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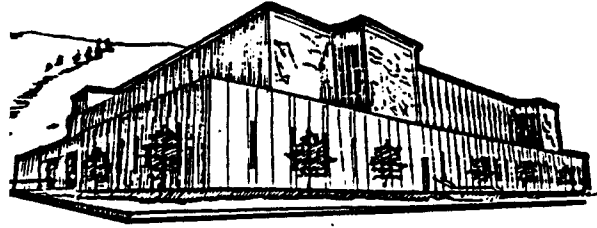
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University of
Montana

A Survey and Evaluation of
Geographic Information System Applications
in Forestland Planning in Northwestern America

By

Tom Olliff

B.S. Auburn University, 1980

Presented in Partial Fulfillment of Requirements
for the Degree of Master of Science in Forestry

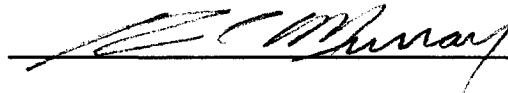
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A Survey and Evaluation of Geographic Information System
Applications in Forestland Planning in Northwestern America

Director: Dr. Alan G. McQuillan



Abstract

Forest planning is a complex process that has evolved with historical trends and changes in technology. While planning requirements and efforts differ between federal, state, and private organizations, planning generally occurs at three levels: strategic, tactical, and political.

Geographic Information Systems (GIS) are an emerging technology that links attribute data with spatial location in a computer format. The forestry profession in Northwestern America has been acquiring and implementing GIS since the mid-1970's. Some authors have suggested that GIS has the potential to change the character of forest planning.

Multiple case study methodology was employed to study this question. Extensive interviews were conducted at four forestland management organizations in northwestern America that have implemented GIS for at least five years. In addition, similar interviews were conducted as a pilot study at a fifth organization. Theory about the usefulness of GIS in forest planning was developed from the data.

It was evident from the data that GIS is useful in forest planning, most immediately at the tactical level but also at the political and strategic level. It doesn't appear, however, that strategic models used to calculate sustained yield harvest will be integrated into GIS at a fast rate.

GIS is not without problems. Data maintenance and update is time consuming; problems with personnel, hardware, and software have limited the usefulness of GIS; and GIS has, for several years, had "teething problems." The early players had to bear high costs for implementing GIS. But all in all, GIS is still the most promising technology on the horizon.

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Table of Contents

| | |
|--|-----|
| Abstract | ii |
| Acknowledgements | iii |
| Chapter | |
| 1. INTRODUCTION | 1 |
| THESIS ORGANIZATION | 2 |
| TERMINOLOGY | 3 |
| 2. FOREST PLANNING: EVOLUTION AND CURRENT STATUS | 4 |
| INTRODUCTION | 4 |
| THE ORIGINS OF FOREST PLANNING IN AMERICA: THE U.S. | |
| FOREST SERVICE AND FOREST INDUSTRY | 4 |
| American Forest Planning Takes Root: 1898 to 1950 | 5 |
| Legal Constraints on Forest Management and Planning: | |
| 1960 to Present | 6 |
| <u>Planning on Federal Lands</u> | 6 |
| <u>Planning on State Lands</u> | 7 |
| <u>Planning on Private Lands</u> | 7 |
| THE EVOLUTION OF PLANNING IDEAS AND MODELS | 8 |
| Planning for Biological Objectives: 1898 to 1960 | 8 |
| Planning for Economic Objectives: 1960 to Present | 9 |
| Planning for Multiple Use Objectives in the Forest | |
| Service: 1960 to Present | 12 |
| CRITICISM OF FOREST SERVICE PLANNING | 13 |
| Problems with the Planning Process | 14 |
| Limitations of the Model | 15 |
| Criticism With Use of the Model | 16 |
| CONCLUSION | 17 |
| 3. GEOGRAPHIC INFORMATION SYSTEMS: A DESCRIPTION WITH SOME | |
| SUGGESTED APPLICATIONS TO FOREST PLANNING | 21 |
| INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS | 21 |
| How GIS Works | 22 |
| Components of a GIS | 23 |
| GIS Products | 25 |
| GIS DEVELOPMENT | 26 |
| GIS PITFALLS | 28 |
| CURRENT APPLICATIONS OF GIS TO PLANNING | 31 |
| CONCLUSION | 37 |
| 4. RESEARCH METHODS | 39 |
| STUDY DESIGN | 41 |
| Phase I--Conducting the Initial Survey | 42 |
| Phase II--Conducting the Pilot Study | 43 |
| Phase III--Gathering the Data | 45 |
| DATA ANALYSIS | 47 |
| 5. HYPOTHESES GENERATED FROM THE PILOT STUDY | 50 |

| | |
|---|-----|
| HYPOTHESES RELATED TO FOREST PLANNING | 51 |
| HYPOTHESES NOT RELATED TO FOREST PLANNING | 57 |
| 6. RESULTS | 59 |
| HYPOTHESES RELATED TO FOREST PLANNING | 59 |
| HYPOTHESES NOT RELATED TO FOREST PLANNING | 74 |
| NEW HYPOTHESES GENERATED FROM PRIMARY CASES | 77 |
| 7. FINDINGS | 84 |
| Appendices | |
| A. Original and Revised Interview Questions | 102 |
| B. Case Study Histories | 111 |
| C. Organization Profiles | 116 |
| Literature Cited | 122 |

CHAPTER 1

INTRODUCTION

Forest planning is a complex process that has evolved with historical trends and changes in technology. Geographic Information Systems (GIS) are an emerging technology that link attribute data with spatial location in a computer format. Some authors have suggested that GIS has the potential to change the character of forest planning (Russell 1978, Caulkins and Tomlinson 1977), but forest planners have been slow to implement GIS (Reisinger and Davis 1987, Reisinger 1989).

The objective of this study was to evaluate how organizations that own forest land integrate GIS into forest planning. Specific goals included:

1. Study the implementation of GIS-related technology in forest land planning by public and private land management organizations in northwestern America
 - a) Document existing applications;
 - b) Identify existing impediments to successful implementation; and
 - c) Suggest which impediments can be readily solved by future research and which will represent limitations to expansion of GIS application.
2. Study the different forest planning requirements and planning efforts in both U.S. and Canadian private

and public organizations.

This study is intended for managers, specifically resource managers who must decide whether to acquire GIS or how to implement GIS once acquired. The results should be useful to managers in two ways: first, the hypotheses generated from the data should give managers a general idea about the role of GIS in forest planning, implementation pitfalls, and GIS effectiveness. Second, managers should be able to find instructive situations within the experience of the participants.

THESIS ORGANIZATION

The research that supports this thesis was conducted using case study methodology; to a certain extent, the research methodology dictated the form of the final report. Since case study methodology is not a common technique in forestry research, an explanation of thesis organization is valuable. Forest Planning: Evolution and Current Status (Chapter 2), and Geographic Information Systems: A Description with Some Suggested Applications to Forest Planning (Chapter 3), serve as a literature review and introduction to, respectively, forest planning approaches and geographic information systems. Research Methods (Chapter 4): the title is self explanatory. Hypotheses Generated from the Pilot Study (Chapter 5), presents initial hypotheses generated from the data gathered during the pilot study which was conducted at Potlach Corporation. These

hypotheses help the investigator code and analyze the data gathered from the four primary cases. The results from the four primary cases, in the form of excerpts from interviews, are presented in Chapter 6. Findings (Chapter 7) organizes and analyzes the data, revises hypotheses, and brings them together into theory.

TERMINOLOGY

Analysis of the case study data was guided by Glaser and Strauss' The Discovery of Grounded Theory: Strategies for Qualitative Research. In accordance with grounded theory terminology, the term "hypothesis" is used to describe elements of theory generated from the data. During the course of data analysis, hypotheses are devised and the derived theories further evolve with the infusion of new data; the end result is an improved theory (set of hypotheses) that is neither "proved" nor "disproved". The use of the term "hypothesis" should, thus, not be confused with the statistician's use of the term, which connotes theory building by standardized hypotheses testing, and declaration that the theory has been proved or disproved.

CHAPTER 2

FOREST PLANNING: EVOLUTION AND CURRENT STATUS

INTRODUCTION

Forest planning has a bad reputation; the most visible strategic planning process, that of the U.S. Forest Service, is being assaulted on all sides. Fourteen years after the National Forest Management Act required plans for each national forest, only 94 of the 123 anticipated plans have been released. Of these 94, 92 have been appealed (Behan 1990). Few people understand the planning process, particularly the mathematical models that form the heart of the planning analysis (Johnson 1986, Bare and Field 1986).

Forest planning is a complex, multi-stage process. It consists not only of strategic planning (planning for the long-term management of a large area), but also includes site-specific tactical planning (deciding where and when a certain activity should take place), and, increasingly, "political planning" (planning for constraints imposed by legislation or public pressure). Planning techniques differ for the different levels of forest planning and between federal and state agencies, large industrial forest land owners, and small woodlot owners. To understand forest planning, one must delve into the history of land ownership, legal constraints, organizational objectives, technical advances, and, increasingly, public opinion.

