sciences in the 1970’s and 1980’s, use of positivist approaches have come under great criticism. In social research, traditional approaches have been replaced by naturalistic approaches that focus on understanding people and the meaning behind their activities using qualitative means (Guba and Lincoln 1989, 95; Williams 1986, 1-2).

Section 2.1 makes reference to the impact of these ideas on planning. In planning, rational attempts to maintain a critical distance between planners and those planned for to maintain a technical neutrality are now discredited (Lake 1992, 415-416). Planning finds itself cut loose from its former bedrock truths of objective knowledge, professional political neutrality, and rationality, and floating adrift with a postmodern weightlessness (Moore-Milroy 1991, 185). These ideas have been slower to gain currency in the resource management sub-discipline of the profession. Certainly, since resource management deals with the management and use of abiotic and biotic elements of a region about which natural science approaches provide key insights, there has been no immediate impetus for resource managers to move away from positivist approaches. However, as detailed in section 2.3, it is partially because positivist approaches have come under criticism as providing incomplete understandings of even abiotic and biotic realities that attempts are being made to integrate indigenous knowledge into resource management processes. Furthermore, it is apparent that resources cannot be managed properly without regard for human activities and valuation of the landscape. For these reasons, if GIS are positivist by nature, they cannot be used

as the sole repository of resource management information without reducing resource management effectiveness.

Concerns that GIS are positivist by nature are based on several observations about the technology. First, some authors state that GIS data modelling assumes a positivist ontology in which one of the bases is the premise that an objective world exists independent of the observer. Furthermore, it is assumed that this world is not only knowable but can be represented in GIS data structures (Sui 1994, 264-265). Because of these epistemological and ontological characteristics of GIS database structures, no provision can be made for different perceptions of characteristics among individuals. Characteristics of things described in GIS databases may vary over time and place, but the social dimensions of knowledge are lost when they are described in GIS. For instance, if several elders speak of a trail, and some describe it as very steep and hard to negotiate while others describe it as reasonably easy to travel, GIS will have a difficult time storing both perceptions because the systems are designed to presume that only one objective reality exists. As a result, GIS data formats oversimplify and distort reality, and bias users toward certain kinds of analyses at the expense of others (Sui 1994, 265-266).

Second, some commentators claim that GIS assume a subject-object dualism between researcher and individuals constituting data in GIS databases. This criticism is related to the positivist principle that valid knowledge is derived from empirical observations using scientific method. Since this assumes that the world has an independent existence to observers and that it may be fathomed by use of formal, "objective" methods, the relationship between observer and object of study is denied. Subjects of analysis in GIS cannot remain subjectively differentiated as individuals but instead are transformed into objectified and non-autonomous objects of study. Even if the individuals who provide information are allowed to participate in projects and allowed open access to GIS databases, they must deny their own subjective elements of experience as a precondition to participation (Lake 1993, 408-409). This is a particular concern in northern aboriginal communities in which the people who provide information and the stories they tell to place the information in context may be understood as important to the meaning of the information. For instance, when compiling a GIS database of moose kills in an area it may be difficult or impossible to include information about the people who made the kills or other information they provided when talking about the kills.

Third, some authors of critical analyses of GIS assert that as computer-based technologies, the systems use deductive (Aristotelian) reasoning implicitly (Shepherd 1993, 458-459). This objection to GIS is related to the positivist use of the D-N method of explanation.⁵² Alternative epistemologies such as dialectical analysis, deconstructionism, or Gestalt logic are precluded when GIS are used (Sui 1994, 266). Possible analytical methods available to GIS users are constrained

⁵² This is discussed further in section 4.3.4.

on this basis, so that analysts using the technologies are led away from methods not possible using the systems. In resource management activities, the main implication of this is that any analyses of information entered into the system will set aside holistic and intuitive approaches to understanding used in indigenous knowledge systems (described in section 2.4) in favour of reductionist deductive approaches favoured by conventional science.

Fourth, some commentators reviewing positivist characteristics of GIS state that assumptions of objectivity and subject-object separation lead to mistaken claims that GIS are value-neutral and politically neutral (Lake 1993, 405-406). These understandings disguise potential impacts of computer-aided planning. For instance, as discussed in sections 4.2.1 and 4.2.3, use of GIS favours technically sophisticated users at the expense of the less technically proficient, unbalancing already unequal power relations and reinforcing status quo interests. As well, the use of GIS allows those controlling the technologies to hide political decisions under a veneer of technical objectivity.

One important question that needs to be addressed when considering the concerns raised above is how much the characteristics of GIS that they describe result from inherent limitations to the technology and how much they arise from the biases of the bulk of GIS users. One important distinction to make when determining whether GIS are inherently positivist is to differentiate between GIS as repositories of data and GIS as analytical engines for those data. Theodore Roszak (1986, 108) observes that:

when we speak of the computer as a “data processor,” it is easy to overlook the fact that these two words refer to two separate functions that have been united in the machine. The computer *stores* data, but it can also *process* these data – meaning it can manipulate them in various ways for purposes of comparison, contrast, classification, deduction. [emphasis in original]

When current GIS are examined as analytical engines for data, criticisms of them as positivist are compelling. Current GIS analytical techniques include generation of spatial statistics, analysis of spatial diffusion, input-output analysis, shift-share analysis, central place theory, and gravity modelling (Sui 1994, 259-263). All these use combinations of numeric analysis and Boolean logic to combine and manipulate data sets. In this regard, the criticism that GIS use formal deductive and inductive reasoning schemes implicitly is valid. Thus, users who seek to analyse data will be led towards positivist methods such as D-N and I-S analyses. This limitation to GIS analysis is discussed further in section 4.3.4 below. Whether GIS analytical methods that do not use positivist approaches are possible is an area open to question. Computer analytical methods of this nature are rare, but some current GIS research is exploring methods that may not be positivist. For instance, one area of investigation focuses on the use of “fuzzy sets” as a means of freeing GIS analyses from strictly formal logic. The fuzzy set concept has arisen in formal logic to deal with sets whose boundaries are not sharply defined (see Kintsch 1977). Instead, their boundaries flow into each other, allowing inexact concepts to be represented. For instance, when

using these methods, a GIS user might classify land by potential timber productivity using measures such as “very good” through “poor.” (Wang, Hall, and Subaryono 1990; Hall, Wang, and Subaryono 1992) These fuzzy measures do not fall into the conventional empirical descriptive measurements that follow from use of the scientific method, nor do the linkages of diverse variables require a unified field of inquiry. Subjective human impressions may be taken into account without implying any causal linkage between them and the physical attributes.

The case for GIS being positivist by nature as repositories of data is much less compelling. To support the idea that GIS are positivist as an information storage medium, one would argue that the systems’ abilities to store data restrict people operating them to using empirical information derived using scientific methods, that they cannot incorporate subjective objects of experience, and that they enforce treating all data in a single, unified framework. The view that this is the case is easy to understand, given the predominance of empirical application examples in the literature. However, the case that GIS are *necessarily* positivist as data repositories seems difficult to support. For instance, the technology does not prevent users from recording subjective impressions of the landscape as attributes. It is much easier to support the contention that, like all media, GIS constrain and mould the information that can be represented and conveyed using them. When examining GIS as repositories of information, a few of these constraints may be labelled positivist, but it is arguable that many are inherently positivist. The association of GIS with positivist approaches may be as much a consequence of their early association with individuals with positivist predispositions as a result of positivist assumptions built into the technology. It seems accurate to contend with Gilbert (1995) that, although GIS have been associated closely with the quantitative geographic tradition up to now, the technology may open up new possibilities for people from other traditions as a new communication medium. This does not reduce the need to have respect for limitations they impose even if these are not strictly positivist limitations. However, it alleviates concerns that use of the technology involves inherently forcing valuable but non-positivist understandings of the environment and landscape embodied in indigenous knowledge into a positivist framework.

4.3.2 Limits to GIS Imposed by their Cartographic Roots

One specific concern regarding limitations that GIS impose is that the systems embody the limitations to conveying information inherited from their roots in maps and mapping described in section 3.1.

The academic discipline of cartography revolves around how maps, as communication tools, constrain information that can be conveyed, means of addressing these constraints, and conventions for using maps to transmit information. In an excellent primer on the subject, Monmonier (1991) points out that the very process of mapping information necessarily involves elements of distortion, omission, and emphasis of information. He summarizes that maps have

three basic attributes – scale, projection, and symbolization – and that each element is a source of distortion, both intentional and unintentional. That distortion is a necessary quality of maps is apparent when one considers the simple example of a small scale road map. If the map is at 1:1,000,000 scale, a 20 metre wide four lane highway represented at true scale would be 0.02 millimetres wide – invisible to the human eye. Even if the highway is represented with a thin but visible 0.5 millimetre line, at scale the line covers a half kilometre swath of land, or twenty-five times the real size of the highway. In addition, elements of human perception distort how maps are perceived. For instance, research into the physio-psychology of vision can demonstrate some pan-cultural responses to colour such as the tendency of people to perceive large patches of colour as more saturated than small patches of the same or the tendency to perceive a higher degree of contrast for juxtaposed colours (Monmonier 1991, 155); these characteristics of human perception are based upon such things as the arrangements of colour-sensing cones in the eye. As well, culture, life cycle, and demographic characteristics affect subjective reactions and preferences for different colours (p. 153).⁵³

Because a map allows only a limited amount of information to be presented in a comprehensible way, such elements of perception will cause some information to be emphasized at the expense of others. As communication tools, maps may be understood as semiotic systems (Head 1991; Nyerges 1991a).⁵⁴ As such, as Head (1991, 237) puts it, like all thought or communication, mapping is selective; it does not present all of reality at once. One author argues very convincingly that all maps may be understood as rhetorical texts and deconstructed, because, “The steps in making a map – selection, omission, simplification, classification, the creation of hierarchies, and ‘symbolization’ – are all inherently rhetorical.”⁵⁵ (Harley 1989, 11) To deal with the limitations imposed by the medium, cartography has, over time, developed a set of largely arbitrary conventions to differentiate different types of information. For instance, choropleth symbolization – the use of a set of similar colours with different saturation intensities – is used to represent quantitative differences in a single variable, while multiple-hue scales are used to represent differences in type. A knowledgeable cartographer must accept that even if maps represent empirically-verifiable features, their representation of these involves gross processes of distortion mitigated only by cartographic conventions (see Wood 1992).

⁵³ This one example, of course, cannot and does not pretend to do justice to the complexity of factors cartographers must consider in producing maps.

⁵⁴ See section 1.3.2.

⁵⁵ Harley also asserts that, “To catalogue the world is to appropriate it, so that all [cartographic processes of compiling, categorizing, and generalizing information] represent acts of control over its image which extend beyond the professed uses of cartography. The world is disciplined. The world is normalised. We are prisoners in its spatial matrix.” (1989, 13) This argument could be used to support associating the act of mapping with the positivist principle of unifying knowledge into a single system that can be comprehended using universal laws and principles described in section 4.3.1.

The roots of GIS as automated mapping tools were described in section 3.1. Viewing them from the media/semiotics perspective described in section 1.3.2, one would expect that GIS would absorb the limitations of the old medium but transform them, intensifying some aspects while rendering others obsolete. This is confirmed by Goodchild (1988). This author laments that GIS have been developed up to the present mainly to emulate manual cartographic methods, with all their inherent limitations. At the same time, he points out that current GIS capabilities may be used to address some of the manual limitations. For instance, unlike maps, GIS may store a much greater amount of information than can be represented on a map. As well, they may be used to visualize the landscape in three dimensions or visualize temporal changes in information through portraying information changes over time on a dynamic map on a computer screen.

The removal of restrictions imposed by the manual cartographic roots of GIS is not without its own set of problems. One particular difficulty is associated with accuracy of spatial data stored in GIS. The problem is defined succinctly by six fundamental points that establish the basis and objectives of the NCGIA research initiative to study accuracy of spatial data and promote incorporation of a measure of uncertainty in every GIS product. These state:

1. precision of GIS processing is effectively infinite;
2. all spatial data are of limited accuracy;
3. the precision of GIS processing exceeds the accuracy of the data;
4. conventional map analysis precision is adapted to accuracy;
5. because GIS allow users to change scales and combine data from different sources easily, precision is usually not adapted to accuracy;
6. there are no adequate means to describe the accuracy of complex spatial objects (Goodchild and Gopal 1989).

A practical example of the implications of how this accuracy issue, which arises from new GIS capabilities that transcend old restrictions imposed by manual cartography, is provided by the way in which they have facilitated increased use of cartographic modelling, which is also known as overlay mapping (Aangeenbrug 1991, 102-103). Although the cartographic modelling approach has existed since the late 1960's, like many of the quantitative geographical analysis techniques referred to in section 3.1, it was impractical to use manually. GIS have freed the technique from practical restrictions to use imposed upon it by manual mapping methods. However, they have not resolved fundamental problems of cumulative error propagated by combining individual maps, each with its own accuracy level. Potentially, the ease with which geographic data may be overlaid using GIS may lead to extremely low accuracy levels in combined products (Chrisman 1989).

For aboriginal communities adopting GIS for resource management efforts, the practical implication of GIS being subject to some of the old limitations imposed by cartography is straightforward: those responsible for using the systems should be provided with basic cartographic training. As cartographic tools, GIS have freed those producing maps from much of the tedium associated with manual cartography (Tomlinson 1988). A skilled cartographer will take advantage of this while having regard for elements of distortion, omission, and emphasis of information when designing maps and using these elements to communicate the information to be conveyed. However, the technology makes it easy for neophytes to generate superficially-convincing maps that violate basic cartographic principles, and will not warn users that they may be making gross errors. There is a danger in allowing GIS users without cartographic training to use the technology for mapping purposes (Goodchild 1993, 12). As Monmonier (1991, 156) correctly, if glibly, notes, “programmers with no training in cartography and little sense of graphic design have been highly successful in writing and marketing mapping software. With no guidance and poorly chosen standard symbols, users of mapping software are as accident-prone as inexperienced hunters with hair-trigger firearms. If you see one coming, look out!”

4.3.3 Technical Limits to Representation of Knowledge in GIS

The preceding sections on possible constraints that arise from GIS cartographic roots and positivist principles programmed into the systems deal in part with a broad concern about how GIS may restrict types of knowledge that can be represented in them. A particular issue that is raised in literature examining GIS critically is specific constraints on information representation in GIS arising from technical design limitations of GIS software and, to some degree, the computer hardware on which it runs. In this section, the nature of these constraints is summarized, their roots in computer database technologies are examined, and their particular implications for use of GIS to record indigenous knowledge are discussed.

One concern about GIS representation of knowledge focuses on the model they use to represent space. All current GIS data models require that all data be stored with reference to numerical spatial co-ordinates referenced to absolute distance ground units. Thus, the conception of space inherent in GIS databases is a Cartesian model (Couclelis 1991, 14-16; Curry 1994, 447-449; Sui 1994, 264). From a planning perspective, because of the absolute, “container” view of space that they derive from the Cartesian model, current GIS are not suited to strategic planning functions, which require a relative or relational view of space, and dealing with political considerations (Couclelis 1991). Other possible conceptions of distance may be useful to consider for planning purposes, such as time distance, economic distance, and cognitive or “proximal” distance (see Gatrell 1983; Tversky 1993). For instance, the importance of hunting areas may be a direct function not of their absolute distance from a community but of how much time it requires to travel to and from them. Two communities may be a great absolute distance apart but enjoy an intimate economic association that means they must be considered as economically proximate. A

timber stand a great absolute distance from a community may be considered cognitively nearby because it contains an important historical meeting place whereas one relatively close in absolute terms may be cognitively far away because it is used little. These examples make it clear that for managing resources effectively, information mapped on a Cartesian basis does not provide a whole picture. However, although there are means of mapping the other spatial forms, none are supported directly by current GIS. For resource managers, the danger of this is that GIS may displace skills and habits of thought that may still be valuable by focusing attention on the type of space the technology is most suited to representing (Couclelis 1991, 17).

Another concern about limitations to representation of knowledge relates to the computer database elements of GIS. As discussed in section 3.1, one of the roots of GIS technology is the computer database, which developed originally as a computer version of paper ledgers and filing systems. Though computer databases introduce a greatly increased flexibility to information management over the old manual systems that they supplant, they still retain some of the conceptual biases of their forebears. At their core is the conception of reality as being made up of discrete objects, each of which can be described with a standard set of characteristics (see Roszak 1986). Thus, computer databases represent reality as atomistic and focus on homogeneous aspects at the expense of understanding interrelationships and unique qualities. As an inheritance, GIS receive a view of the world as being made up of discrete objects with a universal set of attributes. In this regard, the criticisms that current GIS promote positivist approaches to understanding detailed in section 4.3.1 are supported.⁵⁶ A further limitation of many current GIS associated with atomistic data models is planar enforcement. This refers to a basic data model constraint that no two objects in a single data set may overlap (Goodchild 1993, 9). This causes problems for representing spatially-continuous phenomena such as soil class or atmospheric pressure. If GIS are unable to represent continuous distributions, resource managers may be tempted to represent them as discontinuous, creating the danger that they may lose sight of the continuous distributed characteristics of the phenomena.⁵⁷

To the computer database, GIS add graphic representation of spatial features that were adapted from computer assisted design and drafting software, which in turn is a computer version of manual drafting. Derived as they are from manual drafting practice, CADD databases define drawings, which contain computer representations of basic marks that can be placed on mylar using pens and ink, for instance point symbols, lines, curves, offsets, text, and shaded areas. These

⁵⁶ Some of the most recent GIS are beginning to include the possibility of representing multimedia objects such as pictures or sounds as database fields allow a more heterogeneous representation of objects. This improves upon previous designs. However, atomism still remains, along with the restriction that objects may be linked only in formal and explicit ways.

⁵⁷ This is a software programming limitation rather than a fundamental technical limitation. Some development effort is being focused upon dealing with it by major GIS vendors. For instance, ESRI extended its data model in its latest workstation version, release 7, to include "regions" that may overlap.

were borrowed by vector GIS, to which all spatial objects are represented as points, lines (which are the connection of two or more points), and areas or “polygons” (which are spatial areas defined by one or more bounding lines). CADD software, as initially implemented, improved the accuracy of manual drawing features greatly, but at the cost of disallowing inaccuracy even when it is desired. As the rationale for the NCGIA research initiative cited in section 4.3.2 makes clear, GIS spatial databases suffer from the same shortcoming. All mapped information has a degree of inaccuracy, but manual cartography has had the means to deal with this implicitly through the limitations of the medium – maps are committed to paper at a single scale that cannot be changed without redrafting. GIS, to the contrary, are relentlessly accurate. Each spatial co-ordinate is stored at the maximum precision allowed by the system data model and units of measurement. For instance, the location of a cabin may be marked on a 1:250,000 scale map by a hunter using a dot that covers a circle of a quarter kilometre diameter. When this is entered into a GIS database, though, it may be stored as a single point within ten centimetres of an absolute ground location. Current GIS database models do not support any measure of fuzziness of location – they demand exact numeric locations for all data.

Another shortcoming of the computer database models used to represent space in GIS is the stripping of information stored in the systems of all but basic locational and attribute information. Unlike CADD, GIS support modelling of basic topological relationships between the discrete objects on which their data models are based, for instance adjacency, proximity, and direction, but current GIS data models cannot represent other commonly-used spatial information abstractions such as classification, generalization, aggregation, and association (Nyerges 1991b). As well, current GIS data models are bereft of metadata, or “data about data”, such as who collected the information, when, using what methodologies, and how accurate the information is (see Frank, Egenhofer, and Kuhn 1991; Nyerges 1991c). As Fisher (1989) notes, errors of commission or omission are endemic in manual cartography because of a number of factors involved in production of maps, including scaling and associated generalization, symbolic representation, and the like. Although cartographers have traditionally attempted to compensate for these inaccuracies by preparing informative reports and legends, these are most often ignored in the process of digitization of maps to translate them into GIS. As well, in manual cartography, metadata are provided to some extent implicitly in the scale at which the map has been produced and the symbolic conventions used.

Retaining this expert knowledge could improve reliability of GIS and their products, but most current GIS data models, with their emphasis on discrete individual spatial objects rather than the characteristics of data sets as a whole, do not offer support for metadata as part of the basic geographic data model. Instead, users either must maintain such records manually and have regard for them when using the information, or go through an arduous process of developing their own data structures to maintain the information digitally. Lack of metadata is associated with GIS promoting a “flattening” of qualitative judgements about data sets. Since as a medium GIS do not have the explicit and tacit cues of the mapping medium to guide the user to understandings about

qualitative value of information, once information has been transformed into a GIS data set users are guided to treat it as equal with all other data sets. A reader of an article in *Environment and Planning A* will afford it different value from that of one printed in a tabloid newspaper purchased on a street corner on the basis of quality of paper stock, apparent effort that has gone into the design, and numerous other factors, even if she has never read either before. GIS offer little such evidence of the distinguished or sordid roots of the information they present.

Maintaining and paying attention to metadata are important when GIS are used for activities like resource management because of the way that the systems have removed some of the constraints imposed by manual cartography referred to in section 4.3.2. For instance, if spatial information on locations of a protected species of rare orchids mapped to a within 10 metre accuracy is overlaid with information on proposed timber cutting activities mapped to a within 2 kilometre accuracy, the timber harvest boundary may appear to be a kilometre away from the protected plants when in fact it includes the whole area. In a manual cartographic exercise, the differences in the source data sets would be apparent from visual inspection of the maps. However, since current GIS software do not support metadata, allow data sets to be displayed at almost any scale, and store all co-ordinates at the maximum precision available, output maps invite misinterpretation. The lack of metadata means that the systems cannot warn naïve users that they are breaking a basic cartographic rule. The support of multiple scales makes it very easy for the rule to be broken. The precision at which co-ordinates are stored means that boundary lines drawn from different data sources will appear to be of equal precision no matter what the source scales are. For aboriginal resource management processes involving GIS, all of these factors reinforce the conclusion in section 4.3.2 that those responsible for using the systems must be provided with basic cartographic training.

If current GIS have significant limitations for representing space, their ability to represent time is even more severely constrained (Aangeenbrug 1991, 105). GIS data modelling of time is limited by its extremely high demands for data storage space and processing. The basic elements of the problem are:

- Even efficient GIS database designs require fairly large amounts of data storage space to represent spatial features.
- The simple approach of representing temporal changes to the spatial features in time series by saving a complete copy of a data set for every interval multiplies the storage requirements tremendously. As well, it requires increased processing capabilities to perform computer analyses of series information.
- Designing an efficient spatial database that stores only changes to spatial features rather than a complete copy at each interval would address the storage requirements issue raised by the simple approach. However, implementing such a design is a highly-involved

programming challenge. Furthermore, the storage efficiency is purchased at the cost of requiring greatly increased processing capabilities.

Thus far, commercial GIS vendors have not attempted to provide any solution to representing time, preferring to let users who require this capability implement their own solutions.⁵⁸

A less fundamental element of GIS database design, but one of great significance to aboriginal resource management efforts, is GIS software support for languages other than English. As discussed in section 3.3.2, all major commercial GIS are products of urban English-speaking North America. These have caused problems even in non-English speaking first world urban contexts such as Germany (Wegener and Hartwig 1993), where the written language uses characters or accents not included in standard English. Yapa (1991, 55) concludes from Sri Lankan land management experiences that operations of GIS should be conducted in the local vernacular language. Certainly, if a significant number of people in an area cannot speak the language used to record information for resource management in GIS, this is likely to impair their ability to participate in decision-making processes effectively. In aboriginal contexts in the Canadian north, written versions of indigenous languages often use symbols or combinations of letters and accents not used in any of the major languages of the industrialized nations.⁵⁹ Although newer computer operating systems are becoming more able to support multi-lingual use with standard fonts, supporting aboriginal languages in most major GIS remains difficult.⁶⁰ For aboriginal resource managers interested in supporting public input for citizens of their communities who do not read English, GIS may be a stumbling block. As well, since many aspects of indigenous knowledge can be expressed clearly and accurately only in aboriginal languages (Legat 1991, 33), the ability to record information in local languages is important.

A final concern about GIS information representation constraints that may have particular implications for use of them to record indigenous knowledge systems concerns differences in cross-cultural perceptions of space. Some work of cognitive scientists points to differences in the ways people of different cultures structure and experience space (Bjorklund 1991; Campari 1991; Tversky 1993). For instance, in research into conceptual and linguistic conceptions of space between urban and rural Tamils, Pederson (1993) found evidence that fundamental methods of manipulating conceptual representations of space vary according to the basic linguistic system

⁵⁸ Even the possible temporal GIS solutions are open to the criticism, similar to that of spatial GIS database designs that they represent only absolute, Cartesian space, that they are able to represent only chronological time and not narrative time (Curry 1994).

⁵⁹ Even including the proper accents for Deh Gáh Got'ie Kœ in this paper required manual editing of the font definition that is well beyond the abilities of most computer users.

⁶⁰ In association with this, it should be noted that the standard user interfaces and command languages of all major GIS are in English only. Vendors are slowly beginning to support the other major world languages, but even once this occurs, like other standard software such as word processors and spreadsheets most manuals and other supporting materials are unlikely to be unavailable except in English.

used by the manipulator. The research showed that rural Tamils use absolute spatial reference (north, south, east, and west) for both geographic space and manipulable space, whereas urban Tamils (like Europeans) use absolute reference for geographic space but egocentric or speaker-relative spatial reference (left, right, front, and back) for manipulable space. Frank and Mark (1991) point out that since current GIS interfaces are a product of an English cognitive and linguistic culture, it may not be sufficient to translate the 'surface structure' of the systems, such as the command language, menu contents, or manuals, to make GIS useful in other language groups and cultures; instead, attention must be given to the deeper syntactic and cognitive structures that underlie other languages. It is impossible to anticipate when and how cultural systems of understanding space will differ from those embodied in GIS. The best prescription is that at least some of the people responsible for using the systems to represent indigenous knowledge are of the culture and remain sensitive to any ways in which the ways the systems organize information confuse the people providing the knowledge or are incompatible with the information provided.

4.3.4 Technical Limitations to GIS Modelling and Analysis

As stated in section 4.3.1, because current GIS analytical techniques all use combinations of numeric analysis and Boolean logic to combine and manipulate data sets, GIS analytical methods have positivist leanings. However, even accepting that positivist approaches can provide valuable information for resource management, GIS analysis methods have significant difficulties.

First, although GIS as automatic cartography systems represent a great leap forward from manual methods (Tomlinson 1988), many basic cartographic operations cannot be handled except with extensive manual intervention. For instance, map generalization from larger to smaller scales involves integration of knowledge about cartographic conventions and human cognitive processes to produce products that convey meaning to a map reader. Armstrong (1991) asserts that automatic generalization is impossible with current GIS, but could be facilitated if structural and procedural metadata were added to their data models. He acknowledges, however, that some of the knowledge necessary for generalization is extremely difficult to decompose into an atomistic set of facts and deterministic rules that could be used by computer systems, and admits that because of this, certain aspects of generalization are exceedingly difficult to automate and should be left to human operators.

Second, even simple numeric analysis using GIS often is associated with cumulative error that is potentially large but at the same time is difficult to estimate. For instance, as discussed in section 4.3.2, spatial overlay operations are very easy to perform using GIS, but may lead to high cumulative errors. Aangeenbrug (1991, 102-103) provides an effective example suitable to resource management: "If for Plot 1 the coverage status for vegetation type is accurate at the 0.8 level and if the coverage status for wetlands is accurate at the 0.8 level, the probability that the relation of soil and vegetation [is accurate] is $0.8 \times 0.8 = 0.64$. If a layer of . . .wildlife species with

an accuracy of 0.7 is added it would be possible to argue that the combined layer could depict with a probability of 0.448 (0.7×0.64).” The probability mathematics in this example are open to challenge, but rigorous spatial statistics for multivariate relationships that would give defensible results have not been discovered up to now. More complex GIS mathematical modelling operations have the same difficulty. Even a GIS modelling proponent admits that “numeric manipulation of spatial data may seriously degenerate the relationship between spatial model and reality.” (Kemp 1993, 364)

Finally, GIS have a number of specific technical problems for analysing data that may cause problems for aboriginal resource managers and yet may not be solved but only recognized and avoided. For instance, one classic difficulty, which is present as well in manual cartography, is the modifiable unit area problem (“MAUP”). MAUP refers to situations in which spatial bounding of individual data can produce completely different apparent analyses of the same situation (see Fotheringham 1989; Openshaw 1989). Two variants on the problem are the scale problem, in which data values and inferences concerning the data are affected by the number of zones used to report the data, or the aggregation problem, in which the zone boundaries used for aggregation affect the results. For instance, if clusters of diseased bison are spread unevenly through an area, drawing a zone line in one way might cause diseased animals to represent a large proportion of the total bison for one zone and a small proportion in two others, while drawing it in another might leave two zones with a relatively high diseased proportion and only one with a low proportion. MAUP may cause inadvertent errors of misinterpretation or allow information to be manipulated to the benefit of some interests over others. The ease at which areal boundaries may be changed and spatial statistics calculated using GIS make it a particular danger when using the systems. Another type of GIS analysis difficulty is a class of analytical problems referred to as NP-complete. NP-complete problems are mathematical problems in which the only possible means of determining an optimum outcome is brute force, i.e. the evaluation of all possible solutions, and it can be demonstrated mathematically that this cannot be done in a reasonable time with any foreseeable available computer power. Britton Harris (1989) argues that even when planning is defined apolitically as an optimum-seeking activity, the plurality of interests in a planning process makes defining the criteria for optimisation very difficult, and that if they are defined, many simple planning problems will be NP-complete. Ambitious resource managers who wish to use GIS analysis capabilities extensively are likely to encounter this analytical conundrum.

As the discussion above indicates, use of GIS analytical capabilities is associated with some involved technical conundrums with no easy solutions. Furthermore, these problems involve not only extremely complex technical operations that neophyte GIS users are unlikely to encounter, but also basic analytical techniques like overlay analysis that are likely to be used in any resource management process that uses GIS significantly. To address these issues, exposing those who will be responsible for GIS operations to specialized GIS training is the only effective beginning for resolution.

4.3.5 Connections Between Epistemological and Ontological Concerns and GIS Technical Concerns

Like the issues discussed previously in the access to technology, socio-cultural, and distribution of power areas of concern above, the issues described in this section do not stand in isolation, but interact with and reinforce one another:

- Some of the positivist assumptions embodied in GIS constrain ways in which information can be represented in the systems.
- The logical operations structured into computer circuits are positivist by nature and affect the nature of GIS analytical operations.
- The cartographic approaches upon which GIS are based constrain ways in which information can be represented using the technology.
- Basic cartographic problems such as the modifiable areal unit problem continue to pose difficulties in GIS analysis.
- Limits to the way information can be represented in current GIS constrain types of analysis that are feasible using the systems.
- Because, as discussed in section 4.2.4, scientific and positivist methods are respected in southern culture, the positivist leanings inherent in GIS aid their role in legitimizing information.
- Associated with the notion that positivist assumptions in GIS may increase the perceived legitimacy of knowledge contained in them, the limitations to information representation specific to GIS may be perceived as legitimating the information that can be represented, such as quantitative attributes, while casting doubt on the value of information that cannot, such as qualitative information.

4.3.6 Summary: Epistemological and Ontological Concerns and GIS Technical Concerns

The four issues discussed in this section may be grouped into two areas of concern. First, three of the issues – positivist assumptions in GIS, limits to GIS imposed by cartographic theory, and limits to representation of information in GIS – are classified under the heading epistemological and ontological concerns, as they all relate to ways in which GIS, as a medium, constrain representation of the fundamental nature of space and ways in which it may be thought about. Also associated with this category is the legitimation of knowledge through GIS use issue described in section 4.2.4, because valuation of knowledge is a primary influence on how it is processed cognitively. Second, three of the issues – limits to representation of information in GIS, limits to GIS imposed by cartographic theory, and technical limitations of GIS analysis – are classified as GIS technical concerns.

4.4 Summary: A Conceptual Framework For Understanding Aboriginal Community Use of GIS for Resource Management

Figure 3 summarizes all issues, areas of concern, and linkages between them discussed in this chapter. In review, five overlapping sets of concerns are shown: socio-cultural concerns; access to technology concerns; distribution of power concerns; epistemological and ontological concerns; and GIS technical concerns. Within these are contained thirteen issues which may affect or be affected by GIS implementation: impact of GIS on social organization and culture; education and training requirements; physical infrastructure requirements; data availability and maintenance; capital availability; distribution of power within the resource management agency; distribution of power between the community and external interests involved in resource management; distribution of power in the community; legitimation of knowledge through GIS use; positivist assumptions in GIS; limits imposed on GIS by cartographic theory; limits to representation of knowledge in GIS; and technical limitations to GIS analysis. The issues do not stand in isolation, but interact and affect each other. Arrows between the issues indicate linkages among them. This conceptual framework may be used as the basis for clarifying problems surrounding GIS use for community-based aboriginal resource management.

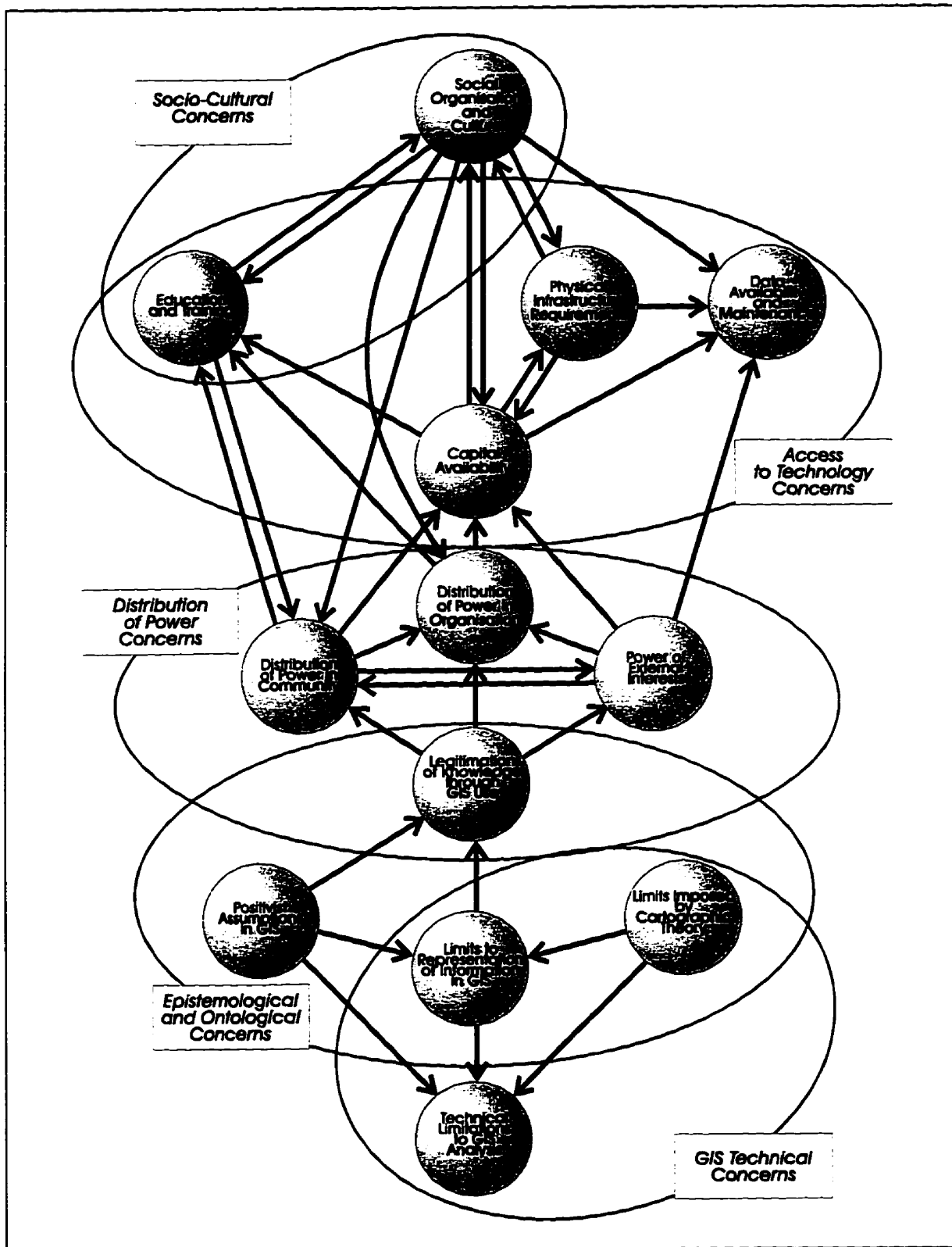


Figure 3: GIS for Aboriginal Resource Management: A Conceptual Framework

Chapter Five

THE CASE STUDY: USE OF GIS FOR RESOURCE MANAGEMENT IN FORT PROVIDENCE, NORTHWEST TERRITORIES

5.1 Background

In summer of 1995, the Deh Gáh Got'ie Kq̓ Dene band agreed to allow me to engage in funded research on the use of GIS as an aid for resource management in the Fort Providence and Kakisa Group Trapping Area. The initial research was carried out in a period of four weeks in October/November of 1995 in the Hamlet of Fort Providence. Subsequently, a second opportunity to visit the community and hone the initial research findings presented itself, and I spent an additional five week period there in February/March of 1996.