THE ORIGINS OF FOREST PLANNING IN AMERICA: THE U.S. FOREST

SERVICE AND FOREST INDUSTRY

American Forest Planning Takes Root: 1898 to 1950

The U.S. Forest Service adopted European-style forest planning from its inception. When Gifford Pinchot began to manage the national forests in 1905, he required working plans for all timber sales. Pinchot's fundamentals of planning -- completing detailed inventories, monitoring conditions on the reserves, determining sustainable use levels, excluding use from specific areas to protect watershed and other resources -- permeated Forest Service planning for the next 60 years and were enacted into law during the 1970's (Wilkinson and Anderson 1987).

The American forest industry was, on the whole, slower to initiate forest planning. But 20th Century world events lent stability to what had been a nomadic industry. The economic boom following World War II resulted in what Duerr et. al (1979) labeled an "industrial forestry movement." Industry accelerated a pre-war program to acquire and permanently manage its own timber. As industry became a large landowner with an eye toward the future, forest planning became a wide-spread industry concern.

The post-war years were a watershed for both public and private American forestry. A construction boom demanded plywood and lumber at almost a threefold increase over pre-war levels (Wilkinson and Anderson 1987). At the same time, the post-war economic boom had created an increasingly

affluent society with leisure time to enjoy that affluence. Recreation visits to national forests increased from 26 million in 1950 to 81.5 million in 1959 (Wilkinson and Anderson 1987). The increased demands for forest products, and the conflicts that arose from those demands, led to new legal requirements for forest management and planning on federal, state, and private lands.

Legal Constraints on Forest Management and Planning: 1960 to Present

Planning on Federal Lands

Passage of the Multiple Use Sustained Yield Act (MUSY) of 1960 marked the beginning of legislative control over federal forest planning. Assaulted from different segments of the public demanding both recreation and wood products from the national forests, the Forest Service had gone to Congress for legal help; agency personnel drafted the bill which mandated that range, water, wildlife and recreation be given equal "consideration" as timber in forest planning.

Continued controversies over federal forest land management led to further legislative reform (Behan 1981). The Resources Planning Act (RPA) of 1974 provided the Forest Service with planning regulations at the national level. The RPA was amended in 1976 by the National Forest Management Act (NFMA) which deals comprehensively with local forest planning. NFMA regulations, completed in 1982, required

each forest to complete a plan and established a ten-step process for developing those plans. The regulations detail how to determine the locations and amount of timber that can be harvested, and state planning requirements for each resource (Wilkinson and Anderson 1987, Coggins and Wilkinson 1986).

Planning on State Lands

A main purpose of the RPA was to provide states with the most recent data on forest resources as a basis for judging timber management programs. In 1978, the Committee of State Foresters encouraged states to adopt forest resource planning programs as a means of producing data for RPA surveys and providing a framework for budgets and grant programs. By 1981, forty-seven states were participating in forest resource planning (Robbins 1985).

Planning on Private Lands

Seventy-five percent of commercial forest lands in the United States are in private hands (Sedjo 1983). Fear of resource shortages and environmental consequences has led to planning regulation on these private lands.

By 1973, 16 states had some form of forest practices act to constrain forest management on private lands. In the Rocky Mountain-Pacific region, only Colorado, Wyoming, and Montana have no such law. All forest practices acts require some form of timber harvest plan (Huck 1977). In California, for example, the timber harvest plan must:

describe silvicultural methods to be used for harvest, indicate regeneration methods, outline methods to prevent excessive erosion, and identify provisions needed to protect "unique" resources in the area of timber operations (Vaux 1983). Planning is also required on private lands by mining regulations, reclamation enforcement, water rights allocation, and control of pesticide use (McQuillan 1977).

Planning on private and state lands, in spite of these legal constraints, is much less structured than on federal lands. Most large industrial owners use a mathematical model to arrive at a sustained yield cut level, but do not attempt to write all-encompassing, Forest Service-type plans. And while the public can be involved in local forest practices issues on private and state lands, there are generally fewer avenues for public input when compared to federal lands.

THE EVOLUTION OF PLANNING IDEAS AND MODELS

Planning for Biological Objectives: 1898 to 1960

Most forest planning efforts prior to 1960 concentrated on timber and aimed at achieving a fully regulated forest based on the concept of "normal" stocking (Thompson 1966). For over 60 years, simple formulas such as Hanzlick's formula were used to calculate allowable cut; these were the first efforts at strategic (long-term) planning that put mathematical models at the heart of the process. Site-specific scheduling (tactical planning) decisions were made

in the field by experienced foresters. In these early days, there was no yawning gap between strategic and tactical planning. Timber, and the desired structure of the forest, was the prime objective for both public and private foresters; all other resources were secondary.

Planning for Economic Objectives: 1960 to Present

By 1960, with increased demand for wood, the development of new mathematical modeling techniques, and the introduction of the digital computer, foresters began to re-think the traditional forest model. Economic benefit, rather than maximum biological production, came to be the new objective of forest management. Nelson and Bennett (1965) stated:

the concept of normality has plagued foresters for many years...insofar as normality is a concept peculiar to biological considerations, it has no meaning when management and economic considerations enter the decision.

One of the guiding forces behind criticism of the traditional model was the means to develop a new model: the principles of operations research (OR) were developed during World War II to provide managers with a quantitative basis for making strategic and tactical decisions (Kittel 1947). Linear programming (LP) was, at that time, the most widely used OR technique. LP seeks to optimize a single linear objective function subject to a set of linear constraints (Bare and Field 1986; Winston 1987; Anderson et. al. 1985).

The first uses of LP in forestry were suggested in the late 1950's for specific problems such as plywood and newsprint productions (Bethel and Harrel 1957, Paull 1956). Curtis (1962) produced the first LP model for harvest scheduling on a forest property, but it saw limited use. In 1968, Clutter and others developed an LP-based forest planning model called MAX MILLION; by 1971, over 10 million acres of industrial forest land in the south were being managed using the MAX MILLION model (Ware and Clutter 1971). It is important to note that, in the MAX MILLION formulation, the land allocation question was decided before the model was constructed. The model addresses only the scheduling question.

After MAX MILLION, new models continued to be developed to plan harvest scheduling and calculate allowable cut based on economic criteria. In addition to LP, goal programming, binary search, simulation models, dynamic programming, control theory, inventory theory, integer programming and quadratic programming were applied to forestry (Bell 1977, Schuler et. al. 1977, Field 1977, Bare and Field 1986).

By the 1980's, most large industrial owners and public agencies that harvested timber were using computer-based calculation procedures to set sustainable harvest levels. Most had adopted either binary search or linear programming models for this job (Johnson and Tedder 1983). While these model formulations have different strengths and weaknesses

(Johnson and Tedder 1983), when used correctly, they both seem to do an adequate job in answering the question "How much timber can be cut from a forest property on a sustainable basis?" (McQuillan 1990). Adaptation of mathematical modeling techniques and development of the digital computer changed the character of strategic forest planning -- it brought forest planning out of the woods and into the office. It also created a chasm between strategic planning and tactical planning, since most tactical planning is completed by experienced foresters without the assistance of quantitative models.

There have been several efforts made to improve tactical planning through modeling. McQuillan (1985) developed ALGOR, a network-theory based model that determines which additions to a transportation network can be logically made in order to efficiently expand the operable stock of timber. Sessions and Guanda (1987) developed methods and microcomputer programs to minimize the sum of roading and skidding costs in planning timber harvests. Jones et al. (1986) tested four techniques for performing "area-level" analysis; that is, designing a plan to manage geographically contiguous land areas 5000 to 50000 acres in size. Jackson (1983) outlined modeling approaches that would allow determination of operable timber stocks in a multiple-resource context. These efforts have not been widely adopted, however, and to this day, the ties between

strategic planning and tactical planning remain nebulous.

Planning for Multiple Use Objectives in the Forest Service: 1960 to Present

Forest Service strategic planning, with the legislated dictate of multiple-use planning and the succeeding legislation mandating forest planning, has become much more complex than forest planning as practiced by other agencies and organizations. The Forest Service responded to planning legislation by developing a series of strategic planning models, each with broader capabilities than the previous model, progressing from Timber-RAM (Navon 1971), through MUSYC (Johnson and Jones 1979), FORPLAN, version 1 (Johnson 1986), and FORPLAN, version 2 (Johnson, et al. 1986). The first rounds of forest plans required by NFMA were a hodgepodge of analysis based on FORPLAN, version 1, FORPLAN, version 2, or some combination of the two. But the essential nature of FORPLAN is common to both versions.

Forest plans written by the Forest Service under the auspices of NFMA are the most visible example of strategic forest planning. Loose (1990) states:

The forest plan is the first level of a two-level decision-making process, the second level being the actual project for activity decision.

FORPLAN is used to conduct the mathematical analysis to develop a range of strategic options from which a manager can choose while developing a forest plan. But strategic

planning involves constraints and decisions, such as land swaps and public access, that FORPLAN cannot analyze. A FORPLAN model is thus only a part of the strategic forest planning process, only a tool used to help develop a forest plan.

Forest Service plans tend to be unwieldy documents: for example, the Bridger-Teton Forest Plan, which includes a Record of Decision, a Final Environmental Impact Statement Summary, a Land and Resource Management Plan, separate maps showing land allocation under each alternative, a Final Environmental Impact Statement, and Appendices for the EIS, weighs in at more than ten pounds and covers 1700+ pages. It is not atypical.