5.2 Community Profiles

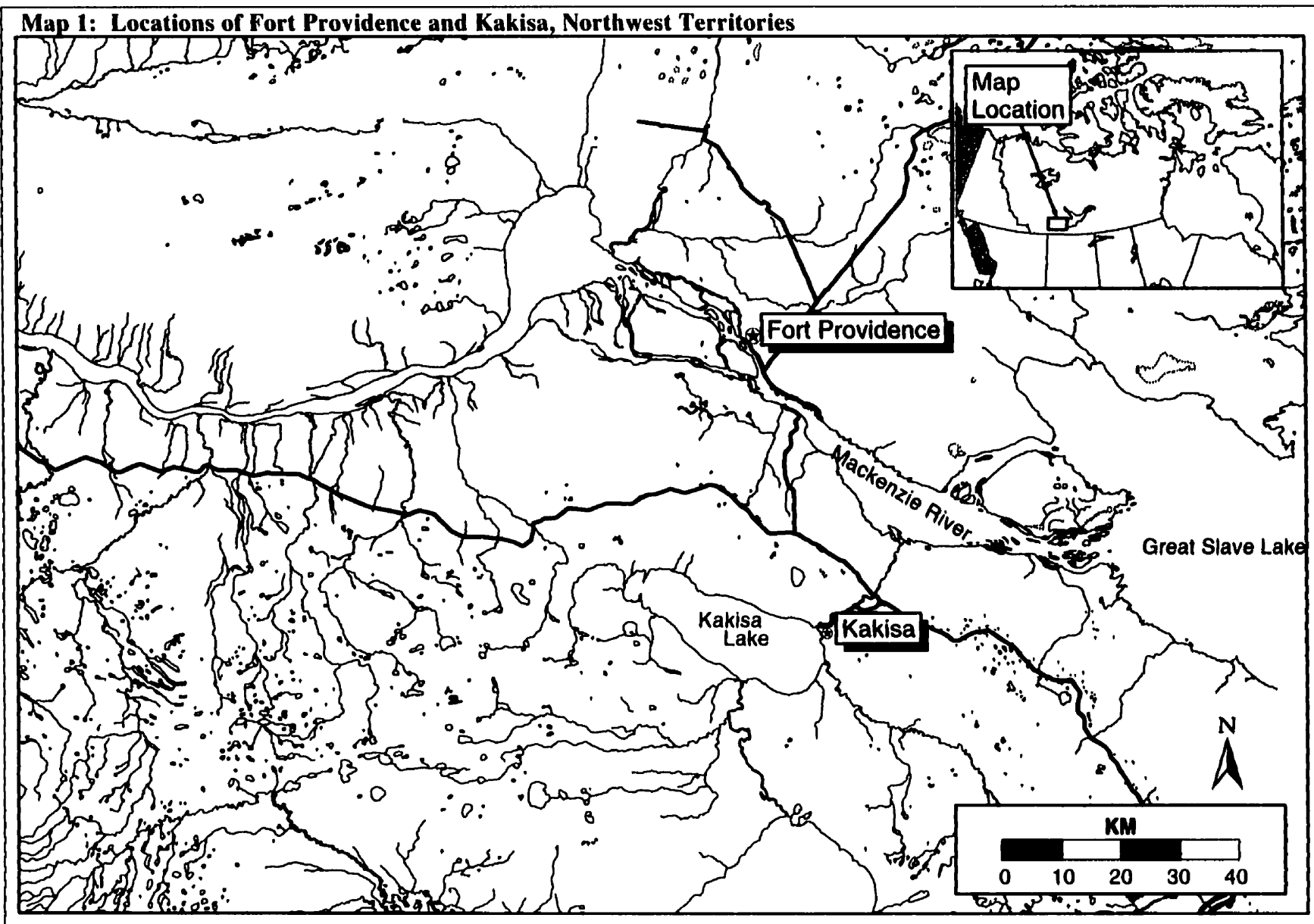
5.2.1 Locations

The Fort Providence and Kakisa Group Trapping Area is located in the Northwest Territories of Canada. The Group Trapping Area extends from the 60th parallel north to the Horn River Valley, taking in land extending from the north-west shore of Great Slave Lake to a line running roughly north-south along the 120th west meridian. This approximately 48,000 square kilometre area surrounds the southernmost section of the Mackenzie River. The communities of Fort Providence and Kakisa are the main settlements in the area, though a small population is scattered widely throughout the area and there is still regular seasonal movement between the communities and cabins or outcamps by people engaged in traditional harvesting activities, particularly in Kakisa.

The Incorporated Hamlet of Fort Providence is located on the west bank of the Mackenzie River about 75 kilometres downstream from Great Slave Lake at 61°22'N latitude and 117°39'W longitude, at an elevation of approximately 160 metres above sea level. The community is located just off of NWT Highway 3, approximately 315 kilometres from Yellowknife and 168 kilometres from Hay River.

The village of Kakisa is located at the head of the Kakisa River on the north-east shore of Kakisa Lake above Lady Evelyn Falls, around 55 kilometres due west of Great Slave Lake, and approximately 20 kilometres upstream of Beaver Lake, a large lake to the north-east which

Map 1: Locations of Fort Providence and Kakisa, Northwest Territories



is a part of the Mackenzie River system, at 60°57'N latitude and 117°24'W longitude, at an elevation of approximately 230 metres above sea level.

The locations of the Group Trapping Area, Fort Providence, and Kakisa are shown on Map 1.

5.2.2 The People

Fort Providence had 645 residents as of the June 1991 census. Ninety-two percent of the people are aboriginal. Ninety percent of the aboriginal population is of Slavey Dene extraction and ten percent is of Métis descent (Government of the Northwest Territories 1996, 4). The Dene band name is Deh Gáh Got'ie Kq̄, which means "home of the big river people" (Deh Gáh, "big river," is the Slavey name for the Mackenzie River). The band is a member of the Deh Cho First Nation. The traditional language of the Dene inhabitants is Slavey, mostly of the South Slavey dialect. The non-aboriginal population is composed mainly of the group of high-turnover white professionals (teachers, police officers, government employees, aircraft pilots and the like) that is typical of small northern communities.

The population of Kakisa numbered 39 as of June 1991, all of whom are Slavey Dene. The people of Kakisa were formerly members of Deh Gáh Got'ie Kq̄, but formed their own band, Káágee Tu, which means "Willow Lake," in 1989. The community members still pursue a very traditional lifestyle, engaging in traditional hunting, trapping and fishing activities, and moving out into small outcamps and cabins for large parts of the year, some still using dog teams.

5.2.3 History

The original Fort Providence was established near the mouth of Yellowknife Bay shortly after Alexander Mackenzie visited the area in 1789. This post was abandoned around 1820, the time of Franklin's Coppermine expedition. In 1861, a Roman Catholic mission was founded at the present Fort Providence town site. This was named Notre Dame de la Providence. During the next two years a small residence, chapel, and nuns' residence were built. In 1866 Grey Nuns left Montreal to take up station at the mission, arriving in August of 1867. At this time, one of the sisters' residences was converted into the Sacred Heart Hospital and Orphanage (Lafferty 1992, 10). During the years that the mission was being established, the Hudson's Bay Company established a permanent trading post at the same location to trade goods for furs with the Slavey Dene, who inhabited the area. At this time, the Dene inhabitants still carried on a traditional lifestyle of hunting, trapping, and fishing. The population was widely distributed through the region in small camps, normally divided along extended family lines. The mission became known to the Dene as Zhahti Kq̄, or "the priest's place", a name that is still used by elders for Fort Providence.

Despite the presence of the mission, hospital, and trading post, no significant community grew up at the town site until the 1930's after the opening of a new residential school, the Sacred Heart School, which was built in 1929 and 1930. The community saw significant growth during the 1930's through 1950's, as the Dene began to abandon the small communities throughout the area, desiring to be near their children while they attended school and attracted as well by government benefits. The community continued to grow during the 1960's from continued inflows of Dene from the land. The last of the outlying villages was abandoned in the early 1970's. The community was an unincorporated settlement until 1987, when it finally was incorporated as a hamlet.

Kakisa is a summering community of long standing, and existed much as it always had until the 1960's. At that time, the territorial government engaged in a program of building new houses and a Band office in the community. Although there have been some informal initiatives from the territorial government to encourage the community to incorporate formally, the people have preferred to eschew this status as they perceive it as conflicting with the way in which they lead their lives.

5.2.4 Abiotic and Biotic Characteristics of the Land Base

The climate of the Fort Providence and Kakisa Group Trapping Area may be characterized as sub-arctic. Permanent river ice usually starts to deteriorate around the beginning of April, with the river ice-free by the middle of May. Summer temperatures top in July at a daily average of around 16°C. River ice normally begins to form in October, with permanent ice cover by November and a winter ice road over the Mackenzie River passable between December and April. The winter months see average daily temperatures of around -25°C in January and winter lows of down to -50°C, with the sun rising for about four hours at winter solstice. The average annual precipitation is around 350 mm, divided into approximately 200 mm of rain and 160cm of snow each year.⁶¹

The Group Trapping Area lies in the Interior Platform geological province, which is an extension of the Interior Plains region of North America. This area was once the lake bed of glacial Lake McConnell. As would be expected of this former lake bed, the geological composition of this area largely is lower Palaeozoic carbonates, Cambrian shales and evaporites, and Middle Devonian carbonates and evaporites (Padgham 1975, 359). Metallic formations in this geological province are rare, and must be large and rich to be economical to extract (Padgham 1975, 360).

⁶¹ Statistics derived from Environment Canada Climate Normals Sheets for Fort Simpson, N.W.T. and Hay River, N.W.T. provided by the Environment Canada Yellowknife Weather Office. These are the closest weather stations with comparable physiographic conditions to Fort Providence. The Yellowknife information was not considered because its location on the centre north shore of Great Slave Lake and its pre-Cambrian geology result in significantly different weather conditions.

No significant finds have been made in the Group Trapping Area, and only two areas (the Cameron Hills to the south and the Horn Plateau to the north) are likely to have any potential for further finds (Pell 1996). One or two small areas, notably Mink Lake and the Horn Plateau, are thought to have Kimberlite pipe formations. In the current diamond mania sweeping the Territories, these have been or are being staked, but exploratory drilling has not taken place and no finds have been reported. Other minerals that may be found in the area are uranium, vanadium, and various industrial ores (Beaurigard 1996). Former lake beds often yield petroleum products, and the area was explored in the 1950's and 1970's for these. This exploration discovered only small natural gas deposits that are uneconomical to develop, and a coal deposit at Mills Lake, which currently is not economically feasible to mine.

The Group Trapping Area occupies the southern reaches of the Taiga Plains ecozone, a 550,000 square kilometre region of low-lying valleys and plains surrounding the Mackenzie River. This section of the Taiga Plains is characterized by dense boreal forests, predominantly black spruce, white spruce, and jackpine. The forest lands are interspersed with intermittent non-forest types such as shrublands, meadows, and bogs. The soils are a mix of areas of heavy silt clay and more sandy locales, another legacy of the area once having been a part of the lake bed of glacial lake McConnell (Chowns 1996).

Large mammals common to the area include moose, woodland caribou, black bears, and white-tailed deer. As well, the area includes the Mackenzie Bison Sanctuary, which includes the world's largest population of wood bison. This was established in 1963 when the Canadian Wildlife Service transferred 18 disease-free pure wood bison to the area, which had been a historically occupied range for the animals. The area provides permanent or migratory habitat to several types of waterfowl, including snow geese, whistling swans, ten varieties of ducks, and scoters. Small game include abundant snowshoe hares, grouse, and ptarmigan. Fur-bearing animals found in the region include several mustelids (mink, marten, ermine, otters, fishers, and wolverines), muskrats, beavers, cross foxes, wolves, and lynxes. The lakes and rivers of the area have numerous game fish such as lake whitefish, pickerel, arctic grayling, and inconnu.

5.2.5 Community Economy

Although no exact statistics are available, it is apparent that a large proportion of the population of the Group Trapping Area participates to a significant degree in traditional hunting, trapping, and fishing activities, supplemented by part-time or irregular employment in the formal sector. In March of 1996, a traditional land use survey identified approximately 150 residents of Fort Providence as active harvesters, where active harvesters were defined as spending a minimum of four weeks per year on the land hunting or trapping. Given that the 1994 NWT Labour Force Survey gives a total labour force of 288 people (Bureau of Statistics 1995), this group probably constitutes over fifty percent of the unretired adult population. As well, the same survey stated

that 107 people were unemployed, for a rate of thirty-seven percent, and that the participation rate in the formal economy was only fifty-one percent. This lends support to the idea that hunting and trapping are very important to the local economy. In Kakisa, every adult member of the community was considered an active harvester. Hunting and trapping activities blend the formal and informal economies, providing both cash income for trapping of fur-bearing animals such as mink, marten, ermine, and lynx, and food from large ungulates, waterfowl, small game, and fish.

Relative to most northern aboriginal communities, Fort Providence has shown significant initiative and success at promoting local involvement in the formal economy to improve local opportunities. In many such communities, opportunities in the formal economy are severely limited, and cash flows into the community take a very short path back out of it without a significant local multiplier effect. Furthermore, wage employment that is available in the communities often requires professional or technical qualifications that exclude local residents from applying. A common northern community formal economy profile is of a few fairly highly paid professional positions with government, or less frequently industry, held by transient non-Native outsiders, perhaps one or two successful local families involved in some sort of business venture or ventures, a pool of intermittent, low-paid jobs, and a high percentage of unwaged residents forced to rely on government transfers to participate in the cash economy.

Fort Providence receives some benefit from its relative accessibility, being positioned just off the main highway between the south and Yellowknife, the territorial capital. However, this in itself is hardly sufficient to produce a bonanza. The Deh Gáh Got'ie Kq̄ Band and Métis Nation Local 57 have worked actively to involve build community capacity to compete successfully for government infrastructure-building contracts such as house building. As well, the community is involved in ownership of local utilities, a wide variety of services oriented to wealthy tourists, and practical resource management activities such as fire management. Most of the individual corporations set up for these ventures are owned by a community holding company, the Fort Providence Community Betterment Corporation. This for-profit corporation has as one of its articles a mandate to promote local employment opportunities, and pursues this with vigour.

It is notable that even with a relatively high level of opportunity in the formal economy, traditional activities involving harvesting of renewable resources on the land still are an important component of the economy of the area, as well as an important cultural tie to a land-based way of life. A particularly challenging problem in most of the Northwest Territories is balancing renewable and non-renewable resource extraction operations that have a high impact on the biotic and abiotic components of the environment with hunting and trapping activities, which often are disrupted by resource extraction activities. As the description of the abiotic and biotic characteristics above would suggest, up to now, the Fort Providence and Kakisa Group Trapping Area has not had to face this problem, a benefit of its relative paucity of resources economically attractive to resource extraction firms. However, the people of the area have come to recognize that even the current resource management activities in the area should be linked to broader

understandings of their effects on the land and the human activities on it so that the greatest benefits can be realised and potential conflicts can be avoided. Furthermore, it is recognized that the current lack of high intensity activities is no guarantee that these will never take place. It is these insights that led the community to undertake a process of community-based integrated resource management.

5.3 The Administrative and Planning Context

5.3.1 Planning Process Initiation and Objectives

In the fall of 1993 the Fort Providence Resource Management Committee (hereafter, the "Committee") was established with representation from the Deh Gáh Got'ie Kq̄ band, the Métis Nation Local #57, the Káágee Tu band, the Fort Providence Bison Management Committee, and the Fort Providence Hunters and Trappers Association. The Committee, under the umbrella of the Deh Gáh Got'ie Kq̄ Band Council, approached the Northwest Territories Community Resource Management Program ("CRMP") for funding to implement an integrated management initiative for land and resources in the Fort Providence and Kakisa Group Trapping Area as a demonstration project.

CRMP is an element of the Arctic Environmental Strategy ("AES"), a northern component of the federal government's Green Plan. The AES is a six-year initiative that has the goal of enhancing the integrity, health, biodiversity, and productivity of Arctic ecosystems. The Strategy's objectives are: to promote sustainable use of resources by aboriginal people; to ensure incorporation of indigenous perspectives, values and practices in planning, development, and conservation in the Arctic; to promote integration of local, regional, national and international interests in decision making arrangements; and to develop international agreements on the use, management, and conservation of the circumpolar Arctic environment. The AES promotes the use of comprehensive, ecosystem approaches to environmental issues, and emphasizes community empowerment and devolution of resource management responsibilities (Indian and Northern Affairs Canada 1991a). The CRMP program has been run under the auspices of the Department of Indian and Northern Affairs. CRMP funds demonstration projects that promote community-based involvement in resource management. In summary, CRMP seeks to promote activities that prepare communities for long term involvement in resource management, with a primary focus on renewable resources, widespread community support and direction from the community, and an integrated approach to management that considers both environment and economic use of it in the long term (Indian and Northern Affairs Canada 1991b).

The Group Trapping Area had been delineated originally through negotiations between Dogrib Nation leaders, Hay River land users, and Meander River land users, and band leaders from Fort Providence and Kakisa in late 1979 and early 1980 in anticipation of comprehensive land claims negotiations (Fort Providence Resource Management Committee 1994, 2). The Band

Council expressed concern that previous resource management decisions had been made solely by the Government of the Northwest Territories (“GNWT”) Department of Renewable Resources, and that community consultation processes were “an exercise in futility” because they were carried out only after decisions had been rendered (Fort Providence Dene Band Council 1993, 1). The community leaders viewed CRMP as a useful means of moving towards increased community input into management and possible co-management of the Fort Providence and Kakisa Group Trapping Area. The specific goals of the Renewable Resource Management Plan Development Project it proposed are as follows:

1. Facilitate the development of a long term Renewable Resource Management Plan for the Fort Providence Land Use Area that meets the needs and concerns of the community members of Fort Providence.
2. Develop an economic development strategy that will effectively utilize and promote all available resources while protecting the environment.
3. Establish a plan for creating an inventory of available resources including traditional knowledge of land use.
4. Establish a committee with representation from all community organizations which will develop a process to implement and follow through with the Renewable Resource Management Plan.
5. Educate the community at-large regarding renewable resource management as an integration of economic development and environmental protection. (Fort Providence Dene Band Council 1993, 4)

Initial funding was received in January of 1994, and the Committee undertook to develop a resource management and land use plan for the Fort Providence and Kakisa Group Trapping Area that would assess resource use and development based on environmental impact and sustainability. The process proposed comprehensive community consultation; development of an inventory of land, habitats, and wildlife; and protection of aboriginal rights and titles to the lands in the area (Fort Providence Resource Management Committee 1994, 4).

5.3.2 Stakeholders and Actors

The main actors in resource management in the Fort Providence and Kakisa Group Trapping Area may be divided broadly into two groups: organizations representing residents of the area, and government agencies involved in sectoral management. In the first group, the Deh Gáh Got’ie Kq̄ Dene Band, the Káágee Tu Dene Band, and the Métis Local #57 all have desired an active role in the resource management process to protect the interests of their constituents. The reliance on traditional economic activities and land-based economic activities by the bulk of the residents of the area leads their representative bodies all to wish for a say in the directions

resource management and development take. In the second group, various units of the GNWT Department of Renewable Resources have engaged in sectoral planning in the area, for instance fire management and fire fighting activities, management of the Mackenzie Bison Sanctuary bison population, and licensing of hunters and trappers. As well, the federal Department of Fisheries and Oceans has jurisdiction over waterways and activities happening in them, although it has not had any involvement in the planning process up to now.

As suggested above, up to now the Group Trapping Area has benefited, at least from a resource management planning perspective, from its lack of economically viable deposits of minerals, petroleum, or timber. In situations where these exist, integrated resource management planning efforts can be derailed by economically and politically powerful private interests that wish to exploit these and government perceptions that the public interest is served best by promoting this kind of economic activity. For instance, sources familiar with the process surrounding the Lower Liard Integrated Resource Management Plan, a plan for an area to the south and west of the Group Trapping Area that was developed using CRMP funding, indicated that because commercial timber harvesting was so widespread in the lower Liard area the plan effectively has become a timber harvesting plan (Bouvier 1995).⁶² The only significant outside pressure for the Group Trapping Area existed during oil and gas exploration in the 1950's and 1970's, when the land was drilled extensively and the Mackenzie Valley Pipeline proposal was still under consideration. Currently there are no important private corporate stakeholders in the area, though an important diamond find would change this dramatically. This also would result in Natural Resources Canada, the federal department with jurisdiction over natural resource extraction, wishing to take an active role in planning.

5.3.3 Administrative Context and Decision-Making Authority

Integrated resource management plans ("IRMPs") have been carried out in other jurisdictions, such as British Columbia and Ontario, as regional or sub-regional umbrella strategies that co-ordinate lower level and sectoral planning and are directed by regional and provincial-level strategies. For instance, the British Columbia model envisions a five stage planning hierarchy, with integrated resource management plans sitting at a third stage, directed by provincial principles, policies, the provincial land use strategy, and regional plans, and providing direction to local area plans and site plans (Integrated Resource Planning Committee 1993, 2). With few exceptions, in the Northwest Territories this resource management hierarchy ends effectively at a regional level in sectoral plans administered by the GNWT. Attempts to place these in an integrated framework have occurred on an *ad hoc* basis only, as has community consultation and input.

⁶² This view was confirmed by other people familiar with this plan who preferred to remain anonymous.

CRMP funding of community-based integrated resource management plans thus promotes an activity without precedent or a legislative basis in the Northwest Territories. The Fort Providence and Kakisa Integrated Resource Management Plan therefore has had the exhilarating opportunity to set precedents for how IRMP administration and decision-making will take place. This opportunity, however, comes in combination with the frustration of having no legal basis for plan implementation. At present, the legal instruments in place for managing land include such federal and territorial acts as the Northern Inland Waters Act, the Territorial Lands Act, and the Fisheries Act. These generally rely on a narrow, reactive, regulatory approach to land management, and lack of co-ordination between the instruments results in a piecemeal approach that conflicts with the desired characteristics of integrated resource management.

Muddying the waters further, in the Deh Cho region land claims negotiations under the federal Comprehensive Land Claims Policy have been rejected by the Deh Cho First Nations Tribal Council, and negotiations attempting to define self-government rights have not been settled. The latter have some potential to complicate the status of community level IRMPs. Currently, the Deh Cho Tribal Council is developing a regional conservation strategy to co-ordinate community lands and resource management planning to avoid overlap and ensure compatibility of resource management information systems in the communities (Deh Cho First Nations 1995, 1). Part of the intention of this is to form the basis for future legislative initiatives on resource management and related land regulation and planning (Deh Cho First Nations 1995, 3). Depending on the nature of the strategy and outcomes of these potential initiatives, the community IRMP effort eventually may fit into a hierarchy in which the broader Deh Cho strategy provides guidance, either as a regional level strategy under the direction of territorial policy or as the strategy of a quasi-provincial body that forms its own policies.

In summary, the Fort Providence and Kakisa IRMP is being prepared in a legislative and administrative vacuum, with no current legislation or precedent anticipating integrated resource management and uncertainty about potential future developments quite unclear.

5.3.4 Process History and Initiation of GIS Use

In the project's first budget year, 1993-1994, a Resource Planner was hired by the Fort Providence Resource Management Committee (in January 1994) to begin organizing existing traditional land use information, land and resource information. Computer hardware was purchased, along with SPANS Map 1.3W GIS software, to set up a GIS system to maintain these data sets. The Fort Providence and Kakisa Group Trapping Area was identified as the land base that would be managed by the Committee. During the following year, 1994-1995, the Resource Planner and a student Computer Technician attended private sector training workshops to gain knowledge of GIS. After one of these, it was decided that Atlas GIS should be purchased to complement the SPANS Map software already purchased. GIS digital base mapping from the National

Topographic Series 1:250,000 series was purchased. During this time, the Committee began to form strategic management relationships with various government bodies, predominantly in the GNWT Department of Renewable Resources, concerned with lands and resources management.

In the 1995-1996 year, the Committee decided that it was inefficient and at odds with the spirit of integrated management to have three separate community organizations each concerned with land management in some way, so conceptual negotiations began to amalgamate the Hunters and Trappers Association, Bison Management Committee, and Fort Providence Resource Management Committee. Support for this was sought from and provided by the GNWT Department of Renewable Resources, the funding agency for the first two bodies. In February of 1996, the three bodies were consolidated into the Fort Providence and Kakisa Resource Management Board. This has the positive implication of providing a direct linkage between the IRMP and community agencies that will have a part in implementing it.

During the 1995-1996 year, the Resource Planner began to identify and accumulate baseline information that could be used as a foundation for making land management decisions. Digital data sets generated from older traditional land use mapping exercises by the INAC Information Management Group ("IMAG") were acquired and loaded onto the computer system. The GIS software was upgraded to Atlas GIS for Windows version 3.02 and SPANS Explorer version 1.1, and the computer system was upgraded in various ways to improve its ability to run GIS. GIS information bases that are held by the GNWT and federal government were requested, and some of these were received and installed. As well, it was decided that a new traditional land use mapping collection process should be undertaken and the product entered into the GIS software. During this time as well, an initial draft of the IRMP was written.

During the 1996-1997 year, collection of baseline information, including traditional land use information, will be completed and a community consultation process will be run to make decisions on designation of land protection areas. It is anticipated that the GIS will play a central role in producing paper output maps that will be used in this process, and in producing final baseline information documents used to support ongoing planning efforts and plan implementation.

Chapter Six

STUDY DESIGN AND METHODOLOGIES

As stated in chapter one, field research conducted in Fort Providence was intended to achieve two objectives. First, it was intended to provide a practical case study of real use of GIS for resource management in an aboriginal community that could provide examples to test the conceptual framework developed in chapter four and refine the framework based on real experiences. Second, it was desired to find concrete approaches to make the use of GIS in community-based aboriginal resource management most effective. This chapter describes the methods used to investigate GIS use by the Fort Providence and Kakisa Resource Management Board.

6.1 Social Science Paradigm and Research Approach

A challenge posed by the critical areas discussed in the conceptual framework is in their largely qualitative nature. Design of research instruments for these critical areas using a conventional social science approach oriented to quantitative analysis is untenable. From within the conventional, positivistic social science paradigm its use could be criticized on the basis that the recency of the technology and lack of cases would make conventional statistical approaches inadequate. From without the conventional paradigm, conventional approaches in social science have come under increasing criticism because they are theory-laden but operate on the basis of being based upon a foundation of objective knowledge (Sayer 1979, 1-5; Guba and Lincoln 1983, 3-7; Yeich and Levine 1992, 1896-1897), for promoting an elitist approach to knowledge (Yeich and Levine 1992), and for presuming that social phenomena are simple, homogeneous, and invariant over time (Douglas 1976, 28; Yeich and Levine 1992, 1896). It is difficult to disagree with Guba and Lincoln's (1989, 183) observation that in social research, "Far from being merely a matter of making selections among methods, methodology involves the researcher utterly – from unconscious worldview to enactment of the worldview via the inquiry process."

As alternatives to conventional social science, Neuman (1991) suggests two other general approaches to social research that recognize explicitly the role of the researcher's understandings in shaping the research: constructionism, and critical social science. Constructionism, which is also referred to as the hermeneutic approach or naturalistic inquiry, focuses on discovering the intersubjective meanings produced by the people being studied, and attempts to describe how a group's system of meaning is generated and sustained. Critical social science attempts to uncover the perceptions of the people being studied, but assumes that experiential reality may include false beliefs that cloud understanding of actual conditions. This approach supports a dialogical approach to research in which the researcher fosters re-examination of perceptions in the research

group.⁶³ In aboriginal research, this latter approach is often referred to as participatory action research.⁶⁴

Since the conceptual framework developed assumes a structure of meaning of GIS that was likely to be partially outside of the intersubjective understandings of people using the technology, a strictly hermeneutic approach was rejected. Because the framework relates to issues of power and cultural imperialism, and because the efforts to implement GIS in the research community were ongoing, it seemed appropriate to foster critical re-examination of the implications of GIS implementation among people interviewed. At the same time, in the interest of testing the value of the conceptual framework it was recognized that doing this early on was likely to inject this researcher's own biases into the people being interviewed. Therefore, a gentle participatory approach was favoured, with initial emphasis being placed on grasping the ways people conceived of GIS and GIS roles in IRMP without commenting on these conceptions but learning from them. Only towards the end of the research period was the dialogue made more critical and directed to helping the informants re-examine their own viewpoints.

The research approach and the framework for analysis used are detailed in the following sections, and research findings are described in the next chapter.

6.2 Research Strategies

Berg (1989, 54-79) offers a useful four segment model of ethnographic research, including: accessing a field setting – getting in; becoming invisible; watching, listening, and learning (research methodologies); disengaging and getting out. Approaches used for each of these in the Fort Providence field research are discussed below.

6.2.1 Gaining Entry

An initial central problem for field investigators engaging in ethnographic research is the problem of gaining entry to the research context (Berg 1989, 54-59). At this stage, methodological decisions need to be made on whether the research is to be overt or covert, and how the researcher will gain permission or consent from the subjects. Furthermore, gaining entry often requires that bargains be struck between researchers and subjects, and these have the potential to constrain or improve the researcher's ability to operate in the field (Berg 1989, 59). Covert investigation to

⁶³ In this regard, participatory action research has antecedents in the dialogical approach of Paulo Freire described in *Pedagogy of the Oppressed* (1970). Yeich and Levine (1992) provide a useful discussion with reference to this idea and the relation between research and empowering oppressed groups.

⁶⁴ See Fals-Borda and Rahman (1991) and Yeich and Levine (1992) for details on this approach. Robinson, Garvin, and Hodgson (1994) provide a good practical guide based upon a specific implementation of this method.

reach the study goals using the proposed methods was neither feasible nor particularly desirable, so it was decided at the outset that communities would be approached with a written research proposal. An initial version of the proposal was written using the terminology of the social science research field. Upon advice from an individual experienced in this type of research, a second version was prepared stripped of academic lingo and suitable for quick consumption by band administrators and other officials. This second version adhered to the idea that a field worker must have a plausible explanation of the research that makes sense to the community (Dean, Eichhorn, and Dean 1969, 68-69).

My initial contact with the Deh Gáh Got'ie Kq̄ band was made through a personal acquaintance who was employed by the Dene Cultural Institute, a Dene research organization based in Hay River, Northwest Territories. My contact recommended two possible research communities and recommended contact people in these. His position in an organization serving the communities and his relatively long contact with them made him a valuable "guide" – a person close to the group who can vouch for the legitimacy and safety of the researcher (Berg 1989, 59-60) – and he phoned introductions to the contact people in advance of my own first contact.

The experience of many northern communities with outside researchers has not been positive, and communities tend to evaluate proposals with a healthy pragmatism. Understanding this, I included a technical evaluation and reporting component in the research proposal, during which I would solve software and problems, evaluate systems technically, and provide a written report recommending actions that would improve system functioning. As well, I included my *curriculum vitae*, which demonstrated clearly a considerable knowledge of the field gained as a consultant. The community and regional political representatives considered the benefits offered to be of sufficient value to accept the proposal.

This research bargain struck for the first stage of research for the most part improved the effectiveness of the research. First, the technical assessment role gave me immediate, hands-on access to the computer systems, GIS software, and data sets used by the community. This facilitated investigation of these, where a person in a purely research role might have been resented for disrupting operations and been impeded in this sort of evaluation. Second, as discussed in the next section, my technical consultant role made my role as an academic researcher become less "visible" to the people in the community. Third, because the people I was observing and interviewing generally perceived me as performing a service for the community by doing high quality unpaid consulting work, they were highly co-operative when I wanted to arrange semi-formal interviews, and assisted me in setting up interviews with others outside the community.

The second stage of research was facilitated when I was approached by the community and hired in a formal consulting role to aid upgrading their information systems, organize a traditional land use collection process, and provide advice on resource management activities. This allowed me to continue informal interviewing in a participant-observation role. Unlike the first stage, the

second stage was arranged in a way that meant my formal role obscured the research role entirely to the subjects, making responses more natural. As well, I was afforded the opportunity to talk to community elders, something that was impossible to arrange while I was thought of as a researcher. The formal consulting role increased the direct impact my activities had on the situation being studied, with a resultant danger that my own biases would slant the findings. To counteract this, I attempted to ask follow-up questions of the group initially surveyed early in phase two, and then focused on increasing the breadth of the population of community interview informants outside of the community technical elite and on further research on outside government agency perceptions.

6.2.2 Becoming Invisible

A problem in participant research is the possibility that the research subjects will alter their usual behaviour and responses because of the presence of the researcher (Denzin 1970: 203-204). To avoid this potential, Stoddart (1986) recommends six strategies to promote researcher invisibility. The roles of technical assessor during the first stage and technical consultant during the second allowed me to use three of Stoddart's strategies: erosion of visibility by time; erosion of visibility by personalization of the researcher-informant relationship; erosion of visibility by display of symbolic attachment.

In the erosion of visibility by time strategy, people being studied lose their awareness of the researcher once s/he has been in the community for a long time (Stoddart 1986, 105-106). In macro-ethnography, depending on the visibility of the researcher, this time period may be measured in months or even years. However, I found that in the more micro-ethnographic research I was conducting my presence was accepted as normal even toward the end of the first stage of research. Shortly into the second stage I found that although I was not completely "invisible", my presence seemed not to be noticed as something out of the ordinary.

In the erosion of visibility by personalization of the researcher-informant relationship strategy, ethnographers lose visibility because informants suspend concern about the research because of personal relations with the researcher. Certainly I identified genuinely with the community aspirations for self-determination that led to wanting a stake in resource management for the community land base. I found all the people I had contact with in the community on a regular basis friendly and likeable, and made no attempt to remain detached.

In the erosion of visibility by display of symbolic attachment strategy, a researcher becomes invisible by participating with people in the research community in everyday activities. Though I was in no position to participate meaningfully in activities in the larger community context, in the micro-ethnographic research context of the Resource Management Office and Band Office I was able to participate by helping with small computer problems and other office tasks. This seemed to help to make my research role less overt.

6.2.3 Research Methodologies

Denzin (1978, 28) suggests that use of even a broad, flexible tool like ethnographic research can lead to a narrow, incomplete perspective imposed by theoretical assumptions inherent to the methodology. In particular, participant-observation methods, while leading to rich understandings of the perspectives of the people researched, offers only indirect information on broad spheres of influence. To counteract this, he recommends that, just like good quantitative researchers, qualitative researchers triangulate their observations. He describes (1978, 295) a four category framework for triangulation. The categories include: triangulation of data over time, place, and person; investigator triangulation, in which more than one investigator observes the same people and compiles research notes independently; theory triangulation, in which multiple theoretical perspectives are used as analytical frameworks for the same observations; and methodological triangulation, which includes within-method triangulation and between-method triangulation. Though limitations of time and research funding made a comprehensive approach using all categories impossible, some triangulation attempts could be built into the research design. In particular, it was decided that the field research be approached using multiple methodologies to allow some within method and between method triangulation.