CRITICISM OF FOREST SERVICE PLANNING

Criticism of Forest Service planning is ubiquitous. "The process is impossible to administer and exorbitantly expensive" (Behan 1990). Barber and Rodman (1990) assert: "When forest planning was institutionalized as a process, product and performance were de-emphasized." O'toole (1983) feels that the Forest Service has reached the level of "total unintelligibility" in planning. Clary (1986) writes:

[NFMA] launched an enormously detailed and complex planning process which involved the eternal generation of turgid documents to be reviewed and revised forever.

Criticism generally falls into one of three categories: problems with the planning process; problems with the models

the Forest Service uses to help complete forest plans, and problems with the way the models are used. Examining criticism of the Forest Service planning process helps one to understand the complexity of forest planning in general and to recognize pitfalls in strategic forest planning.

Problems With the Planning Process

Force and McLaughlin (1982) argue that no conscious effort was made to adopt an overall planning philosophy and/or theory of planning which would be most appropriate to federal forest planning; indeed, legislation, forester training, the rapid transition from functional planning to comprehensive forest planning, and emerging technologies naturally led forest planners into a "technique approach" which emphasizes technological thinking in planning.

Miller (1985) describes technological thinking as:

A way of thinking that assumes a primary role for the factual and technical information, as well as technical experts, in environmental decision-making and policy development.

But certain problems may not be solvable by any means, let alone the technological approach. Miller (1985) and Allen and Gould (1986) argue that forest planning on public lands is a "wicked" problem: the solutions are good and bad rather than true and false, their validity cannot be tested objectively. In dealing with wicked problems in the environment, technological thinking establishes a narrow perspective on the problem at hand and leads to a

preoccupation with data generation at the expense of conceptual insight (Miller 1985).

Limitations of the Model

Models are an abstraction of reality; any mathematical model has inherent assumptions and LP is no exception. Linear programming requires the assumptions of proportionality (changes in activities proportionally affect outputs), additivity (the activities must be independent; the sum of the outputs of the individual activities will equal the output if these activities are combined), divisibility (all the activities or variables in the problem can be divided into smaller parts), and certainty (all coefficients in the objective function and constraints are deterministic) (Winston 1987, Anderson et. al. 1985, Bell 1977). Each of these assumptions is almost certainly violated in every FORPLAN run (Bare and Field 1986, Shugart and Gilbert 1986, Cortner and Schweitzer 1983). The extent of these violations, and their affect on the model solutions, are virtually impossible to measure.

Another criticism is that FORPLAN, like other LP-based models, has difficulty allocating activities spatially. This widens the gap between strategic forest planning and tactical forest planning. When modeling a forest, it is often more important how an activity is laid out than how many acres are involved, especially when considering water,

wildlife, fish, and aesthetics. FORPLAN, especially version 2, has attempted to deal with this problem. Within the practical limits of LP, however, only a small number of the possible spatial layouts can be considered; otherwise, the model can quickly become too large to solve.

Criticism With Use of the Model

Barber and Rodman (1990) state:

Most of FORPLAN's shortcomings are not technical; they are problems of institutional bias, lack of analytical rigor, personal advocacy, and unrealistic expectations.

FORPLAN does not "spit out" a forest plan; it is merely a tool to help meet the legal requirements of Forest Service planning. But Barber and Rodman (1990) conclude:

the model often ended up in the wrong hands, solving the wrong problems, for the wrong reasons, and thus led to great disappointment in its results.

FORPLAN models tend to be large and complex. Size generates the illusion of refinement and that uncertainty is being reduced. But FORPLAN models were so large and time-consuming to build, planners had little time to analyze the results (Johnson 1986).

Multiple-use forest planning is in itself complex, but the Forest Service compounded the problem by trying to simultaneously solve two problems of forest planning: land allocation and harvest scheduling. They may have taken on too much. McQuillan (1990) states:

The forestry profession has not developed an acceptable methodology for allocating forest land under often mutually exclusive uses. Faced with this void, and the need to plan under the NFMA, the Forest Service implemented a process which simultaneously answers the allocation question and the scheduling question. Trying to find an answer to these two questions at the same time confounds and obfuscates the problem and confuses the public.

Perhaps Congress demanded too much; perhaps the Forest Service succumbed to a hubristic belief that mathematical modeling could solve all its problems; perhaps their vision of forest planning is merely an early evolutionary stage with a bright future. As it stands, no one is happy with the Forest Service planning process.

CONCLUSION

The Forest Service follows the most complex strategic forest planning process in America, thus the differences between planning on national forest and other lands, particularly forest industry lands, are salient. For industry, planning issues are simpler. They focus on timber and economics, so the objectives are well defined. By law, the Forest Service must treat all resources -- timber, wildlife, range, water, and recreation -- equally; their planning objective is an utilitarian ideal of "highest net public benefit." The compounding factors of planning for all resources and the nebulous objective confound the planning process.

The Forest Service feels the pressure of intense public involvement, most often from interest groups that do not

agree on the "highest and best use" of the forest.

Successful planning must be a consensus-building process, but the government is feeble at allocating losses (Thurow 1980). Not everyone is going to be happy with the results of forest plans; those that are not can derail the process with an administrative appeal or lawsuit.

Industry, too, feels the increasing force of public involvement (Mott and Peters 1986). The involvement, however, typically comes into play at the implementation of a particular project rather than at the strategic level. Conflict resolution can be handled locally, and since it is specific, more easily. Mitigating a particular project is much easier than mitigating a broad goal.

Finally, industry is not legally bound to its plans. The plans are often viewed as a broad guide, not as a specific regulation to be followed to the letter (Newbury, pers. comm.). Forest Service plans, when approved, become legal documents that can be challenged administratively and in court.

So what is forest planning in 1990? That depends on one's perspective: state foresters, private foresters or federal foresters see it differently.

However, some important general points about forest planning are:

1. Forest planning is not a cookbook activity; even the Forest Service, with the most rigid planning requirements, does not have a planning handbook that covers all aspects of creating a forest plan. For

other forest landowners, planning differs depending on ownership, objectives, and legal requirements.

2. Forest planning has evolved with the development of new technology and ideas. It is not easy to understand what forest planning is today, or project what it will be in the future, without some historical perspective. Forest planning is a dynamic process which changes as new techniques and technologies become available and as societal value systems evolve.

3. Forest planning has, at times, been similar on Forest Service and private lands, but is not today. Both use computer-based mathematical models to achieve certain planning goals, but Forest Service planning goes far beyond planning on other lands in terms of complexity. While forest planning has employed hundreds of people and supplanted other programs as the highest-cost item in the Forest Service, many private companies do not even employ anyone with the title "forest planner."

4. When considering forest planning, there is reason to use the Forest Service method as a point of departure for discussion. Forest Service planning is complicated, rigid, legally mandated, and mired in controversy. The Forest Service has put more effort into forest planning than any other agency or organization. With all the controversy and disillusionment, Forest Service planning has sparked debate over what forest planning should be. Not all the results have been negative.

5. Forest planning encompasses at least three different but overlapping levels: strategic planning, tactical planning, and "political planning." The chasm between strategic planning (long-term, goal-oriented planning) and tactical planning (short-term, project specific planning) is broad, especially since the advent of computer-based strategic planning models. "Political planning" is a more recent addition to forest planning based on outside pressures from legislation and public pressure.

Where does forest planning go from here? Some authors suggest that a computer-based system for manipulating spatial data called a Geographic Information System (GIS), will be the next technology to change the character of

forest planning. Chapter Three examines GIS, some of its potential and pitfalls, and its suggested role in forest planning.

CHAPTER 3

GEOGRAPHIC INFORMATION SYSTEMS: A DESCRIPTION WITH SOME SUGGESTED APPLICATIONS TO FOREST PLANNING

INTRODUCTION TO GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information Systems are computerized systems for collecting, manipulating, analyzing, and displaying spatial data (Robinson et. al. 1987, Cowan 1987, Clarke 1983). GIS is distinguished from other management information systems in its ability to address the geographic location of the data (Ozernoy et. al. 1981). GIS is distinguished from other types of computer graphics or computer-assisted cartography in its ability to create new databases, in essence, create new information based on existing data, rather than be limited to retrieving previously stored information (Cowan 1987, Parker 1987, Parent and Church 1987). A GIS could be non-computerized, but non-computerized systems are essentially worthless for large areas containing many discernible units (Richards and Eiber 1985).

The GIS user community is diverse: foresters, geographers, hydrologists, engineers, municipal governments, and academic researchers all use GIS in their work. The common ground is spatially referenced data. GIS users deal with attributes of a specific area on the earth's surface. Applications require the reduction of these different layers of data into new information that can be used in management.

How GIS works

In a GIS, spatial information is converted from analog to digital form and stored in two-dimensional space. Conceptually, a GIS database is a set of layers registered to a common reference point; each layer represents a different type of thematic information (Friedl, et al. 1988). Because each cell in a plane can hold only one character, different geographic attributes are represented by a separate set of "overlays" or "layers." These layers are essentially a set of "floating maps," with common control points that allow the user to look down and across the stack of maps (Berry 1986). Non-spatial attributes associated with geographic areas in each layer are stored using database management software. Manipulation of these layers, and the associated non-spatial attributes, is the emphasis of GIS operations.

Digital elevation models (DEM -- also called digital terrain models) are incorporated into GIS to effectively represent and use information about continually varying surfaces (e.g. elevation) (Twito et al. 1987, Burrough 1986). DEMs provide the planular data sets with a digital representation of the third dimension. By replacing elevation with any other continuously varying attribute, DEMs can represent surfaces of data such as travel time, costs, population, and levels of pollution.