One methodological approach that was attractive for the field setting was interviewing. Berg (1978, 15-19) defines three major categories: the standardized (formal) interview, the unstandardized (informal) interview, and the semi-standardized (guided-semistructured) interview. The participatory research approach allows many opportunities for unstandardized interviewing in the course of ongoing contact with individuals. Informal interviewing allows the researcher a great deal of flexibility to explore issues in the course of natural conversation. This natural, conversational approach can put the informant more at ease, leading to less inhibited responses. However, it normally does not permit records to be made until well after the interview, requiring that the researcher sharpen memory and recording skills and have the discipline to record interviews. As well, care must be taken to avoid bias when asking questions, a much less significant problem when working from standardized questions, which may be reviewed, revised to avoid bias, and pre-tested numerous times before actually being used.

Because fully-standardized interviewing may be reliable for describing the characteristics of a large population, but is weak for assessing attitudes, orientations, and experiences (Babbie 1983, 237-239), it was inappropriate for dealing with a relatively small number of informants and testing a broad conceptual framework. Furthermore, this type of interviewing suffers most heavily from what Mishler (1986, 117-122) describes as a striking asymmetry of power in the interviewer/interviewee relationship, with the interviewer totally controlling the structuring of meaning. As well, people familiar with research in aboriginal contexts indicated that asking questions from a fully-standardized questionnaire would lead to an artificial and culturally-inappropriate mode of communication. At the same time, it was recognized that formalized interviewing had a number of benefits for research as a complement to informal interviewing.

First, setting up a formal interview allows the researcher to talk to people in controlled circumstances with less chance of interruptions. Second, though a formal interview can make informants more inhibited in answering than informal circumstances, even if they have been assured of full confidentiality, the formalized process also can lead to more serious consideration of the questions being asked and more in-depth responses than informal contexts. Third, comparison of answers in formal and informal settings can reveal what the “party line” is and how it differs from personal perceptions. Fourth, the act of arranging semi-formal interviews reduces attention to informal ones among informants, increasing researcher “invisibility” in the latter.

With this rationale, it was decided that a dual category approach to interviewing would be used. First, informal interviews were conducted throughout the research as situations permitted, with notes being taken at the first opportunity. Second, a semi-formal interview was designed before the first stage of the fieldwork began with pre-written probe-questions.⁶⁵ The people were told in advance that these interviews would be arranged at their convenience during the fieldwork, and permission to conduct the interviews was secured from the Chief. In the semi-structured interviews, whenever possible the interview was conducted one-on-one with the informant. In all semi-structured interviews, the whole course of the interview was tape recorded. Though some authors feel that this can lead to stilted or unnatural interviews (e.g. McCall and Simmons 1969, 73-75), informants did not appear to pay much attention to it, probably because they had been interviewed frequently on an informal basis before the semi-formal interviews took place. Recordings were transcribed and the informants were invited to read the transcriptions and elaborate their responses whenever they felt this to be necessary. The two different forms of interviews could then be used for within-method triangulation of responses.⁶⁶

A second approach used for triangulation of interview responses was to arrange interviews with territorial and federal government officials who had familiarity and involvement with the resource management activities in the community. These interviews were conducted largely from the semi-structured interview questionnaire, with occasional opportunities for informal interviewing.

A third methodological approach used to triangulate the findings of the ethnographic research was a non-ethnographic technical evaluation of the computer system used for the community GIS efforts. This effectively is a form of unobtrusive research strategy similar to accretion measurement such as examination of graffiti or other physical traces (see Webb *et al*

⁶⁵ The lead questions for the semi-standardized interviews are included in appendix B.

⁶⁶ Interviews of both types were conducted with attention to Douglas’s (1985, 19) observation that in most social science research, questionnaires are “administered as much as is practically possible without any consideration of the individual and situational factors that emerge,” and recommendation that interviewing strategies be used that approach each informant (Douglas refers to them as “Goddesses”, and to the researcher (1985, 55) as a “handmaiden of knowledge and wisdom who must become a supplicant to those who have both”) with a profound respect for individual perspectives and circumstances.

1981). To a knowledgeable eye, this investigation was able to provide a considerable amount of information. Aside from triangulating the findings of the interviews, the findings of this technical research were used as the basis for additional questions in interviews.

Finally, the interviewing and technical evaluation approaches were complemented with straightforward review of correspondence, annual reports, invoices, and annual budgets. These were used to clarify chronologies when interviews left uncertainties about the timing and order of events. As well, the invoices and budgets allowed capital expenditures for GIS-related items and services to be ascertained. Additionally, in the presence of extensive correspondence records it might have been possible to use formal content analysis as another triangulation method. However, the sparse and terse nature of the available documents made this unfeasible.

Informant selection was handled using a “snowball” sampling technique (see Babbie 1983, 251-252) from an initial core group identified because of their formal positions in the resource management process, specifically Board members and employees. The intention was to speak with everybody who had been involved in the current process and as many as could be contacted who had peripheral contact with the project. As well, it was hoped that community members at large could be questioned on their opinions, although this was not very fruitful, as making contact with these individuals through the snowball was much more difficult and community members largely were unaware of the activities underway.⁶⁷ In total, I conducted ten semi-structured interviews with individuals directly involved with the resource management process either as Board members, Board employees, or government officials of the territorial and federal governments. As well, I conducted informal interviews with these ten and twelve other members of the community who were aware of the GIS efforts to varying degrees.

6.2.4 Disengaging and Getting Out

Berg (1989, 79-80) cautions on some of the difficulties that can be encountered when concluding research. In summary, he favours avoiding abrupt, clinical severing of relations once a study is over. He notes that researchers and subjects make personal, emotional commitments, and recommends care when disengaging to avoid negative repercussions for the research community. Certainly, the cautious view northern aboriginal communities take of research is a partial product of abrogation of commitments to deliver promised benefits such as written reports or references, and resulting feelings of being used and manipulated. One might add that if such researchers can look in the mirror without shame it is a negative reflection on their personalities. Though the research is complete, I continue to have regular contact with individuals in the community and

⁶⁷ This probably was a result of a resource management process that had not yet come to grips with how to organize public participation, even though the terms of reference for the Board made it clear that the resource management process was to be community-based.

have delivered on all promises as quickly as possible. Although my time in Fort Providence was brief relative to many ethnographic studies, I have a deep interest in seeing this community succeed in charting a course through the mostly untravelled waters of northern community-based resource management and GIS use.

6.3 Analytical Methods

Two basis approaches to analysis of the field research findings were used. Interviews were subjected to content analysis on the basis of the conceptual framework developed in chapter four. The technical analysis of computer systems was approached as a form of accretion measurement.

6.3.1 Interviews

Content analysis involves the coding of records of communication according to a conceptual framework (Babbie 1983, 278-279). Coding was undertaken using a wide, or open coding method moving toward classification of information in a coding frame (Berg 1989, 117-121; Strauss 1987, 28-33). Interviews were coded on the basis of latent content, or the meanings of communications, supplemented to a modest extent by coding of manifest content, or the use of words and phrases (Babbie 1983, 279).

Initially, an open coding approach was used to analyse the interview research. Four practical guidelines put forward by Strauss (1987, 28-30) were used to direct open coding. First, the researcher should ask a specific and consistent set of questions when coding. Since the conceptual framework already had been developed and since the purpose of the research was to test, illustrate, and extend it, a set of questions existed before the research began. Open coding thus was conducted using the categories of analysis in the framework and looking for material pertaining to them. Second, the information should be analysed minutely, with attention to fine details. A wide coding approach (Berg 1989, 118) was used for the coding in the field, with narrow, systematic coding postponed until after the field work concluded. Third, the researcher frequently should interrupt coding to write theoretical notes. During the field work, these were prepared to guide further interview inquiries and reviewed each day. Fourth, the researcher never should assume the analytical relevance of standard social variables such as age or sex until the data show them to be relevant. Because of the small number of informants, analysis based upon most of these variables would have been ineffectual. However, some attention was paid to age inasmuch as it was of interest from the standpoint of distribution of power in the community.

Although the field research was oriented towards confirming a broad set of hypotheses about the nature of GIS implementation in aboriginal communities put forward in the conceptual framework rather than generating hypotheses, the research approaches used allowed analysis of

findings to begin during the field work rather than *post facto*. During the first stage of research, field notes compiled on informal interviews were reviewed using open coding with a wide coding approach, with theoretical notes used to guide additional queries. Open coding at this stage was an iterative process, with earlier notes being re-visited weekly. As well, though final detailed systematic coding was not begun until after I had returned from the field, by the time the semi-formal interviews were conducted, enough initial coding had been completed to suggest probe questions in addition to those prepared initially.

Once the first stage of the field research was completed, the semi-structured interview tapes were transcribed and checked with the informants. The checked transcripts were open coded in a similar manner to the informal interview notes. Once this was completed, an axial coding approach (Strauss 1987, 32) of intensive coding around the categories in the conceptual framework was undertaken. As well, indications of linkages between categories were coded.

6.3.2 Technical Analysis of Computer Systems

Technical analysis of the Board computer systems was understood as a means of unobtrusive research similar to accretion measurement such as that described by Webb *et al* (1981) for examining physical traces such as graffiti. The technical analysis sought to see how empirical evidence supported and supplemented interview findings. The following questions were posed to guide the technical review:

1. Were the system software and hardware set up in a way that allowed them to be used for the tasks that informants reported performing?
2. What were the file last saved dates and times for files associated with GIS software? Did these support claims about intensity of use of the system from interviews?
3. What data sets were available and installed on the system?
4. For GIS data sets related to traditional land use and other indigenous knowledge, how were these structured internally and how did they relate to the raw source information?

6.4 Summary: Study Design and Methodologies

As detailed in the preceding sections, several basic strategies were used for the research undertaken in Fort Providence. The main methodological tool used was interviewing. Within-method triangulation of responses was achieved by using unstandardized interviews throughout both research periods and complementing these with tape-recorded semi-structured interviews of some of the key subjects conducted late in the first research period.⁶⁸ Ten semi-structured

⁶⁸ The questionnaire used to guide the semi-structured interviews is included in Appendix A.

interviews were conducted with Fort Providence and Kakisa Resource Management Board (hereafter, the “Board”⁶⁹) members and employees, and government officials of the territorial and federal governments. In addition, unstandardized interviews were conducted with the people who participated in the semi-structured interviews and twelve other individuals in Fort Providence who were familiar with the GIS activities. A critical social science framework, in which it was intended to foster critical re-examination of the implications of GIS implementation among people interviewed, was used, but a gentle participatory approach was favoured in which earlier research focused upon grasping the ways people conceived of GIS and GIS roles in IRMP while reserving critical judgements, with dialogue made more critical and directed to helping the informants re-examine their own viewpoints toward the end of the research. Between-method triangulation of the interview findings was achieved using a non-ethnographic technical evaluation of the computer system used for the community GIS efforts. This unobtrusive research strategy examined how the system was set up, available data sets, the contents of data sets, and file last saved dates and times. As well, a review of correspondence, reports, budget documents and invoices was used to clarify the way in which events unfolded and provide insight into capital expenditures related to GIS implementation. The unstandardized interview notes were analysed initially during the research using iterations of open coding with a wide coding approach. Once the research was completed, the semi-structured interviews were transcribed and systematically coded using the same approach. Finally, an axial coding approach of intensive coding around the categories in the conceptual framework was undertaken for both unstandardized and semi-structured interviews, and linkages between categories were coded. Analysis of the unobtrusive research was guided using the set of questions detailed in section 5.3.2. As well, it was directed to some degree during the research process by claims made during interviews that could be verified using the technical evaluation approach.

⁶⁹ Strictly speaking, as detailed in section 5.3.4, the Fort Providence and Kakisa Resource Management Board did not exist until 1996, when it was constituted from the Fort Providence Resource Management Committee, the Hunters and Trappers Association, and the Bison Management Committee. However, “Board” is used in this chapter to refer to the Fort Providence Resource Management Committee, the Board proper once it was formalized, and their respective employees.

Chapter Seven

RESEARCH FINDINGS

In this chapter, the findings of the field research are detailed. The findings are organized using the issues identified in chapter four. For each issue, the Board experiences are detailed, evidence of perceptions of actors in the resource management process that pertain are explored, and steps taken to deal with the issues are reviewed. Often, research findings illustrate linkages between various issues. Therefore, evidence of interaction of the different issues is also explored.

7.1 Capital Availability

In section 4.1.1, the idea that implementing GIS requires significant capital budgets is put forward. Expenses associated with GIS include the costs of: purchasing computer systems and specialized computer hardware; purchasing GIS software; providing staff training; hiring technical consultants; acquiring data sets; and maintaining communications with people able to provide GIS technical support. As well, other GIS prerequisites such as required infrastructure, which is discussed in the next section, may require additional funds to provide.

In its three years of operation, the Board has spent significant sums of money to purchase and maintain GIS-related items and services. Although I was not able to obtain financial summaries for all GIS-related expenditures, it was not difficult to piece together a rough estimate of total direct expenditures for GIS with knowledge of the items and services acquired.⁷⁰ In summary, during the 1993-1994 year, the Board purchased the initial computer hardware (a brand name system close to the leading edge in processing capabilities at the time of purchase), an inkjet printer, a C-size black and white inkjet plotter, various office automation software, and SPANS Map GIS software (Fort Providence Resource Management Committee 1994). During the second year, additional computer hardware and software were acquired, including a thirty-six by forty-eight inch digitizing tablet, an uninterruptable power supply, an A-size colour inkjet printer, and Atlas GIS software; digital versions of eight National Topographic Series maps that cover the 48,000 square kilometre Group Trapping Area for which resource management plans are being developed were purchased; and two Board employees took an intensive week-long GIS course in Edmonton (Fort Providence Resource Management Committee 1995). In the 1995-1996 year, additional computer hardware and software were purchased, including an E-size colour plotter, a DAT tape backup unit, an additional hard disk unit, and GIS software upgrades. As well, the services of a technical GIS consultant were contracted, and community fieldworkers were hired to

⁷⁰ Estimates for items for which real expenditures are not known are made extremely conservatively in this section.

collect traditional land use information from community hunters and trappers for conversion to a GIS data set. The items and services acquired and known or estimated costs are summarized in table I.

Three facts about the estimated expenditure figures provided should be noted. First, they include only expenses incurred directly in relation to operating the Board GIS – costs for computer hardware, software, GIS data sets and data collection, and GIS technical consulting services. Indirect but necessary adjunct costs such as office space costs, computer office furniture, and GIS-related communication expenses are omitted. Although compared to the direct costs these are relatively small, they may still be significant. For instance, during the initial research period it was necessary to consult by telephone and fax with GIS software company technical support personnel in California and Ottawa to deal with some basic technical issues. I was told during the second research period that the office manager “had almost had a heart attack” when he had received the \$300 phone bill. Second, a true costing would estimate the percentage of Board employee time devoted to GIS-related tasks and include that percentage of employee salaries. Third, the Board resource management plan has not been completed, and significant additional expenses are likely to accrue during its production, mostly for a combination of Board employee training and technical consulting fees (see section 7.4 below). Therefore, the \$74,000 three year budget should be understood as an extremely conservative figure.

Interviews with members of the Board made it clear that when the decision to proceed with GIS use for resource management planning, the expectation was that the financial commitment required to use the technology would be much lower than the actual costs. Initial advice to acquire the technology seemed to focus exclusively on hardware and software costs, and greatly underestimated even these (Nyuli 1995). Fortunately, because significant funding was available to the community for developing its resource management plan, to date the actual costs have not disrupted implementation.

7.2 Physical Infrastructural Requirements

Section 4.1.2 points out that GIS require basic physical infrastructure to operate effectively. One infrastructural requirement involves providing a sheltered location protected from extremes of temperature, humidity, and dust that allows the system to be secure from unauthorized use. Associated with this, a reliable electrical supply free of power spikes, surges, and brownouts must be made available. As well, a second order of infrastructure is necessary to support system use, including reliable communication and transportation facilities.

Purchase	Cost (* estimated)
1993-1994 Budget Year	
Computer hardware and software: brand name PC system inkjet printer C-size black and white inkjet plotter Office automation software SPANS Map 1.3W GIS software	*\$9,000
1994-1995 Budget Year	
Computer hardware and software: 36 x 48 inch digitizing tablet uninterruptable power supply A-size colour inkjet printer Atlas GIS software	*\$5,000
GIS training course transportation accommodation per diems tuition	*\$6,000
NTS digital base map data 8 x 1:250,000 digital base maps	\$22,000
1995-1996 Budget Year	
Computer hardware and software: E-size colour inkjet plotter DAT tape backup unit Computer hard disk upgrade Atlas GIS software upgrade SPANS Explorer software upgrade	\$14,000
GIS technical consultant	\$12,000
Traditional land use collection fieldworkers	\$6,000
Estimated Total, 1993-1996	\$74,000

**Table 1: Estimated Direct Expenditures for Fort Providence and Kakisa
Resource Management Plan GIS Operations, 1993 to 1996**

A significant infrastructure problem the Board encountered in relation to its GIS activities was associated with a lack of available office space in which to set up the systems. Empty office space available for lease is a rare commodity in small northern communities. Because initial funding for resource management activities first was received nine months into the 1993-1994 government fiscal year, the Board was compelled to act quickly to make significant progress before year end. Because of this, initial operations were set up in a room in the community fire hall. The Resource Planner of the time summarized how the lack of suitable facilities affected operations:

The initial office for resource management was in the fire hall and it was just a little 10 x 12 room. We had one desk in there, one drafting board, a pile of maps, and then we got the computer and we couldn't even set the computer up in that room – there just wasn't enough room. . . (Sanderson 1995)

Informal recollections of the months spent at this office by the Board employees of the time indicate that the lack of space made GIS operations effectively impossible.