When GIS incorporates a DEM, the product is a powerful,

three-dimensional analysis tool. Analysis is still essentially static at this point though; temporal changes in the resource cannot be represented. Computer-based mathematical models are linked to GIS software to achieve dynamic analysis. The University of Montana GIS, for instance, will incorporate several models into its GIS, including: PROGNOSIS and SPS (timber growth models), PSIRIS (a road optimization model), WATSIM (a sediment yield model), FIBERPLAN (a model to track timber inventory over time), and MTVEST (an investment analysis model) (Zuuring, per. comm.). GIS with linked models have been distinguished with terms like Integrated Resource Information Systems (Zuuring, pers. comm.) and Integrated Spatial Information Systems (Dahlberg and Jensen 1986).

Components of a GIS

Geographic Information Systems have two primary components: computer hardware and sets of application software modules.

The hardware consists of a computer (CPU) with a keyboard, disk and tape drive devices, video terminal, digitizer or scanner, printer, and plotter. The CPU is linked to the disk drive, which provides storage space for data and programs. The digitizer or scanner is used to convert analog map data into digital form and send it to the computer. A plotter, or printer, is used to present

results, and the tape drive stores data or software on magnetic tape. Finally, the video terminal is used to control the system and preview output (Burrough 1986).

There are five basic software modules which are used for:

- (a) data input and verification;
- (b) data storage and data-base management;
- (c) data output and verification;
- (d) data transformation;
- (e) user interaction (Burrough 1986).

The data input module transforms data from maps, field observations, and sensors (e.g. aerial photographs, satellites, and recording instruments) into digital form. The data storage/data-base management module deals with the position, linkages, and attributes of spatial information. Data and analysis results are displayed by the data output and presentation module. Results can be presented as maps, tables, and figures (Burroughs 1986).

The data transformation module performs two operations: it removes errors in the data or brings the data up to date, and, it applies analysis methods to the data to answer user queries. Finally, the user interaction module is essential for acceptance and use of any information system; generally, English-like command languages or menu-driven command systems are employed by GIS.

Several authors include organization, or "warmware," as

an important GIS component (Burrough 1986, Richards and Eiber 1985, Smith and Prisley 1987). Clearly, the organizational context must be considered when implementing a GIS; it is not sufficient for an organization to purchase the equipment and software, hire one or two enthusiasts, and expect satisfying results.

Early versions of GIS required minicomputers, such as the PDP 11/70 and the VAX system. PC based systems are now available, but these have proven to be limited in their ability to handle large volumes of data. Vendors have now joined the hardware: their systems can be used in a PC mode for data loading, while providing a mainframe solution for processing large volumes of maps and geo-referenced resource information. PC-based systems can also be connected through a network (Hegyí 1989, Kussie 1988).

GIS Products

Geographic Information Systems produce documents (either lists of data or graphics) that the planner or manager can use (Caulkins and Tomlinson 1977). Thematic maps, contour maps, viewsheds, reports tying attribute data to spatial information, and reports detailing the results of dynamic modeling can all be produced by a GIS.

Burrough (1986) poses several questions a GIS can answer more easily than can conventional spatial analysis:

- (a) Where is object a?

- (b) Where is A in relationship to place B?
- (c) How many occurrences of type A are there within distance D of B?
- (d) How large is B (area, perimeter, count of inclusions)?
- (e) What is the value of function Z at position X?
- (f) What is the result of intersecting various kinds of spatial data?
- (g) What is the path of least cost, resistance, or distance along the ground from X to Y along pathway P?
- (h) What is at points X1, X2?
- (i) What objects are next to objects having certain combinations of attributes?
- (j) Using the digital database as a model of the real world, simulate the effect of process P over time T for a given scenario S.

GIS DEVELOPMENT

During the 1960's, in response to the need for evaluating resources in an integrated, interdisciplinary way, new trends arose in the way maps were being used for resource assessment and planning. Planners realized that, in principle, data from several monodisciplinary maps could be combined and integrated simply by overlaying transparent copies on a light table. One of the best known exponents of this technique was landscape architect Ian McHarg (McHarg

1969).

Printed maps, however, were problematic. The printed map is a static, qualitative document: once the data have been put on the map, it is not easy or cheap to retrieve them to combine with other spatial data. Extraction of a single theme of data can be prohibitively expensive if the map must be redrawn by hand (Burrough 1986).

GIS technology has its origins in thematic mapping (Parent and Church 1987). The first developments in appropriate mathematics for spatial problems began to appear in the 1930's and 1940's, paralleling developments in statistics and time-series analysis. Only since the 1960's, with the widespread availability of the digital computer, have both the conceptual methods and the actual possibilities for quantitative thematic mapping and spatial analysis been able to blossom (Burrough 1986).

Geographic Information Systems were initially developed by private companies and educational institutions. By the mid-1970's, the field was lucrative enough to attract a few vendors offering systems of varying quality. The vendor/user relationship became a self-fueling fire: as more organizations began using GIS, it became better and more affordable. Vendors produced and advertised systems; users found more and varied uses, providing vendors with feedback to improve and sell more systems. Computer prices fell as technology improved; systems became more affordable. By

1989, over 100 vendors produced GIS. Most GIS users turned to vendors for commercial systems rather than build systems in-house (Ferguson 1989).

The road from computerized maps to fully functional GIS has not always been smooth. Vendors made promises they could not deliver. For example, they often used small data bases to demonstrate their GIS; when organizations tried to apply the system to large databases, hardware and software were overloaded (Hegyi 1989). Product support and longevity was questionable for many vendors; the pursuit of increasing the installed base superseded user support efforts (Ferguson 1989). To survive in a competitive industry, GIS vendors produced generic products; individual users had to develop applications suitable to their own requirements (Reimer 1989).

Still, GIS has advanced in the last ten years. GIS packages are commercially available and affordable; GIS use has been pioneered by a wide range of resource specialists. GIS is presently an emerging technology with potential and pitfalls.

GIS PITFALLS

GIS systems appear to be an exceptional forest land planning tool: they combine layers of spatial data to create maps quickly and efficiently; they are capable of site-specific resolution and of performing analysis which is

difficult by conventional methods; they incorporate powerful analysis, and they can link mathematical models to predict temporal changes in the resource.

In spite of the recognized potential, forest land planners have been slow to implement GIS for long-range planning (Reisinger and Davis 1987, Reisinger 1989). There are several reasons for the delay. Implementing GIS requires a huge initial investment, both in money to purchase equipment and in time and manpower to digitize maps, build a database, and develop customized reporting (Reisinger and Davis 1987, Devine and Field 1986). Software packages range from \$100 to \$50,000 for micro-based systems (Zuuring, pers. comm.). The cost of keeping data current can quickly outstrip the initial investment (Devine and Field 1986). A lack of in-house expertise and added duties piled on already overburdened personnel have also slowed GIS use (Robinson et. al. 1987). In a survey of 18 forest industry companies, Reisinger (1989) found that only 5 rated their GIS as "fully integrated" into the management information environment of the company's operation; these companies had an average of 9.6 years of experience with GIS.

Management can impede implementation. Technological development is occurring so rapidly that it outstrips the ability of managers to keep pace (Burrough 1986, Antenucci 1989). Hegyi (1989) estimates the optimal lifespan of GIS is

currently 3 to 5 years. Structural changes in workflow are often necessary to utilize a GIS (Burrough 1986, Smith and Prisley 1987). Some managers are unsure of their needs, and thus unsure of the ability of a GIS to fill them (Hultquist and Scriptor 1987, Reimer 1989). Cost/benefit analysis is difficult with GIS: many of the costs are incurred after the GIS package is purchased, in digitizing and system maintenance, so the costs are difficult to determine. The benefits are even more difficult to determine. In fact, benefits are often not recognized until the system is in place (Couch 1989).

Problems with GIS technology discourage some potential users. Variation in data collection accuracy and human error while digitizing lead to inaccurately coded data; as this data is used to create new information, the errors accumulate (Ottawa 1987). Walsh et. al. (1987) reported errors of 13 to 29% when two or more layers were combined in slope-aspect and soil data maps. Data errors can lead to wrong decisions with serious consequences.

GIS is an evolving technology, thus there is no common data structure. Information sharing is often impossible and data can become obsolete when new software is acquired (Hultquist and Scriptor 1987). The sheer volume of data required by GIS could make restructuring a database cost prohibitive.

Finally, modeling uncertainty adds to the confusion.

Many spatial relationships are not adequately quantified (Berry 1987). Traditional statistical procedures are not adequate for spatial data; GIS provides the means for rigorous spatial analysis, but some higher level analysis techniques are still lacking development (Berry 1987).

According to Reisinger (1989) to successfully integrate GIS into forestry operations requires:

1. a long-term commitment of several years;
2. financial commitment for GIS development personnel and the hardware/software configuration capable of sophisticated analysis; and
3. management commitment, at all levels, to using the GIS system.

Smith and Prisly (1989) add:

considerations such as personnel, control, coordination and allocation of resources may determine the usefulness of a GIS more than the number of layers of data it can handle.

CURRENT APPLICATIONS OF GIS TO PLANNING

By the 1970's, managers had realized the potential for applying GIS to improve the forest land planning process (Russel 1978, Caulkins and Tomlinson 1977). The technical difficulties, however, were daunting. Devine and Tucker (1986) described an early effort to integrate GIS with forest planning at North Carolina State University:

Our original intention...was to simply experiment with some new computer mapping procedures in a forest

planning context and then to move on to the construction of more sophisticated mathematical models that would employ these new procedures. However, the use of GIS itself was found to be so difficult that our research shifted to focus on better GIS applications development.

GIS has since been applied to forest planning, though the systems described seem to be more prototypes than fully functional planning tools. Reisinger (1989) reports that relatively few companies are using GIS as a tool for making operational and long-range planning decisions. Designing models that can be efficiently implemented, allowing extensive use without requiring enormous amounts of computer resources, is not a simple problem (Hermansen 1989). Still, several applications bear mention.

Dippon et. al. (1989) describe GIS-based strategic planning on 2.4 million acres of BLM land in western Oregon. The planning strategy breaks from traditional planning models; it depends on the availability of spatial and relational data to evaluate spatially oriented natural resource management policies. The system uses GIS to calculate operational inventory acreage for alternative management scenarios. When the Resource Management Plan is written, there is no attempt to determine analytical optimal land use allocation. The Resource Management Plan specifies goals for natural resource protection through spatially oriented prescriptions on the commercial timber base. After the timber base is defined, timber production is estimated

based on expected silvicultural treatments and biological potential.

The authors explain the strategy which they use to determine the preferred alternative:

The alternative management scenarios are defined, then the alternative which "best" meets the expectations of the political world in which the plans must be adopted will be adopted.

The system is not yet in use. The critical link -- joining the GIS data bases and harvest scheduling model -- does not currently exist. The software and procedures for this planning application are currently under development; at the same time, the data is being digitized. The authors mention no date when the system is expected to be operational.

Covington et. al. (1988) describe the Terrestrial Ecosystem Analysis and Modeling System (TEAMS), developed at Northern Arizona University. TEAMS is a GIS-based tactical, rather than strategic, planning model. It is designed to take the preferred alternative from a forest plan and develop site-specific management schedules.

The TEAMS authors joined commercially available software and a driver program that enables the user to produce an optimal, site specific treatment schedule. TEAMS consists of: R:Base 5000 (a relational database); CLOUT (database query system); ARC/INFO (a GIS); ECOSIM (a multiresource forest management simulation system); RANREC

(a program that calculates the economic consequences of recreation or range development); LINDO (a linear programming package); CHART (a graphics package); GRAPHS (a program that calculates the consequences of implementing the linear programming solution for input into CHART); and TABLES (a program that generates summary tables to complement the CHART output).

To use TEAMS, stand inventory is entered into R:Base 5000 and stand boundaries are digitized into ARC/INFO. Selected alternatives are simulated using ECOSIM; biological, physical, and economic yield tables are developed from simulation results. Users can also enter information on recreational alternatives and range options into R:Base 5000. RANREC then calculates cash flows and present net values.

After the data are entered, the problem structure is specified. The user can specify treatments for some or all stands, or use the TEAMS optimization function. If the optimization function is chosen, the user must decide on an objective function and set constraint levels. When the problem is set up, LINDO solves it. The optimal solution indicates the treatment alternative for each stand.

GRAPHS projects future yields of multiresource outputs, costs, and net benefits associated with implementing the optimal solution. ARC/INFO displays maps of current and future spatial arrangement of the management area.

The TEAMS system is being operationally tested at Northern Arizona University. It is currently used as a teaching aid, and being tested operationally on projects ranging from 2,500 to 20,000 acres.

Forest Service planners have used GIS to help develop forest plans in at least two instances. On the Nicolet National Forest in Wisconsin, planners used a GIS to tie FORPLAN solutions to the ground. While creating a FORPLAN model, planners assigned each stand an analysis area number. When FORPLAN arrived at an optimal solution, GIS displayed the stands matching the analysis area numbers in the solution. This visual display helped resource managers begin to design and schedule project plans (Stephen 1986).

In this case, GIS could not be applied forest-wide due to inadequate computer storage and memory. In addition, Stephen (1986) urges caution when using this approach: the Forest Plan, not FORPLAN, is to be implemented. FORPLAN is full of averages. A FORPLAN average acre may or may not be an acre of the forest. Perhaps more importantly, social and political constraints are decided outside the model and do not enter into the FORPLAN solution.

The Bridger-Teton National Forest in Wyoming also used GIS to help develop a forest plan. The final forest plan needed to be prepared quickly -- a court order placed the forest supervisor in contempt if plan deadlines weren't met -- and it had taken 3.5 years to complete the draft plan

maps using manual methods. Planners turned to GIS to complete the project in a timely fashion.

The mapping problem was not trivial. The Bridger-Teton covers 3.4 million acres, spanning 115 quadrangle maps. Digitizing alone would take months.

Consultants were hired to complete the digitizing. The actual analysis was also contracted out. As a first cut, physical factors -- soils, slope classes, landforms, and vegetation -- were combined in overlays to display lands "tentatively suitable" for timber harvest. Maps with the tentative timber base were constructed with GIS.

The maps were taken to a series of public meetings; interested parties were encouraged to attend the meetings and actually draw on the base maps. The information provided by the public input -- things such as historically significant areas and high-value hunting and scenic areas -- were incorporated as social and political constraints on the commodity base. The new boundaries, once agreed upon, were digitized. This new map became the basis for the tabular data needed to build FORPLAN models (Warrington 1988).

Now that the Bridger-Teton has started using GIS, other projects are in the works. Presently, oil and gas leases are being digitized; the finished maps will enable bidders to have site-specific information on the leases. The Bridger-Teton is also merging thematic mapper landsat data with GIS to build a vegetation classification system.

Ground truthing will begin in the summer of 1990. Finally, Bridger-Teton managers are merging GIS with the Global Positioning System to locate thematic mapper pixels on the ground. The landsat vegetation classes will be used in the next round of forest planning (Warrington, pers. comm.).

Other reported applications include: planning timber sales on the Tongass National Forest (Bobbe 1987); incorporating spotted owl habitat in forest land planning in Washington state (Young et al. 1987); scheduling timber harvest in the forest-products industry (Reisinger and Davis 1987); modeling recreational policy alternatives on the Hoosier National Forest (Gobster et al. 1987); and planning wildland fire prescriptions for the Forest Service (Bradshaw et al. 1987).

CONCLUSION

GIS has been hailed as the newest technology that will change the character of land management and forest planning. GIS workshops, conventions, journal articles, books, and classes are mushrooming.

At the present time, applications seem to be more theoretical than useful. GIS technology is changing rapidly; GIS is expensive, the data needs are enormous and digitizing data is time consuming.

Yet several forest land owners in northwest America have invested time and money into GIS. How do they plan to

use their systems? Is GIS currently, or will it be in the near future, useful in forest planning?

CHAPTER 4

RESEARCH METHODS

This study was conducted with case study methodology. Case studies, while rare in forestry related research, are a standard research tool for studying organizations, and are used frequently in conducting management-related research.

Case Study Research: Design and Methods by Yin (1984)

guided the research design. Yin explains:

In general, case studies are the preferred strategy when "how" or "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life concept.

Case study methodology was chosen over other research techniques to obtain more in-depth data. Yin states:

"How"...questions are more explanatory and likely to lead to the use of case studies...as the preferred research strategy. This is because such questions deal with operation links needing to be traced over time, rather than mere frequencies or indices.

Much of the information needed to complete this study was not available to the public; it comprised internal memos, progress reports, and other internal documentation. The predominant data, however, was the experience of the people involved in acquiring and implementing GIS for forestry applications. Yin again states:

The case study is preferred when examining contemporary events, but when the relevant behaviors cannot be manipulated. Thus, the case study relies on the same techniques as a history, but adds two sources of evidence...: direct observation and systematic interviewing.

This study was designed as a multiple-case study to compare and contrast different types of organizations. Yin writes:

The evidence from multiple-case studies is often considered more compelling, and the overall study is therefore regarded as being more robust [than single-case studies].

The disadvantages of a multiple-case study -- it requires extensive resources and time -- were more than offset by the additional data provided and the opportunity to investigate a wide variety of organizations.

Case study research is being accepted in such diverse fields as public administration, management sciences, sociology, psychology, anthropology, and education. But Yin cautions:

Regardless of the type of case study, investigators must exercise great care in designing and doing case studies, to overcome the traditional criticisms of the method.

Yin suggests two research design methods to ensure that a case study is conducted with high quality and managed smoothly:

1. Develop a study plan for the investigation, including an overview of the project, field procedures, case study questions, and a guide for the final report; and
2. Conduct a pilot case study. The pilot study helps develop the investigator's skills, and refines data collection techniques, both with respect to content of

the data and the procedures to be followed.

Subsequent sections show how both procedures were employed.

Yin also suggests several strategies to maximize the validity and reliability of the study. These include:

1. Use multiple sources of evidence;
2. Establish a chain of evidence;
3. Use replication logic for theory building in multiple case studies;
4. Follow a written study plan; and
5. Develop a case study data base.

These strategies were employed in this study and are described in subsequent sections.

STUDY DESIGN

The primary units of analysis for this study, or cases, were natural resource management organizations located in northwestern America. To be considered, an organization had to have acquired GIS at least 5 years before the study began in 1989. Reisinger (1989) found that, in a survey he conducted, the companies that indicated their GIS was fully integrated into the management information system had an average of 9.6 years of experience. In light of that finding, the investigator felt that a company needed at least 5 years of experience to be instructional.