In the summer of 1994, Board operations were moved to space in the Métis Nation Local 57 office, a space they still occupied during the initial research period. For GIS operations, this facility also had shortcomings. The room used for Board operations was perhaps fourteen by twenty feet, but it was shared with the Métis Local staff, leaving a usable effective area of about eight by ten feet. Although the Board had purchased a three by four foot digitizing tablet before April of 1995, it remained boxed and unusable because the agency lacked free space in which to set up a table for the tablet. It was not until late February of 1996 that the Board finally was able to arrange to lease a large space (the "White House") and allocate a fourteen by fifteen foot space exclusively for GIS operations in which all computer hardware could be set up in an accessible manner.

Another problem associated with the office space occupied before the Board leased the White House was that the computer system could not be kept secure. The Métis Local office is a centre of a large amount of activity; a hunt guiding business is run from it and supplies for local dances and other events staged by the Local are sometimes stored there temporarily. Examination of the Board GIS computer during the initial research period revealed that several computer games had been installed. Interviews with Board employees suggest that although two had been installed by them for after hours use, the rest were placed on the system by other individuals who had access to the office space. When the system was examined initially, the system initialisation files were set up in such a way that made some of the GIS software unusable. It seems likely that the individuals who installed the games were partially responsible for this state of affairs.

The storage of purchased equipment because of lack of space in which to set it up left the Board open to another infrastructural issue of concern in northern communities – unreliable electrical power supplies. As part of 1994-1995 year computer hardware acquisitions for GIS, which included the previously mentioned digitizing tablet, an uninterruptable power supply was purchased. Mistakenly, this device, which conditions electrical power to eliminate variations and provides temporary backup power in the event of a power outage so that work will not be lost, was thought to be a component of the digitizing tablet. Therefore, it was stored in its original shipping carton along with the digitizing tablet for several months before being put into service. In the author's experience, northern electrical power is prone to many variations that can damage computer equipment. Power line conditioning equipment in northern communities is not an option but a necessity. Fortunately, no equipment damage occurred before the power supply was installed. However, on at least one occasion during the research before the uninterruptable power supply was discovered at the storage location, several hours of work on a document were lost to a three second blackout of local electrical power.

In Fort Providence, communication infrastructure was reliable by northern standards. Telephone connections were not as reliable as in the south – during the second research period the whole community lost all outside phone service for a day because a solar flare damaged a local switching station – but reliable fax and modem connections could be established most of the time. As noted in section 7.1, the major constraint to telecommunications for the community was the high cost of long-distance telephone service.

The position of Fort Providence just off the major highway between Yellowknife and the south made the issue of transportation infrastructure less a problem than in many, more remote northern communities. However, even in this relatively favourable location, securing basic supplies such as plotting pens, tape cartridges, and large form paper required weeks of waiting. The Board responded to this problem by securing such supplies in bulk and ordering them well in advance of using up the stock. This approach, which seems the only effective solution to the problem, requires additional space to store supplies, re-emphasising the need to secure adequate space for GIS operations.

7.3 Social Organization and Culture

In section 4.1.3, arguments are reviewed that assert that GIS may require particular types of social organization to implement. In particular, some authors imply that GIS require formal division of roles and responsibilities in a way typical to southern bureaucratic organizations, and that systems implementation may be constrained without such organization. Once implemented, the systems may demand changes to reporting relationships and communication networks based upon position in formal and informal hierarchies. As well, it is possible that cultural forms of social interaction may affect formal organization at an agency level.

The research provided very little evidence of impacts on internal organizational relations in the Board implementation of GIS. Five factors contributed to this. First, since GIS were acquired shortly after the Board began resource management operations, there were no pre-existing hierarchies to be altered by the technology. Second, the Board has an extremely flat organizational structure, with one or two employees reporting directly to the Board proper. In a fascinating juxtaposition, Board meetings are operated very formally using Robert's Rules, but formal or even informal hierarchical relations appear to be completely foreign to the way the Board members relate to one another. Third, although GIS operations were an important facet of the Board activities, they had not assumed a core role in resource management planning that would lead to significant impacts. Fourth, probably because of the size of the community and intimate relations between residents based upon long term associations built up since childhood, formal employment roles appeared to have little bearing on personal relations between individuals. Instead, it seemed that relationships, roles, alliances and rivalries that exist have been built up between individuals over many years and had little to do with their work roles. Fifth, all people involved in the Board

efforts to implement GIS had a common interest in promoting resource management success in the interest of the community as a whole. This may have discouraged people from acting upon interpersonal rivalries in the context of this activity.

One finding that relates to the assertion that GIS implementation requires formal bureaucratic structuring of the organization pertains not to the Board itself, but to other agencies such as the Deh Gáh Got'ie Kq̄ Band Office. As is discussed in section 7.5 below, a significant problem the Board had securing data revolved around information that was known to have been gathered in the past but had not been archived properly and had either been lost or had been damaged and lost much of its value. One former Board employee described the frustration associated with trying to secure information that was known to have been collected:

I saw a lot of people saying, "Yeah, we have to get this information and that information," but there was no one person saying, "OK, get that information and give it to me and I'll take care of it." There was no stationary position where all this information could be accumulated. It was moving from Simpson to Yellowknife, and we were trying to get some sent from Kakisa to Yellowknife. The actual material never entered my hands – it was all word of mouth, everybody was talking and nobody was doing the walking. So once we get the information now I'm going to make sure that it stays here, and if somebody wants a copy they can come here and take a copy under my supervision, but until that time occurs we're just going to try to get this information together and get it logged and into the computer. (Sanderson 1995)

This lack of archival storage may be related to a lack of bureaucratic continuity and formal allocation of responsibility for maintaining archived information to a Band Office staff member.

One negative impact of informal culturally-based understandings and modes of acting on GIS operations relates to the continuous and dedicated effort that GIS operators must make to explore and become familiar with software capabilities and techniques used to take advantage of the software capacities. During its three years of activities, each summer the Board effectively has ceased operations for three to four months. One employee of the Board stated to me that he preferred to be out on the land during the summer months instead of inside an office. Since in Fort Providence at summer solstice the night-time is a short four hour twilight between about midnight and four a.m., this is not an altogether incomprehensible desire. It is one that may have a cultural basis as well. However, from the standpoint of making GIS operations most effective, the long summer break in activities appears to have been disruptive for system users accumulating knowledge of the software. For instance, the examination of the GIS data sets on the Board system revealed that some significant experimentation had taken place using the software in the late winter and spring of 1995. However, it ceased during the summer and did not resume in the fall. One of the operators involved admitted to me that he had a difficult time recalling what he had been doing with the software in the spring when he returned in the fall. Another stated that it seemed that the whole resource management project was shelved during the summer and that nobody in the community could carry it on (Sanderson 1995).

7.4 Knowledge, Education and Local Participation

Section 4.1.4 discusses the education and training needs required to use GIS. First, for operators of the systems, considerable expertise is required to apply them effectively. As sections 4.3.2 through 4.3.4 detail, knowledge is required of cartographic principles, GIS database design limitations, and technical constraints to analysis imposed by the systems. This knowledge can be acquired either by hiring people who have it or by educating people through formal and informal means. Second, to promote public participation in resource management, it may be valuable to introduce interested members of the public to basic principles of the technology.

In Fort Providence, lack of technical knowledge during the initial decision-making process led to poorly-considered decisions that arose from reliance on ill-considered advice from agencies outside the community. For instance, the initial decision to acquire GIS was made largely based upon advice from GIS technical personnel in territorial and federal government agencies:

We checked with two different government departments – GNWT Renewable Resources and DIAND – to make sure that we were compatible with them so we could incorporate their information into our system. We did a bit of research ourselves, they had a couple of recommendations, and we ended up getting what we have. (Nyuli 1995)

I think that the driving force behind [the idea to use GIS] came from the Band and GNWT officials from the Renewable end. . . (Sanderson 1995)

Although compatibility with the systems used by these agencies was an important concern, other factors were essential and should have entered into the decision. In particular, if the Board was to be able to undertake resource management effectively, it needed the ability to generate and update its own data sets as well as make use of ones provided to it by government agencies. However, the SPANS Map 1.3W software that it was advised to acquire and initially installed was incapable of dealing with this. The Board lost a number of months of potential progress before it determined that its initial software purchase was inadequate and obtained more capable GIS software. In addition, the expenditure for SPANS Map was in essence wasted. This loss of time and money could have been avoided if the Board had more knowledgeable advice.⁷¹

In Board GIS operations, problems that could have been avoided or resolved with specialized GIS training and knowledge were encountered. As mentioned in section 7.2, during the initial research period an examination of the Board GIS computer revealed that some of the GIS software

⁷¹ To be fair to the advising agencies, much of the advice the community had received, such as that on what hardware purchases to make, was sound. Furthermore, the software advice was sound if the presumptions that the Board would be merely a consumer of territorial and federal government data sets and that it would rely upon the territorial GIS agency for expert assistance when undertaking non-basic GIS operations was correct. As discussed in section 7.7, however, these were positions that reflected the political interests of the territorial government, and not necessarily those of the Board and community. Lacking technical expertise, the Board was put in the disadvantageous position of accepting the advice without insight into these implications.

could not be run without revision of system settings. Because the Board employees lacked the technical background to make these changes, they had accepted these software problems and re-focused efforts on software that could be run. Additionally, the technical examination of the computer system provided evidence a basic error had been made when using the GIS software that people with more specialized computer knowledge would have avoided. An error in the SPANS Map 1.3W software allowed GIS data set directory names to be specified including embedded spaces. Limitations of the MS-DOS operating system used for the computer made it impossible to perform most operations on files and directories with included spaces. Thus, SPANS Map could generate data sets with this naming problem, but then could not retrieve the data in subsequent sessions. The process of correcting this error was relatively trivial, but it required a small amount of specialized knowledge concerning technical aspects of MS-DOS. Lacking this knowledge, users of the Board GIS had lost access to the products of days of work and had become discouraged by their lack of progress.

Lack of specific technical knowledge was responsible for a several month delay between receiving and loading the NTS digital base maps that were acquired in early 1995. These had been shipped to the community on diskettes in DXF format, a standard transfer format developed to allow transfer of CADD drawing files between systems. Neither the SPANS Map software nor the Atlas GIS software had a function to convert information from this format to the form they use internally. With the necessary technical knowledge of the problem, operators could have determined that a relatively inexpensive converter program was necessary to make the information usable. However, without this the data remained on diskette and unusable.

One approach used by the community to address the need for specific technical knowledge to operate GIS was to contract outside technical consulting services. This was used to address the lack of specialized GIS knowledge among Board staff. A problem associated with this, however, is that opportunities are not provided for community residents or even Board staff to learn new GIS skills that a technical consultant commands. Operating as a consultant during the second research period, with a large number of tasks to complete in a limited time, I was frustrated by the lack of time available to review the technical steps I was taking with Board employees and with a local resident who Board members told me was under consideration for employment as a GIS operator. As one Board employee noted, "We're losing a lot of our human resources here, because a lot of the students who graduate from grade 12 move out of Providence, because there's no future for them here." (Bouvier 1995) Thus, an important concern in the community is to provide employment opportunities for ambitious residents. In a resource management process in which a completed initial plan was expected within three years of commencement of operations, contracting technical consultants was an effective means of avoiding technical problems without the delays and possible errors of letting staff with less expertise attempt to deal with the technical challenges. However, it did not foster long term building of skills for community members and increased self-reliance.

In general, shortcomings in training among Board GIS operators were not found to have led to significant errors in use of the systems, but rather to ineffective use of the software. Formal training opportunities had been relatively limited. Staff members had participated in GNWT Department of Renewable Resources hosted two day workshops to introduce the technology to communities considering its use, and in a week long intensive training course held in Edmonton. However, interviews indicated that these opportunities were insufficient to transfer real technical operating skills and associated cartographic skills as well as conceptual overviews of the technology and its use.

One area of real apparent success related to education was in Board attempts to make its GIS efforts comprehensible to community residents. As is noted in sections 4.1.4 and 4.2.3, GIS are understood to have the potential to reduce public input into planning processes by making the information base used to aid decision-making less accessible for members of the public without the technical skills required to use the systems. This is a particular concern in northern communities in which residents may not have the long formal educational background normally assumed in the literature that discusses GIS education. In interviews, Board resource managers pointed out that in their culture, the southern approach of allowing public input through public meetings or delegations to committee meetings was not appropriate. First, many community residents spend a considerable amount of time on the land; these individuals might easily not hear about public meetings without months of advance notice, and would sometimes have a very difficult time attending one even if aware of it. Second, the cultural approach to decision-making, particularly for the community elders, often involves people listening to discussion about a problem and its various facets without comment, and only coming to an opinion after much reflection (Bouvier 1995). Therefore, once the move to the White House provided sufficient space, a coffee pot and mugs were provided in the area with the GIS equipment, and maps of traditional land use activities for community members were plotted and tacked to the walls. The word was spread that people could drop by at any time for coffee. This strategy appeared to be very successful. Community members appeared, sat and drank coffee and discussed other matters for long periods, and then were shown some of the work in progress by the Resource Planner, for instance the raw paper maps on which a hunter had marked land use, the computer-printed version of the same, and finally the on-screen version represented by the software.

7.5 Data Sources and Maintenance

In section 4.1.5, the idea was introduced that without timely and complete data to feed GIS, the systems are useless no matter how functional. In northern communities, digital versions of government agency map series may be unavailable. As well, other information useful for resource management may be difficult or costly to accumulate, convert into digital form, and maintain current.

One of the most basic data sets for resource management in Canada is contained in the federal National Topographic Series maps. The Canadian Centre for Geomatics (“CCG”), the agency responsible for these maps, has undertaken a program of converting all series maps to digital form. However, in a huge country like Canada, this is a tremendous endeavour. Priorities for digital map conversion have been established through an evaluation of potential demand for the digital versions. Not surprisingly, relatively populous areas and regions with proven or potential reserves of commercially-viable natural resources have the highest status, while remote areas with few inhabitants or commercial activities are given a lower order of importance. Although as has been emphasized in previous sections, relative to most northern communities Fort Providence is not remote. As detailed in section 5.2.4 the extractable resource potential of the land around it is thought to be fairly low. Fortunately, when the Board investigated availability of the eight 1:250,000 map sheets that cover the resource planning area, seven were already available in digital form. On the strength of the order for all eight, CCG agreed to increase the conversion priority of the unconverted map. There was a three or four month lag between the Board request and the time at which it received these important base line data sets, but this did not delay resource management activities.

A hurdle that the Board had considerable difficulty surmounting was securing GIS data sets related to resource management from territorial and federal government departments. Three separate difficulties were encountered. First, information on what GIS data sets exist and in which departments they were located was very difficult to obtain. When the Board attempted to secure this information, it sometimes found that in a given agency higher level officials were not aware of what information their department recorded and maintained, while lower ranking personnel who did have this information were difficult to contact and reluctant to discuss data set contents with outsiders without higher level approval. Second, once GIS information sources had been identified, bureaucratic resistance to providing copies to aboriginal resource management agencies was sometimes considerable. The Board’s lack of a legislatively-defined set of roles and responsibilities detailed in section 5.3.3 probably aggravated this difficulty. Simply put, since there was no formal precedent for community-based resource management, there was no precedent for how information sharing should take place between the Board and government agencies. Although a few individual managers agreed to provide information without a struggle, some sought approval from the highest level. For instance, the GNWT Centre for Remote Sensing, which was a repository for many useful GIS data sets, required Deputy Minister approval before it would release any data to the Board. Third, even when approvals had been granted, conversion of information to formats compatible with agency GIS software and acquisition of documentation detailing the content sometimes was an additional technical stumbling block. For instance, a 1:100,000 scale forest inventory provided by the GNWT Department of Renewable Resources had been developed using GIS software not standard for GNWT. Converting this for use with the Board GIS software required several technical operations to be performed.

As mentioned in section 7.3, the Board encountered difficulties when it investigated obtaining previously collected traditional land use information. The chief problem was that although the information was known to have been collected in several separate exercises under the auspices of a federal government agency, the GNWT, and the Tribal Council in anticipation of land claims discussions, it was either impossible to locate the raw information or only damaged sections were located. People employed as fieldworkers during information collection exercises typically reported that the map products had been shipped out of the community:

I think the mapping was sponsored through the Department of Renewable Resources in Yellowknife, and we sent it up there. We don't have a copy for ourselves. (Bouvier 1995)

Once we had all our resource data DIAND wanted to digitize all the traditional land use maps. There were about twelve sets of maps, and we sent them down to Yellowknife. I think that the majority of the maps were completed and they were sent to the Fort Simpson office. . . (Nadli 1995)

However, when inquiries were made to staff at the offices that interview subjects suggested were where the raw information should be, inevitably it was either reported simply that the information was not there or that it had been transferred to another office. As one Board member summarized, "A lot of money is being spent on information gathering and somewhere along the line it's being shelved." (Sanderson 1995)

It was only toward the end of the second research period, after the move from the Dene Local #57 office to the new office that one set of maps with information collected in the late 1970's or early 1980's surfaced. Reviewing it with one of the staff was a frustrating exercise. The information had been collected for all respondents onto a single set of 1:250,000 National Topographic Series maps that had been cropped and taped together with broad strips of masking tape. They obviously had not always been stored with the greatest of care and in optimal environmental conditions; sections of some of the maps had fallen off altogether and the remaining sections were creased and crumpled. The staff member pointed out information that had been provided by community elders who had since passed away, obviously valuable elements of community history. However, no legend was attached indicating what the map symbols were intended to represent. Thus, we were presented with a hieroglyphic script of obviously valuable information, some of it missing, with no Rosetta Stone to aid decoding.