The research was conducted in three distinct phases:

(a) a survey of GIS users, consultants, and vendors; (b) a design phase, in which the case study framework was designed

and tested via a pilot study; and (c) selected case study analysis.

Phase I--Conducting the Initial Survey

The survey of GIS users, consultants and vendors served two purposes: it identified the population of organizations which met the criteria and key individuals within those organizations, and it helped devise a set of substantive questions with which to direct interviews.

The survey was conducted by telephone and in person to ensure an adequate and timely response. Most of the in-person interviews were completed at the GIS '89 conference in Vancouver, B.C., in March, 1989. The remainder of the interviews were either conducted by phone or in-person in Missoula, Montana.

The results of all these interviews were surprisingly similar. Only 7 forest land owning companies in northwest America met the criterion of using GIS for at least 5 years. These organizations include:

1. Simpson Timber (located in Shelton, Washington)
2. Murray Pacific (Tacoma, Washington)
3. Weyerhaeuser (GIS in Tacoma, Washington)
4. MacMillan Bloedel (Nanaimo, BC)
5. British Columbia Ministry of Forests (Victoria, BC)
6. Washington Department of Natural Resources (offices in Olympia, district offices throughout

Washington), and

7. Boise-Cascade (located in Boise, Idaho)

In addition to these seven, Potlach, in Lewiston, Idaho, had acquired GIS approximately 3 years before the study began, and had impressed many of Phase I informants with their design and use of the system.

Phase II--Conducting the Pilot Study

Phase II included two critical steps in completing the research: designing a set of questions to guide interviews, and conducting the pilot case study.

Before beginning the data collection, questions to help guide interviews were developed. Literature review, suggestions from participants in Phase I, and suggestions from committee members helped to develop the questions.

The questions comprised two distinct sets: one set for the organization's GIS expert and one for the manager/planner. Each question referenced a category important in GIS implementation and forest planning. During interviews, questions were used only as a guide. Participants often had information that did not fit into the question format; they were free to interject that information into the interview. At the end of each interview, the set of questions was reviewed to make sure that all pertinent topics had been covered.

A pilot case study was also conducted during Phase II.

The pilot case study "calibrates" the investigator; it helps the investigator refine both the content of the data collection and the procedure to collect the data. Potlach proved to be an excellent pilot case. Even though they did not meet the exact criteria established for primary cases, they had invested a lot of energy into their GIS and made great strides due to extensive research and planning for the system.

Potlach was also chosen for the pilot study for several reasons unrelated to the selection of the final cases. First, they were geographically convenient: Lewiston is less than 200 miles from Missoula. They also had extensive documentation: they routinely demonstrate their system. These are both valid reasons for choosing a pilot study as outlined by Yin (1984).

The Potlach interviews were conducted in April, 1989. Participants included Forest Economist Jim Newberry as the planning expert and both Steve Smith, Inventory Group Leader, and Systems Analyst Dennis Murphy as the GIS experts.

The interview questions were redesigned after the pilot study, based on information gained while conducting the pilot study and comments from committee members. The second set of questions improved the "flow" of the interviews, placed logically sequential categories together, was less repetitive, and better covered the categories. Both sets of

questions are presented in appendix A.

Phase III--Gathering the Data

Because of time and monetary limitations, the research was limited to 4 primary cases (in addition to the pilot case). Cases were chosen to maximize two types of obvious variance: between private and governmental organizations, and between U.S. and Canadian organizations.

The only two Canadian organizations comprised both a private and governmental organization; Washington DNR was the only American governmental organization. The last case was thus a choice between 4 private companies in the United States. Phase I participants indicated that Murray Pacific owned too little land to conduct intensive planning and that Weyerhaeuser guarded access to their in-house system; Boise-Cascade provided, in the parlance of two informants from Phase I, "an example of how not to do it". Thus Simpson Timber was chosen as the private company in the United States.

Within each organization, two types of people were interviewed: a GIS systems expert, and a manager/planner. The systems expert was defined as the person that made the system work; his primary job was to manipulate the system and produce results. The manager/planner was defined as an end user of the system; he may not know how the system works, but does know how the products are useful in his job.

These two types of people might have radically different views of how GIS worked within an organization, and of the system's utility. Interviewing two people within each organization also helped test for consistency.

All interviews were conducted between 22 May and 2 June, 1989, in this order: Simpson Timber, BC Ministry of Forests, MacMillan-Bloedel, and Washington DNR. Simpson Timber participants included Keith Simmons, Harvest Planning and Road Construction Supervisor (planning expert), and Forest Inventory Supervisor Paul Wing and Resource Biometrician Mike Naccarini (GIS experts). British Columbia Ministry of Forests participants included Timber Supply Forester Allen Prelusky (planning expert) and Remote Sensing Officer Raoul Wiart (GIS expert). Brad Whitehead, Coordinator of Information Services (GIS expert), and Inventory Section Manager Patrick MacDonell (planning expert) participated for MacMillan Bloedel. Washington DNR's representatives were Al Vaughan, GIS Coordinator (GIS expert) and George Flanigan, Hoh District Manager (planning expert). The sessions at all four cases resulted in approximately 15 hours of taped interviews. Transcriptions of the tapes totalled over 300 pages. Several internal and published documents were also provided by the participants and used as data in the research. Full case histories are presented in Appendix B. Organization profiles are presented in Appendix C.

DATA ANALYSIS

The Discovery of Grounded Theory: Strategies for Qualitative Research (Glaser and Strauss 1967) guided data analysis. Glaser and Strauss offer a rigorous and systematic method for analyzing qualitative data. The purpose of the grounded theory method is to generate theories, in the form of hypotheses, that are robust and fit the research data. Grounded theory is "theory derived from data and then illustrated by characteristic examples of data" (Glaser and Strauss 1967). As Glaser and Strauss explain:

This is an inductive method of theory development. To make theoretical sense of so much diversity in his data, the analyst is forced to develop ideas on a level of generality higher in conceptual abstraction than the qualitative material being analyzed. He is forced to bring out underlying uniformities and diversities, and to use more abstract concepts to account for differences in the data...

Glaser and Strauss recommend using the 'Constant Comparative Method of Qualitative Analysis' to generate theory and describe it thus:

The analyst starts by coding each incident in his data into as many categories of analysis as possible...While coding an incident for a category, compare it with previous incidents in the same or different groups...as the coding continues, the constant comparative units change from comparison of incident with incident to comparison of incident with properties of the category that resulted from the initial comparisons of incidents...[as this process continues], major modifications become fewer and fewer.

The analysis eventually reaches the point of clarifying

logic and taking out non-relevant properties of the theory. Theory thus generated provides relevant predictions, explanations, interpretations, and applications.

An excellent example of using case study methodology to develop theory is provided by Stephen Herrero, author of Bear Attacks: Their Causes and Avoidance (Herrero 1985). In this book, Herrero generates theory concerning the causes of bear attacks and how to avoid or survive such attacks. He began his research by collecting all known cases of human-bear encounters. He then began analyzing the cases to pull out common circumstances, and began to develop theory from the common circumstances. For example, one theory was that when a human is attacked by a grizzly bear, the best survival strategy is to "play dead." As he developed the theory, Herrero continued to analyze cases, comparing the particulars of the case with the developing theory, noting both confirming and disconfirming evidence, modifying the theory to better fit the data. Hence, the original theory was further developed to state that "playing dead" is a good survival strategy when the attack is a "sudden encounter" with a grizzly bear, but fighting is the best survival strategy when one is pulled from a tent by a grizzly bear. As he continued to analyze cases and compare them to the developing theory, Herrero modified his theory until it was robust and fit the data. The final version of the theory, illustrated with specific incidents from the cases, not only

explains the cases under study but also predicts what the best survival strategy will be during a human-bear encounter.

In the present study, data from the pilot study was first used to generate the original hypotheses. The number of cases used to generate theory is not crucial, especially when the theory is to be refined using data from other cases (Glaser and Strauss 1967). The hypotheses developed from the pilot study guided coding and classifying data from the 4 primary cases. Hypotheses generated from the pilot study are presented in Chapter 5.

Using the hypotheses generated from the pilot study as a guide, data from the 4 primary cases was then coded and classified using the Constant Comparative Method. The results are presented in Chapter 6. No attempt has been made at this point to refine the hypotheses; only clarifying examples of data are presented.

In Chapter 7, the data are organized and analyzed, and hypotheses are revised and brought together into theory. The final version of the hypotheses, based on the data, are presented in this chapter and then clarified with relevant examples of the data.

CHAPTER 5

HYPOTHESES GENERATED FROM THE PILOT STUDY

Potlach Corporation began redesigning its forest inventory system in 1979, completing the evolution from a Continuous Forest Inventory (CFI) through a unit inventory (a point-sampling scheme) to an in-place, stand-based inventory. The new inventory system created a need for stand maps as well as acreage information and associated attribute data. The complexity of the new inventory was magnitudes higher than the older inventories: A computer-based system that linked spatial information with attribute data was needed to handle the large amounts of information. No such system was available at that time, however, nor was Potlach ready for one. They had to first build the data structure, collect data, and link models to the system.

They spent nearly 7 years designing the inventory system. By 1986, they were ready to acquire the commercially available ARC/INFO (Environmental Systems Research Institute, Inc.) software package.