It is apparent that the same lack of administrative and bureaucratic processes described in section 7.3 that may present challenges for implementing GIS in aboriginal community contexts affect orderly retention of important records such as these. In addition to the discussed traditional land use and occupancy maps, three Resource Management Board members referred to a map on which Deh Gáh Got'ie Kq̄ leaders and leaders of the northern abutting Dogrib community of Rae Lake had agreed to a boundary line. At some juncture, this map had been taken out of the community and somehow lost. It was indicated that as the Dogrib community was considering pursuing a

land claim settlement and was claiming a boundary considerably more advantageous to it than the one that had been agreed to, the loss of the map was of great significance.⁷²

The worst example of problems of missing or damaged raw map information was associated with several GIS data sets representing information collected from hunters about locations of species during different seasons. These digital data had been obtained by the community and were stored on its computer system. However, a review of their content suggested that it was incomplete, no supporting documents describing survey and recording methodologies used to accumulate the information were included, and no technical documentation was available to define coding schemes used. Even a representative of the DIAND agency involved, who had been involved directly in converting the mapped information into digital form, did not know where the original maps were stored. Because of this, with the reliability of the digital information in question, the data sets had to be set aside in favour of a new indigenous knowledge and traditional land use mapping exercise. This meant that the Board incurred additional costs and was delayed further.

The implementation of the new indigenous knowledge and traditional land use mapping exercise revealed an issue that relates to the lack of archival maintenance of records discussed in section 7.3 and to the promotion of community knowledge of resource management and the GIS operations mentioned in section 7.4. Some of the community residents identified as in the group of subjects the Board wished to be interviewed expressed dissatisfaction at being asked to spend time answering the same type of interview questions they had been asked several times before during other traditional land use mapping exercises. The harvesters had not perceived any positive benefit for the community in previous exercises. This was an understandable reaction given that at least three separate collection processes have taken place in the last fifteen years. One inspired response to this issue which the Board plans to implement is to print an individual map for each interview participant once the information has been digitized. It was felt that this would give the hunters involved an indication that their information was being used to further community interests and generate further community interest in the Board resource management efforts and GIS.

A final data-related issue for the Board GIS efforts was maintenance of GIS data sets. Although some information, particularly concerning the physiographic characteristics of a region, does not change a great deal from year to year, many data sets of concern for resource managers must be updated on a regular basis. Even the manually-mapped information available from the territorial and federal governments was not updated regularly:

I go through Renewable Resource maps quite often, and they've really made a gallant effort to try to record all these traditional land use areas, especially hunting

⁷² In instances in which facilities for and bureaucratic continuity necessary for archival storage of records are lacking, the ability of GIS to allow distribution of multiple paper and electronic copies of information would improve the likelihood of avoiding information loss.

areas and trapping, but. . .the maps they have from five years ago are totally obsolete today. (Sanderson 1995)

The Board's own information gathering activities have not yet required it to consider ongoing updating and maintenance. However, in order to keep the GIS information base used for resource management current, agreements will have to be struck with other agencies supplying information and a routine of updating these on the Board GIS will have to be developed. As well, information such as that collected in the new indigenous knowledge and traditional land use mapping exercise will have to be updated on a regular basis.

7.6 Distribution of Power Within Organization

Section 4.2.1 discusses the possibility that GIS implementation will cause realignments of power within the organization into which it is introduced. Some argue that increased information accessibility associated with GIS will result in increased power for upper echelon staff and the expense of lower-ranked employees. As well, technically-knowledgeable personnel will gain power while those lacking GIS know-how will lose.

The study findings associated with the within-organization distribution of power are detailed in section 7.3. In summary, there was little evidence to suggest that GIS implementation had resulted in any significant power shifts. This may have been because: GIS were acquired shortly after the Board began operations and there were no pre-existing hierarchies to be altered; the Board had an extremely flat organizational structure that did not lend itself to hierarchical relations; GIS operations had not become central to Board resource management planning activities, although they were important to them; formal employment roles appeared to have little effect on relations between individuals in Fort Providence, perhaps because the community is very small and relations have been built up over many years between individuals; everybody involved in the Board GIS implementation and resource management activities had a stake in the success of resource management, and may have been discouraged from acting upon rivalries in ways that would be disruptive to Board actions.

7.7 Power Balance Between Community and External Interests

In section 4.2.2, the possibility that GIS affect and are affected by the balance of power between the organization implementing them and outside interests with stakes in resource management is discussed. Since resource management planning involves a political process of stakeholders attempting to exercise power to influence decisions and further their own interests, and since information is central to decision-making, GIS, by changing the directions and speeds of information flows, will alter power relations between stakeholders.

From the initial decision to consider implementing GIS, relations of power between the Board and external interests came into play. As is documented in section 7.4, a lack of knowledge of basic GIS technical issues left the Board in a position of accepting uncritically technical advice from GIS experts employed by the GNWT on what purchases should be made. An interview with one of the individuals who provided this advice indicated that the software recommendation had been made on two bases. First, it was assumed that the Board would develop little internal GIS expertise. Second, without internal expertise, the Board would be exclusively a consumer of GIS information provided by the GNWT, and to a lesser extent the federal government, making the consideration of software compatibility with the information providers of paramount importance. Because of this, a limited GIS data browser and map production tool, SPANS Map, was recommended.

Though framed as a technical recommendation, this advice had significant ramifications for Board autonomy in analysis of GIS data. Essentially, with SPANS Map the Board was cast in the role of a poor cousin of GNWT departments. With this GIS software the Board would be reliant on territorial and federal government agencies for all digital information. Any additional information the Board desired as a GIS data set would have to be generated externally, either by request to government agencies that had the full featured SPANS GIS software, or through contracting private sector firms with digitizing capabilities. In the same way, any GIS analysis beyond the severely limited capabilities of SPANS Map would have to be requested in the same way. However, without the political representation that government departments ultimately enjoy, requests would not be political expedient and could be dealt with more at the pleasure of the bodies considering the request. As well, the potential for ambitious Board employees to expand their capabilities would be curtailed, as such a possibility would require an investment in a completely new computer and software that retails at a minimum discounted rate of \$12,500.

It seems unlikely that all these implications of the recommended GIS for the Board role vis-à-vis territorial and federal government agencies entered into the rationale for the advice explicitly. However, the recommendation is in keeping with territorial government interests. In light of reductions in the role of the territorial government in the last few years through the imminent splitting off of the Nunavut territory and reductions in federal government transfers, it is doubtful that an initiative that promotes devolution of resource management responsibility from the territorial level to a regional level would be understood as positive. In addition, a relationship of technical dependency between the Board and the GNWT Centre for Remote Sensing would improve the ability of the latter to insulate itself from reductions in demands for its services.

The research interviews made it clear that the implementation of GIS by the Board was understood to some degree as an element in a broader political exercise of gaining power for community interests and reducing that of external interests:

Another reason for using GIS is that we wanted to put all our traditional information together – all our traditional land use – and have everything prepared for a

resource management plan in Providence. It's another way of asserting our traditional and aboriginal rights. This way we can make our own decisions based on our traditional knowledge and historical background, and not have somebody from Ottawa coming in and dictating how we should manage our resources. We're tired of that. (Bouvier 1995)

In light of this, it is not surprising that after working with the recommended software for a few months and attending a GIS training seminar in Edmonton in which Albertan municipal GIS approaches were demonstrated, the decision was made to purchase GIS software and additional hardware that allowed the Board to create and maintain its own data sets. In this way, the loss of autonomy to outside interests that the initial decision involved was set aside. The Board still had compatible GIS software that allowed it access to territorial and federal government data sets. However, it was no longer beholden to the providers of those data sets for all but the most basic of GIS activities.

As detailed in section 7.5, it sometimes required significant political wrangling to have Board requests for data sets from government agencies acted on. Given the association of information with power discussed in section 4.2.0, it is not surprising that control of information provides an arena for exercises of power. Power of external agents affected the Board in two ways when requesting data sets. First, individual employees of an agency were able to choose what information they provided about internal data sets under the jurisdiction of the agency. Second, once this information was obtained, formal political approvals for data set release were sometimes withheld. Both of these exercises of power reduced the ability of the Board to act and the knowledge it had available on which to base resource management decisions and its associated decision-making effectiveness.

Control of information as an exercise of power also manifested itself in various traditional land use mapping exercises run by territorial and federal agencies. As discussed in section 7.5, information gathered in these inevitably left the community and could not be obtained later on. Control of traditional land use and occupancy information was discussed by both Board members and government representatives. The concerns expressed on either side of the issue were not specific to GIS. From the government perspective, information should have been openly accessible, and there was frustration over aboriginal groups not wanting to allow it to be released. As well, it was felt that the most complete information would lead to the best decisions:

... you are investing hundreds of thousands of dollars of government coin on these projects, and you get up to a certain stage and then they suddenly decide that they don't want to have that information released. I think you have to have some kind of agreement at the outset that says this is what this information is being collected for – this is its purpose – and this is what it is going to be used for. (Spek 1995)

If you are using GIS for resource management, say there is a proposal to put a road into an area, it can be used to find what resources are there, what graves are there, what spiritual sites are there. The band may know about the land, may even have it mapped, but if you don't know things are there, if according to the map you have

things are not there, how can you know? We have to try to push the point that if it is not complete it can cause these problems. (Balsillie 1995)

From the community perspective, however, there was great concern that public access to traditional land use and occupancy information could damage community interests, and that government interests did not correspond to these:

I remember having a talk with a lady from the Deh Cho First Nation out of Simpson and it's my understanding that they're holding a lot of this traditional knowledge at their office in Fort Simpson for that reason – they don't want it falling into outside hands. There was a big confidentiality spiel given to everyone – you don't be too free with this information; keep it local. (Sanderson 1995)

The questions we used [for traditional land use mapping] were set by the government for its own purposes. (Bouvier 1995)

These divergent views are polarized when traditional land use mapping is entered into GIS, because of the ease with which GIS data sets may be copied and distributed relative to paper maps. Government representatives understood this as an opportunity to promote better decision-making:

If BHP [a diamond mining concern] has used some GIS, and they have mapped out the area where they are going to develop – the road, the hydro line, the water resources – and the band comes along with a mylar or a paper map or ideally information on GIS, we could just overlay it. (Beaulieu 1995)

We don't have to release our information to BHP, but we could take a diskette from BHP and tell them, "Yes, there is a conflict here, you will have to move the road," or, "No there isn't a conflict." (Balsillie 1995)

From the community perspective, ease of access was understood as opening the possibility for damage or exploitation of community lands and knowledge. In this regard, much concern was expressed about protecting the traditional land use and occupancy mapping from release once it was digitized.

7.8 Distribution of Power Within Community

Section 4.2.3 summarizes arguments that GIS use for resource management planning in aboriginal contexts may change distribution of power within communities. First, there is a generic concern that when used in planning processes, GIS will make information used for decision-making less accessible for citizens without technical knowledge and expertise who already have a reduced ability to affect decisions. Second, the gathering of knowledge from elders and storage of it in GIS may affect the power of elders both negatively by reducing their control over to whom and under what circumstances their knowledge is imparted, and positively by increasing the influence their knowledge has on resource management decisions.

Because the segment of the resource management process that involved public consultation had not taken place when the research was conducted, it was impossible to study the impact of GIS on public input into resource management. Furthermore, because the snowball sampling method for interview subjects described in 6.2.3 favoured people actively involved in resource management or band administration, it was only late in the second research period that opportunities began to arise to discuss the Board GIS activities with elders and others not directly associated with the Board. The few contacts with elders suggested that they had no concern at all with impacts on their status and influence in the community of their knowledge being stored in GIS. Instead, I was told that they were pleased that they were being afforded the opportunity to have their knowledge recorded so that it could continue to be of benefit to the community once they passed away. The first elder whom I spoke to directly – at the local bar on a Friday evening – told me, in a combination of French and Slavey, that he knew what the Board was doing and thanked me for my role in it. The hunters and elders who visited the White House to inspect the GIS and maps generally expressed approval for the activities when asked what they thought of them. Although of course this very limited sample may have been skewed toward people in favour of Board activities, it provides first evidence that GIS are perceived as having positive benefits among community members.

7.9 GIS and Legitimation of Knowledge

In section 4.2.4, it is observed that one way in which GIS use can affect power relations is through increasing the perceived legitimacy of information stored in them. This is related to the association of computers with science and objectivity, which are understood to have great value in southern culture.

When questioned about the reasons for the decision to use GIS for resource management in Fort Providence, most informants made reference to the idea that using the technology increased the community's prestige:

You have to keep up with the times and the technology in order to get to your goals and objectives. One of the things that we want to do is keep up with the government. . . . There have been changes even in the last month here, and the Board is starting to realise its goals now. You can see it when you meet with the government officials from departments, and they come in here and they see that Fort Providence is a community to be reckoned with in the Northwest Territories. They're always talking about Providence being a role community in taking over community transfer initiatives and co-management initiatives. . . . A lot of the [government] departments know that we've gotten our act together here. A lot of these departments come in here and they don't know what to expect, but once they see what we are doing they are really impressed. We're starting to gain a lot of respect from the departments, and they talk about Fort Providence all over the government. (Bouvier 1995)

Among employees of government agencies involved in resource management planning, the idea that the community's GIS endeavour increased its perceived legitimacy was supported. Generally, government staff attempted to extract an assessment of the Board's GIS capabilities from this researcher. It was not surprising that the concern with ability to use the system effectively discussed in section 4.2.2 manifested itself most prominently in interviews with the GNWT Centre for Remote Sensing staff and DIAND GIS technical personnel. However, non-technical personnel sought the same information. There was no question that ability to use GIS was part of the external assessment of the Board's legitimacy. Therefore, the key question for government officials was how effective the Board's use of its system was as an aid for resource management.

7.10 Positivist Assumptions of GIS and Limits to GIS Imposed by their Cartographic Roots

Section 4.3.1 summarizes concerns that GIS may promote positivist ontological and epistemological assumptions. It is concluded that because of the mathematical logic built into the underlying computer systems, analytical operations conducted using the systems have inherently positivist characteristics, while GIS approaches for information representation, although limited, were not predisposed to strictly positivist forms, although they had some positivist elements. Section 4.3.2 points to one of the important limitations for GIS information representation, restrictions inherited from the cartography. As mapping tools, GIS necessarily present data sets only with elements of distortion, omission, and emphasis of information.

There was little evidence of an impetus toward positivist approaches to knowledge and analysis in the study community during the research period. The traditional land use and occupancy study had methodological aspects that could be termed positivist, but these arose out of concern that information collected be defensible in public fora such as environmental impact hearings in which information may be questioned by expert witnesses with a scientific background. Unfortunately, for the most part it was too early on in the Board GIS implementation process to assess these concerns meaningfully during the research.

7.11 Technical Limits to GIS Representation of Knowledge, Modelling and Analysis

Section 4.3.3 details literature concerned with GIS limitations for representing knowledge. In particular, current GIS database designs strip information of important metadata that help users to estimate information value. As well, the technology has serious problems as a storage medium for qualitative information such as indigenous knowledge, even when that knowledge could be referenced spatially. The main worry is that even with provisions made to the contrary, even relatively straightforward recording of such things as cultural landscape features will result in severe losses of important information. Section 4.3.4 builds on the observation, mentioned in the previous section, that GIS as analytical tools embody positivist modes of reasoning, and points out

as well that specific technical limitations for GIS analysis can cause difficulties for users of the systems.

Although the Board has been involved only in a single exercise of collecting information for inclusion in a GIS data set, even this initial experience demonstrates that people familiar with how the technology is being used are concerned about its shortcomings for representing qualitative information:

GIS systems are so new for us. They don't incorporate a lot of the valuable information that we should be holding important. [Resource management is] a holistic exercise, but people don't [understand] that. It hasn't been perceived as a community development exercise. People perceive it as an exercise for resolving land use conflicts, and a lot of the information that could have been stored and archived wasn't and it was probably because it had to be prescribed and in a sequence and it had to be done in a certain way that discriminated against certain information and processed into the computer. A lot of information that was really valuable wasn't recorded, and I don't know of any other systems that could incorporate that information, especially knowledge of the people like the elders and the historical information that they have that has been passed from generation to generation. (Nadli 1995)

A subtle effect of GIS use for recording indigenous knowledge is how anticipated use of the technology may affect information on which collection processes focus. For instance, fieldworkers in the gathering process for the seasonal animal habitat information GIS data sets described in section 7.5 reported that anticipated GIS use affected the research methodologies used:

... it was describing a sequence – the process of retrieving information was going to be prescribed, sequential, logical. (Nadli 1995)

... we had to make the methods produce things that could go into the GIS, like polygons and vectors. (Beaulieu 1995)

Because the information was to be converted into GIS data sets, the methodologies recorded locations of different species using a standardized coding schema. Upon reflection, one of the fieldworkers expressed concern that because interviews had not been tape recorded, many valuable insights that hunters provided were lost and only the most basic locational information was retained.

An extreme example of how restrictions in the abilities of GIS to store and analyse qualitative information can mould the approaches their operators use to represent information was provided by one of the government GIS technicians interviewed. Asked how he would deal with representing qualitative knowledge such as the location and meaning of sites of spiritual significance, he responded that the best approach would be to rank the value of sites on a scale of one to ten. This, he felt, would allow spatial analysis to determine how serious potential land use conflicts were.

At the time when the field research was undertaken, Board GIS activities had not developed sufficiently to allow GIS analytical techniques to be used. Because of this, the research could not investigate the effects of technical limitations to GIS analytical operations on resource management activities and responses to these. Interviews with Board employees indicated that significant analytical operations had not been considered. Instead, the chief anticipated use of the system was to facilitate transfer of information pertinent to resource management to the Board and to allow production of paper maps to support decision-making processes. Because of the technical pitfalls associated with current GIS analytical capabilities, this was a pragmatic approach.

Chapter Eight

IMPLICATIONS AND RECOMMENDATIONS

In chapter one, six objectives were laid out for this thesis:

1. Synthesize critical discussions of GIS into a single conceptual framework to aid understanding the potential implications of GIS at a generic level.
2. Extend critical discussions of GIS to examine specific concerns that they raise in aboriginal community contexts to make the framework more suitable for understanding issues surrounding GIS use in aboriginal communities.
3. Research actual use of GIS for resource management in an aboriginal community and determine how they illustrate the practical aspects of the implications raised in the conceptual framework.
4. Identify difficulties encountered and practical approaches used by the research community to address shortcomings to GIS.
5. Recommend what steps should be considered to improve further the effectiveness of GIS use in the study community.
6. Determine practical issues surrounding use of GIS for resource management in aboriginal communities generally.

Chapters two, three, and four address the first two objectives, examining in detail the many facets of concern surrounding GIS use for resource management in aboriginal communities. First, they contrast the qualities of conventional and traditional aboriginal resource management approaches, consider the nature of knowledge used to understand the area managed, and discuss approaches to combining the two. Then, they review the qualities of GIS and concerns raised about implementing the systems with particular emphasis on how these concerns apply to aboriginal communities, and put forward a framework linking them. Chapters five, six, and seven address objectives three and four, describing how field research was conducted. They describe the specific characteristics of the community that agreed to allow the research, the methods used to undertake the research and identify community experiences with GIS, and the findings of the research.

This chapter addresses the last two objectives, discussing how the theoretical and field research may be applied practically. First, it recommends steps that should be considered by the Fort Providence and Kakisa Resource Management Board (hereafter the "Board") to improve further the effectiveness of GIS for resource management activities. Second, it summarizes practical issues that aboriginal communities should consider before and during implementation of GIS for

resource management. Finally, it details areas of inquiry associated with the thesis research that could be explored in greater depth.

8.1 Recommended Steps for the Fort Providence and Kakisa Resource Management Board to Improve GIS Effectiveness

Despite setbacks caused by lack of suitable office space, delays in government bodies granting approval for the release of necessary data sets, and false starts made while learning the nature of the technology, up to present the Board GIS implementation has been successful. In order to continue to improve GIS effectiveness for resource management, the Board should consider the following steps:

- 1. The Board should formalize a long term GIS implementation action plan with an associated budget plan.**

Although GIS operations have not been adversely affected by the lack of such plans to present, as section 7.1 notes it is clear that GIS-related expenditures have been much higher than originally expected. Developing staff expertise in use of the technology through ongoing training and generating and maintaining GIS data sets are both long term endeavours that require advance planning and funding.

- 2. The Board should attempt to employ at least one individual to operate its GIS and engage in resource management planning activities year round.**

As detailed in section 7.3, the lack of continuity in GIS operations has been disruptive for system users accumulating knowledge of the software and its capabilities. To make the long term GIS implementation action plan effective, planned training for GIS operators needs to be complemented with ongoing opportunities to apply it.

- 3. When the services of technical consultants are contracted, the Board should include a teaching component in the contract agreement.**

Because of tight deadlines, the efforts of technical consultants hired by the Board have been focused upon achieving specific ends. GIS operators have benefited from working with consultants and asking questions informally. An explicit session of at least a day of formal instruction should be included in consulting contracts to increase staff opportunity to learn from consultant expertise.

- 4. The Board strategy of encouraging community members to drop by the office for coffee and to examine the GIS is a good one, and should be continued as the plan is completed and revised.**

5. **The Board plan to provide each hunter who participated in its traditional land use mapping exercise a personalized map printed using GIS once their information is digitized is a good one and should be carried out.**
6. **The Board should strike agreements with government agencies from which it obtains GIS data to be sent information updates as they are completed. As well, it should plan to update information that it collects about changing subjects such as traditional land use on a regular basis.**

Effective resource management decision-making requires information that reflects most current knowledge. Because obtaining GIS data sets from government agencies has been an arduous exercise marked by long waits for bureaucratic approval of information release, there may be a tendency to consider the information gathering segment of GIS implementation over once all data sets finally are received. Instead, the Board should take advantage of approvals as they occur to ask for formal agreements that updates be sent as they become available.

7. **The Board should make certain that it keeps paper records describing all GIS data sets that it generates, including an explanation of information collection methods. These should be stored in a secure location such as the Band Office.**

The loss of various valuable records described in section 7.5 has been a stumbling block for Board resource management activities. In order to avoid the same fate befalling information it collects, in the future the Board should ensure that descriptive records, raw information maps and tapes, and copies of GIS data files are stored securely, and that copies are stored in a separate location.

8.2 Implications of Findings for Aboriginal Resource Management Exercises

The theoretical research and practical study of Board GIS use for resource management provides valuable lessons on challenges for implementing the technology and means to overcome them. An aboriginal resource management agency considering using GIS as a decision-making aid should take the following steps:

1. **When considering use of GIS, an agency should estimate the resources that will need to be secured and dedicated to the technology, how the systems will affect resource management activities, and whether anticipated benefits outweigh anticipated costs and justify proceeding.**

It should be clear from the discussion in this thesis that GIS are not a panacea for resource management difficulties. The technology has strengths that can benefit community resource management activities, but it also has weaknesses. A halfhearted implementation may produce few returns while consuming money and staff time that could be used to greater benefit in other ways.

As well, even a successful implementation may distract attention from other activities that would benefit the land, such as consulting elders and other knowledgeable community members on what should be done. Resource managers should not acquire GIS until they have a clear vision of how resource management as a whole will be carried out and how the technology will contribute to this.

2. The possibility of pooling resources with other communities should be investigated.

GIS require considerable resources, both human and financial, and that significant time be spent acquiring basic skills before any outputs of value can be produced. Sharing skills and resources with other agencies offers the possibility of reducing the demands the systems make on each party. For instance, if a resource management agency in another community has already implemented GIS, it may be most cost-effective to contract it to provide GIS services.

3. Before GIS are implemented, a formal long term GIS implementation action plan should be prepared, including: anticipated uses; required hardware and software; required data sets, sources, and formats; necessary facilities; and necessary skills for operators and how these will be fostered or obtained.

Although the Board GIS operations have not been derailed by the lack of a formal implementation plan, some of the delays and false starts it has experienced might have been avoided with thorough advance planning.

4. An aboriginal resource management agency planning to implement GIS should be careful to budget realistically for the costs of necessary computer hardware, software, data, GIS training, and technical consultants.

The Board experience illustrates that costs may be significantly underestimated without thorough budget planning and appropriate consultation.

5. It should be understood that even apparently impartial technical advice about system selection may have political ramifications. When advice on GIS-related decisions is offered or sought, the interests of the parties providing it and how they relate to the agency and community interests should be considered.

As discussed in section 7.7, initial advice received by the Board led it to purchase severely limited GIS software that would have placed it in a servile role in relation to territorial and federal government agencies. Although it is by no means certain that this implication of the software purchase was either considered or desired by the advising agency, this experience demonstrates the need to proceed carefully and consider the broader implications of GIS use for the agency and the community that it serves.

6. Before GIS computer hardware and software are purchased, an agency should secure adequate and secure office space for the technology.

The Board experience emphasizes that the lack of this basic requirement can be significantly disruptive to GIS operations, both because equipment cannot be set up in a usable way, and because access of unauthorized individuals to the computer equipment can lead to inadvertent changes to system configuration that make GIS software unusable and require expert assistance to correct.

- 7. In most northern communities, power line and telephone line conditioners are essential to protect investments in computer equipment from infrastructural shortcomings.**

Problems encountered by the Board before installing such equipment were relatively insignificant. No equipment was damaged irreparably, and effects were restricted to the occasional lost of work time to the computer system re-starting because of power line flickers. However, computer equipment is at significant risk without such equipment and even the loss of valuable staff time to such problems is unacceptable.

- 8. Stocks of GIS-related supplies should be secured and maintained to avoid long delays while they are transported to the community.**

- 9. Very early during system acquisition, government agencies and other information providers identified as sources of GIS data should be contacted and initial requests for information should be made.**

The Board delays in obtaining GIS data sets demonstrate that even if information exists, there may be substantial delays before approvals are granted to release it. As well, as the Board experience with ordering digital NTS base maps illustrates, if particular data sets have not been generated, there may be delays in producing them even if they are given priority. Making requests for data sets well in advance of the time at which use is anticipated will reduce the impact of such delays.

- 10. When the services of technical consultants are contracted, provision for a teaching period to transfer skills to GIS operators should be included in the contract agreement.**

Although hiring skilled technical consultants may supplement GIS operator skill sets and allow goals to be reached quickly, if skills are not transferred this reduces organization self-reliance and discourages staff from increasing their own knowledge. Therefore, the hiring of technical consultants should be viewed in part as an educational opportunity for GIS operators.

- 11. Aboriginal resource management organizations should assure that GIS users work with the software on a regular basis so that they can continue to build their knowledge of how the systems are used.**

The Board experience indicates that lack of continuity can interfere with build up of critical knowledge of the systems.

- 12. Community members should be encouraged to drop by the resource management office to see the systems being used and printed versions of the information so that they may participate better in the resource management process.**

The Board idea to provide a coffee pot, mugs, and chairs, and encourage people to drop by was inspired and successful. Since one of the concerns about GIS use is that it will result in reduced public participation and input into management plans, it is important that community members be allowed to become familiar with the systems, the information contained in them, and how they are used.

- 13. Particularly in aboriginal communities, in resource management exercises GIS should be used not as a sole archive for information and replacement for other information sources, but as a complement.**

The theoretical research and field findings indicate that valuable qualitative information is lost when converting indigenous knowledge into current GIS formats. It is important that GIS used for the purpose of storing information like traditional land use and occupancy studies be supplemented by the raw source information and preferably by discussions with the people who provided the information originally.

8.3 Research Limitations and Areas for Further Study

The research described in this thesis has a number of shortcomings, some which are inherent and some which resulted from the limited amount of time and funds for conducting the study:

1. Babbie (1983, 267-269) points out that although field research allows a depth of perception that can lead to highly valid understandings of research contexts relative to more superficial formal survey and experimental approaches, results can suffer from problems of generalizability. Whether the research detailed in this thesis is representative of typical experiences implementing GIS in northern aboriginal communities is open to question.

Although they share common concerns and challenges, northern communities differ greatly from one another because of such fundamental issues as the nature of the community's formal economy, persistence of traditional activities, and accessibility to other communities through transportation and communication infrastructure. Mulvihill (1990, 121) concluded that the input of key individuals is critical to distinctive and imaginative environmental assessment approaches. It seems likely that this could be the case in resource management using GIS, particularly in small communities in which individual residents may have great influence on how processes unfold. The question of

representativeness of the findings of this thesis could be addressed by undertaking a comparative study of the experiences of several communities.

2. The research was conducted on a compressed schedule over a relatively short period of time before the resource management exercise undertaken by the study community had been completed. A longitudinal study conducted over the whole course of GIS implementation in an aboriginal community planning exercise from process initiation through plan completion would provide more complete insights into the issues identified in the conceptual framework.
3. The perspectives of female community residents were omitted in the research. This is a result of the domination of resource management and local administration by men. The Fort Providence Resource Management Board is a male enclave.

Addressing the lack of female perspective would be a difficult task for a male researcher. Gender roles and behaviours are fairly strictly differentiated in Dene culture. Women of the community to whom this researcher spoke were very reserved in most circumstances. A successful research approach probably would require a male and female research team,

4. The research into the capital expenditures required to implement GIS in Fort Providence was conducted without complete access to all budgetary records. As well, since the research was conducted before the final resource management plan was completed, the final sum of GIS costs could not be ascertained. Furthermore, as indicated in section 7.1, necessary indirect expenditures related to implementation and staff salary amounts devoted to GIS activities could not be estimated. More rigorous and thoroughgoing research would provide valuable information for communities attempting to estimate financial costs of system implementation.
5. Although the literature reviewed in section 4.1.3 and section 4.2.1 indicates that GIS may alter power relations within an agency into which they are introduced, little evidence to support this contention was uncovered during the fieldwork in Fort Providence. As is suggested in section 7.3, a number of basic differences in relations between employees and officials of agencies in small aboriginal communities may be responsible. However, because GIS were introduced to Board operations very shortly after it was formed, and since the research could provide only a snapshot of relations at a given stage in GIS implementation, no conclusive evidence to support or reject the idea that relations between individuals will be altered in a community-based aboriginal agency implementing GIS. Conducting a rigorous longitudinal study of this could be very interesting and fruitful.
6. GIS critical literature referenced in section 4.2.3 makes an initial case for GIS use in aboriginal communities for resource management changing power balances within them, first by changing the accessibility to residents of information used for decision-making, and second, when GIS are used to store the knowledge of community elders, by altering the

elders' control over the information while at the same time increasing its influence on resource management decisions. As detailed in section 7.8, because of the intermediate stage of GIS implementation and resource management in the research community, little evidence to support these contentions could be gathered. The one initial finding, that elders appeared to support the gathering and use of their knowledge because they perceived it as of benefit for the community as a whole, suggests a fascinating line of inquiry. Successful research likely would require that a culturally-knowledgeable resident be involved.

7. The discussions of social science approaches to examining power in section 4.2 make it clear that this area of research is very challenging. Presuming that the decision-making approach discussed in section 4.2 is set aside in favour of one that seeks to explain the nature of power and its distribution, rigorous inquiry into this aspect of GIS implementation might be carried out through a thorough set of interviews focused upon perceptions of the power of actors in a GIS-related process. Establishing convincing counterfactual cases in small aboriginal communities, however, would be very difficult. In the case of northern aboriginal communities, it seems likely that individual differences resulting from the personalities of key community actors, differing histories of success in community actions on resource management, presence of internal and external interests with stakes in the resource economy, and myriad other factors would make use of a counterfactual approach unfeasible. However, rigorous longitudinal community research undertaken to compare power relationships and dynamics before and after GIS implementation would be a productive study, particularly if it could be carried out in more than one community.
8. The possibilities detailed in section 4.3 that information representation and analysis using GIS may conceptually bias users in favour of positivist approaches, and that the systems limit types of information that can be represented in them because of technical constraints and built-in cartographic limits is an extremely interesting area of inquiry. The short-term broad inquiry conducted for this thesis did not permit any conclusions to be drawn. Research into this topic would require an extremely well-designed, subtle research approach such as comparing the importance of various information to decision-making processes in a cross-section of organizations including some that used the technology and others that did not, or doing a detailed longitudinal study of this nature before and after GIS implementation in a single agency.
9. A fascinating area of concern is raised in the discussion of evidence of cross-cultural differences in the perception of space referred to in section 4.3.3. The mere investigation of the nature of spatial perception requires an inspired researcher. The limited survey of the literature made in association with this thesis did not turn up any work on the perception of space in Canadian aboriginal cultures. The investigation of how this might interact with indigenous knowledge systems on one hand and GIS on the other might

suggest ways in which the technology could be altered to accommodate indigenous knowledge more effectively.

8.4 Conclusion

This thesis has revolved around two basic insights into planning. First, fundamentally, planning is a process of applying technical knowledge to aid making decisions about the future. Second, planning cannot be apolitical, because it is always a forum in which the different interests of stakeholders are affected. Therefore, political disengagement by planners is an impossibility.

In resource management, these insights have been slower to be accepted because much of the knowledge used to make decisions has a gloss of empirical objectivity. Resource managers have continued to be able to pretend that they are merely technical conduits of the best information available upon which to base decisions. However, even when the rationale for decisions is disguised by being presented as based upon “objective” technical considerations, as long as different stakeholders with differing interests are involved, decisions have political implications. Residents of northern aboriginal communities, with their close economic and cultural ties to the land, are better aware than many of how directly resource management decisions may affect their interests. Sadly, they have arrived at this awareness largely through the experience of having the interests of others treated as more important than their own.

In this regard, community-based aboriginal resource management is a step in the right direction. Through involvement in resource management, aboriginal communities are afforded an increased opportunity to promote their own interests. Since the currency of resource management decision-making is information, when communities decide to manage resources they will gain the greatest ability to influence decisions by fostering a thoroughgoing ability to deal with information. GIS, as tools for integrating, organizing, and manipulating spatial information, are one means of improving this ability. However, often in resource management, the dominance of powerful political interests is hidden with a veneer of “objective” information on which decisions are based. The technology that is used increasingly to store and manipulate this information participates in this camouflage. If one lesson is to be taken from this thesis, it is that it is misguided to understand GIS as a benign means of dealing with abstract and objective knowledge. Certainly, GIS should not be rejected for resource management – at their best they are valuable tools that can allow people more access to the information that is used to make decisions affecting their lives. Such promotion of better access to decision-making and associated information is in keeping with the demands of the principle of social justice, introduced at the outset of this thesis, that marginalization and powerlessness be combated vigorously. At the same time, this thesis indicates that many issues must be considered when implementing the technology to understand GIS implications and avoid problems.

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Appendix A

SEMI-STANDARDIZED INTERVIEW QUESTIONNAIRE

Note:

- Italicized items were questions that were posed the respondents. Normal font items are guides to indicate the area of inquiry but were not asked as questions.

1. Why are GIS used?
 - a) *What are the reasons for using GIS for lands and resource planning?*
 - b) *How was the decision made to use GIS?*
2. How are GIS used? What benefits have been realized and what costs have been incurred using GIS?
 - a) *How has using GIS changed lands and resource planning activities in the community?*
 - b) *How has using GIS changed what you do? How has using GIS changed how you do it?*
3. How was the traditional land use knowledge collected and how was this affected by anticipated GIS use?
 - a) *What process was used to collect the traditional land use information?*
 - i) (If an individual interview process indicated): *Was the knowledge combined (aggregated) into a single community dataset? How was this done?*
 - b) *Was GIS use anticipated when traditional land use information was collected?*
 - i) (If yes): *What preparations were made for using GIS before the information was collected?*
 - ii) (If yes): *How did the anticipated GIS use affect the way knowledge was collected?*
4. What problems were encountered representing traditional land use knowledge in GIS datasets and how were these addressed?
 - a) (For technical personnel): *What problems did you have designing the GIS database structures to handle the traditional land use knowledge?*
 - b) *Do you think that anything was lost moving the traditional land use into GIS?*

- i) (If yes): *What do you think was missed?*
 - ii) (If yes): *What has been done to make sure that the missing information still gets considered?*
 - iii) (If yes): *What other things do you think could be done to keep the missing information from getting lost?*
5. What lessons are to be taken from the community GIS experience? (A different route to all of the questions above, and a means of assessing the value assigned to different aspects.)
- a) *If you were advising another band who were thinking about using GIS:*
 - i) *what would you tell them the best things about it are?*
 - ii) *what would you warn them about?*
 - iii) *what would you tell them to do?*
 - b) *In summary, what have the best and worst things about using GIS been?*