Inventory Group Leader Steve Smith downplays the role of GIS in the Potlach system:

In our system, GIS doesn't mean anything to anybody. Yes, we have graphics capabilities. Yes, we have a digital map database. Yes, we can integrate the two. But you don't see the word GIS here: We are looking at a system. GIS is invisible in the system. So when you talk about GIS it is kind of hitting a raw nerve because we don't really have GIS here. It is all behind the scenes.

Potlach's step-wise, methodical inventory design led to well-defined requirements for acquisition and use of a GIS software package. Thus they are an excellent source from which to build hypotheses concerning the usefulness and implementation of GIS in forest planning. The hypotheses generated by the pilot study will be tested using information from the other 4 cases.

HYPOTHESES RELATED TO FOREST PLANNING

1. *GIS is more readily implementable for tactical rather than strategic planning (i.e., the benefits of a GIS are more immediate for tactical planning).*

Forest economist Jim Newberry thinks GIS is more useful for tactical rather than strategic planning:

I think right now the GIS could be used more in tactical planning than in terms of strategic planning. I don't see in terms of strategic planning that we are using it that much. But in terms of tactical planning, our foresters use maps and ask questions about where certain types of stands are and things like that. With those things, GIS is great. GIS makes those types of things easier to do.

There are several reasons why GIS is more readily implementable in tactical planning.

- a. *Strategic plans are often not concrete.*

Newberry states:

The specifics of our plan often don't mean a whole

lot. It is the intent rather than the letter of the plan that gets implemented.

Potlach uses a team approach to strategic planning. The team, which includes the research director, forest economist, logging supervisor from each district, head forester and district foresters, establishes general guidelines that are passed off to operations people.

b. Attempting to be site-specific on a strategic plan would pose data storage and retrieval problems.

Newberry would like to be specific enough in the strategic plan to map stands and set prescriptions for a given piece of ground. The combination of treatments in the strategic plan, however, makes the data set too big. Potlach now has approximately one-half million records for the total ownership. He states:

If you want to talk about doing anything interactive with one-half million records you need to have your head examined.

c. The links between GIS and strategic planning are not established.

The Potlach inventory is housed by stands; the strategic plan is based on homogeneous, non-contiguous planning units. A planner could spatially link the strategic plan by plotting a map of all the cuts by period, but linking to the GIS as an analytical tool is difficult. As Newberry says:

I don't see a real easy link between GIS and strategic planning. I can certainly envision what you might do but doing it easily is another thing entirely.

Tactical planning, in contrast, can now be done on-line. District foresters can use the GIS to produce scenario maps that were done with a xerox machine and colored pencils in the past.

d. Planners do not envision GIS as a strategic planning tool.

Newberry remembers anticipating the ARC/INFO software:

I don't think I even thought of [GIS] as a planner. I think I thought of it as an inventory tool. I think we saw it as a tool that could tie inventory, cruising and things like that into the system.

e. Sophisticated models, particularly those used in strategic planning, require large amounts of time to integrate into the system and are often a low priority.

Smith describes the Potlach system as a pyramid:

We've got some cornerstone applications. The resource database and the map database are at the bottom of the pyramid and it took us eight years of work to design and build and implement what we call our resource data base. And that was kind of totally independent of GIS. The map database probably took us three years. And two of those years were before we even had the system. Those two things [the resource database and the map database] are essential to making anything happen.

On top of that we started to build some of our specialized databases. Our woodlands applications; technical applications like land records. And those things become the next base level of things. You can't do logging budgeting until you have harvest planning

and update figured out.

And on top of that you have the very highest level of things like the strategic planning which frankly we have not implemented yet. We are still working [on that].

Systems Analyst Dennis Murphy adds:

The applications development is a really long process for each one of these applications. And everyone of them has their own unusual quirks and their own data that needs to be updated and maintained.

2. GIS is more accessible at the tactical planning rather than the strategic planning level in the organization.

The Potlach ARC/INFO software is housed on a Prime mini computer in Lewiston, Idaho, in the Inventory Systems Group of the Technical Services Department. Potlach currently has 27 terminals, about half of which are graphic, two digitizing stations, and two plotters.

The two woodlands divisions remote from Lewiston have terminals and data communications with the Lewiston office. But the system has not developed as an on-line clearing system where people sit down at the terminal and use the menus to get quick answers to complex questions. Smith gives an example:

Dennis has got a land agent using the land record system; it has a super menu interface and the first thing the guy wants is just can we get this on eight-and-a-half by 11 so I don't have to use the computer.

What we produced for him was essentially an atlas in a three ring binder. And it sits by his desk and he can use it anytime he wants to.

We [originally] expected 65% of the products would be electronic and 35% would be conventional. And it is about the opposite of that. We are producing about 20% electronic and about 80% conventional.

And that is really where we are headed with a lot of this stuff. That is a reality that we came to. People really don't want to use the system necessarily on an interactive basis. What they want is the answer and they want to use the system to get the answer for them.

Many of the applications the Potlach system supports are too time consuming to use on an interactive basis. Smith explains:

The real power and the real potential of the system is to be able to ask a complex question and then formulate the structure of the system commands in such a way to be able to answer [questions] and to work out the logistics of doing anything you want for the 2.2 million acres Potlach [administers]. It doesn't have to be interactive to work.

Since the Potlach GIS developed as part of the inventory system, it has close ties to the operational forestry side. Smith states:

We attempted to start at the grass roots level and build everything up from the bottom so that we still have the site specific detail to produce maps. [But] what started off as a very narrow specialized inventory function has grown into a resource information system that cuts across everything from tracking our research plots plus trees to automating the logging budgeting process.

3. GIS products are more readily usable in tactical rather than strategic planning.

Potlach produces a lot of maps on the system. They produced 1200 stand maps and have requests to map the other

4000 stands. They produced 1000 management block maps, and 1200 harvest plan maps, with orders for more. They produce the three-ring atlases for land agents. They also have 110 township maps and wall maps they want to produce.

They also support models linked to the system, including a growth model, stand appraisal and economic analysis package, a merchandiser package, and silvicultural prescriptions.

4. GIS has potential to help bridge the gap between strategic and tactical planning.

Smith and Murphy think GIS can help bridge the gap between strategic and tactical planning:

(Murphy): My impression of the way things work is that the linear programming [strategic] model ends up developing kind of the broad scheme of things for the long range. And then almost independent to that in the past the areas have developed a five year plan. And what the [strategic planning] team is trying to do is really bring those two things together and make it more of a two-stage process. But you know the mechanism to get there is to first have both processors use the same information.

(Smith): Right. They have exactly the same problem that we have always had between cruise and inventory; the tactical plan verses the strategic plan and those two things are oil and water. The guys say, 'here is our [tactical] plan and we developed this on our PC and here is your [strategic plan] and they are not the same. And so what--inventory is in the middle of all that and we can provide answers for both of them. We are supporting both [strategic and tactical planning]. They are getting the same data presented at a different scale. The data that goes into the [strategic plan] is the same data that goes into the [tactical plan]. We are using the same data so we can take the [strategic plan] harvest prescriptions and take the tactical plan harvest prescriptions and do a

map to compare the two. We've done that kind of stuff. So what I see is that the inventory system or resource data base is in the middle and what it does is kind of referee. It just helps standardize and lets them make real comparisons and maybe improve the process on both ends of it.

HYPOTHESES NOT RELATED TO FOREST PLANNING

1. GIS update and maintenance is a larger proportion of the workload than organizations originally conceive it will be.

System administration is a big part of the job, especially since Potlach went to quarterly updates. Smith estimates that between 25% to 75% of the staff is working on inventory updates at any point. But the update mechanism and the system administration are by far the most important part of any application. Nobody wants to use old data. The benefit is that the districts see the data more often and they see the changes that they make more often. And there is a lot more credibility in the data base on their side of it.

Smith states:

We thought that the application would kind of peak then drop off. But what we are finding is that applications are increasing indefinitely. And they are requiring more and more effort. The system administration keeps getting bigger and bigger and bigger.

Training is on-going and cuts into staff time. There have been three ARC/INFO software releases since Potlach bought the system; each one is so different it blows away the training from the previous one. Training occurs over the life of the system.

2.The greatest GIS limitations are related to personnel rather than technical matters.

Smith can not think of anything Potlach has been unable to do because of software limitations; the limits are primarily time and available people.

People limit the system's usefulness to themselves.

Smith and Murphy explain:

Implementation isn't hardware or software. Implementation is people. We tried to make this system happen in a way that makes the user want to have a vested interest in his database.

(Murphy): I think you can have all these components and if they don't fit into somebody's job they don't use it.

Some people do not really want to go through the learning curve to use the system or they do not have time. And some people are simply not "computer people." But the system can still help them do their jobs. According to Murphy, the trick is to make the system look like what they have been doing.

CHAPTER 6

RESULTS

HYPOTHESES RELATED TO FOREST PLANNING

1. GIS is more readily implementable for tactical rather than strategic planning (i.e., the benefits of a GIS are more immediate for tactical planning).

a. Strategic Plans are, almost by definition (or at least because of the data limitations), usually not concrete.

Keith Simmons, Harvest Planning and Road Construction Supervisor, explains the Simpson planning process:

We have a corporate staff we work with that do their own modeling with projections for allowable cut. They hand down the allowable cut but we work with them as far as the assumptions they used in it...We usually come up with three or four different scenarios, maximize harvest in the first five years and then non-declining after that, for example, or non-declining starting today. They will give us the allowable cut depending on which scenario we are talking about...

...we have always put together five year plans. But the five year plan has usually been strictly a cash forecast plan--what are the expenses, what are the revenues--just a projection under these assumptions for future marketing conditions. How many acres will we harvest, what will be the volume?

And then on an annual basis we put an annual plan together...It covers what we'll harvest, operating costs, market conditions, mill needs and export markets. Through the year we will have quarterly updates.

The British Columbia Ministry of Forests administers two distinct types of units: Timber Supply Areas (TSA) and

Tree Farm Licenses (TFL). Within a TSA, wood is sold through licenses to small companies; the Ministry of Forests completes the forest planning for each TSA. Larger companies, such as MacMillan Bloedel, acquire twenty year renewable leases for TFLs. The TFL licensee completes the required planning for the TFL, and it is then reviewed by the Ministry of Forests.

Forest planning for TSAs is a multi-stage process that becomes more site-specific at each successive stage. It begins at the Headquarters Inventory Branch, which uses MUSYC to calculate an AAC for each TSA. The regional staff then uses this AAC and input from other resource disciplines to initiate a planning process for each TSA that results in a TSA Resource Management Plan. The Resource Management Plan outlines resource management goals for each TSA but is not site-specific.

District staff uses the Resource Management Plan to guide both local resource use planning and resource development planning. Resource use planning is designed to resolve multiple resource use conflicts and is carried out at the watershed level. There is no standard format for resource use planning: it varies to fit local situations. Resource development planning is the site-specific, tactical planning that is carried out on 5-year development areas. It results in Timber Development Plans that specify locations, methods, and schedules for harvesting.

MacMillan Bloedel manages both crown TFLs and its own land (app. 80% crown land and 20% private land). Their forest planning is also a multi-stage process that becomes more site-specific at each stage. Pat MacDonell, Manager of the Inventory Section, explains:

We [the region] provide an Annual Allowable Cut (AAC) [to the divisions] but it is not site specific. We have nothing to do with where it is going to be logged.

We do make a 20 year plan that is site specific, but it is sort of no use after two years. We're forced to do it by the Forest Service. We do it and it won't be followed. One of the reasons it won't be followed is the constraints are so great that in five years time we don't know what we'll be allowed to do anymore.

We [also] have a Management and Working Plan for each TFL. It's a document that lays out what we did in the last 5 years and what we will do in the next 5 years...The key part of the Management and Working Plan is the justification of your annual allowable cut. Highly sensitive, highly political type of thing these days.

We have 5 year development plans which are more site specific in that they reach logging operations, they show the openings that are going to be logged. These have to pass by the Forest Service, the Fish and Wildlife people, public hearings and a whole host of different parties. And you never get a whole five year plan approved. You might get the first two or three years, just enough to be logging. And when enough of it is approved, you put in a cutting permit application which, again, applies to those specific openings, but two years worth. And those undergo more and more detailed scrutiny than the five year plan and then when you want to cut a specific opening you have to get permission to cut from the Forest Service...Then each year, according to the Management and Working Plan, you put out an annual report. Then you hold a public meeting to explain what you did in the last year.

MacDonell and Brad Whitehead, Coordinator of Information Services, talk about the ramifications of being

a planner in MB's organization:

(Whitehead): All the planning departments were cut back when the recession went on [in the early 1980's]. MB does not refer to people who do planning as planners.

(MacDonell): Very dangerous. You are anything but a planner. A planner is not a good term to use...We used to have all kinds of planners; they've all been fired, retired or died. So, there is no such thing as a planner anymore. Nobody plans, officially.

These guys (that run the AAC model) are sort of back room boys that are sprung out every five years to help with AAC and then they go back to dusty dungeons and you never see them again for five years.

Washington DNR also follows a multi-stage planning process that becomes more site-specific at each stage.

George Flanigan, the Hoh District Manager, explains:

We are guided by two basic documents. One is called the Forest Land Management Plan (FLMP). It is a programmatic environmental impact statement covering the whole range of operations of Washington DNR. That provides basic direction as a policy statement. Just recently we've come out with a strategic plan and that dovetails in with the Forest Land Management Plan. The FLMP and the strategic plan are general, large, broad-coverage documents. [They] just provide basic direction.

Then we have cut levels that are calculated by the Olympic office, and they are sent out here and they are further divided by the assistant regional manager to the districts...From there on our planning process is pretty much up to us...Our normal process is a five year development plan which will show our proposals for five years out and then the most specific is our one year action plan. These are written documents, but not grand documents. They are a map, probably a GIS run, with color coded polygons showing different action years with units to be prepared for sale plus description of any supplemental needs to go with that sale.

b. Attempting to be site specific on a strategic plan would pose data storage and retrieval problems.

MacMillan Bloedel has already run into storage and retrieval problems.

(Whitehead): Right now we have 2.75 gigabytes [one billion bytes) of disk completely full. We are at 90 to 95% CPU utilization and it is just killing the system and that is largely because of the demand that has been placed on the system. If we went back to straight inventory maintenance we would probably be able to handle it but we've had a lot of special projects come in. So, we are in the process of trying to resolve that.

c. Links between GIS and strategic planning are not established.

MB's Whitehead thinks GIS will change the nature of forest planning:

It will give a divisional engineer the chance to ask the question, 'given this set of criteria, show me the stands that are going to be the most productive to log within this time frame.' Getting into a decision support kind of operation is really the next phase that we will be ready to move into and at that point, we will start to make much better use of the spatial analysis kinds of things... We are probably a couple of years away from that.

d. Planners do not envision GIS as a strategic planning tool.

Simpson's Simmons explains his perception of GIS:

We thought GIS would provide the tie between the attribute information which subscribes to the resource and the map base that [locates the resource].

Washington DNR's Vaughan states:

From the aspect of silviculture I wouldn't say that the system does planning for you. The planning has already been done. What it does is it facilitates an activity being done and it affords the person who

receives that map the ease of mind that they won't have to worry about remembering what's going on over here.

e. Sophisticated models, especially those used in strategic planning, require large amounts of time to integrate into the system and are often a low priority.

Simpson's Simmons talks about the problem of getting the system on line:

It probably took us three or four years just to get the database mature enough and to get acceptance by people.

Mike Naccarini, Resource Biometrician, adds:

Quite a while ago we knew [GIS] would be a great planning tool and we just never had the time to do it.

British Columbia Ministry of Forestry has slowly added applications. Allen Prelusky, Timber Supply Forester, explains:

The original GIS was designed to replace manual drafting. It was not until about 1985 that applications came along. [Applications have] taken a long period [to integrate into GIS].

Remote Sensing Officer Raoul Wiart adds:

So what we are doing is not going headlong into an application, we are evolving in applications. We are finishing up our input stage, which should be done by 1991, to have all 6600 maps loaded. Once we get that in place, we are evolving applications...One definite phase would be data input. The next phase might be applications. The next phase might be integration.

MacMillan Bloedel has not tied models into the system yet. Whitehead explains:

None of the supporting systems that we have around now are directly tied into our GIS. When we transfer information to growth and yield models it is a file

transfer over.

The only model presently tied to Washington DNR's GIS is, interestingly, a strategic planning model. Vaughan explains:

There is a model that is in the system now. It is used by our biometrician, Charlie Chambers, and he uses it to calculate our sustained yield cut. His model is in the system but it is kind of his baby. No one messes with it.

[Other than that] It's not a direct link, i.e. pull this data and plug it right in [to a model]. It won't do that yet. We are working toward that.

2. GIS is more accessible at the tactical planning rather than the strategic planning level of the organization.

Simpson Timber's GIS is physically located at the tactical level of the organization and they encourage users to access the system. Simmons states:

We have tried to set up access to the system so a lot of information can be put in by the users.

(Naccarini): We [Naccarini and Wing] do the programming and the updating of inventory and databases. The other guys from the field come down and make maps and they definitely help us out and interact a lot.

Paul Wing, Forest Inventory Supervisor, adds:

There is no way you can justify putting a bunch of people dedicated to a computer. We've tried to make as much of the simple stuff as possible available to other people that come in and retrieve information, so you don't have as much of a service bureau. But it varies a lot between people. Some have the potential for using the system. It is not something you can force on people.

British Columbia Ministry of Forestry first acquired

GIS in the headquarters branch (which provides support for strategic planning). It then filtered down to the regions and is in the process of going to districts. Wiart and Prelusky explain:

(Wiart): Each of the [six] regional offices has a GIS system on an IBM-type system. They have PAMAP [PAMAP Technologies Ltd] right now and they are going to be getting Terrasoft in three to six months. Then six districts will have them; [this is a] prototype for a phase one implementation of district GIS. So we're going for six districts and eventually putting PAMAP on the entire province.

(Prelusky): There's going to be six GIS systems going out in June [1989] to six districts. They'll initially be updating their forest cover inventory maps but they will also be looking at applications, how they can use their information in their TSA...Right now a couple of districts have GIS. They were the districts that showed the most interest in their region. All the regions have had it for a number of years...Within two years all of the districts will have it...The implementation of these systems is being done by the [headquarters] branch in consultation with the region. So that means the onus is basically on the [headquarters] branch to organize the training, the implementation of these systems and everything else.

(Wiart): Ultimately, they [the districts] will get the GIS tool and how they decide to use it is up to them. We'll give them the techniques on how to do routine things or the things they show interest in. And as they show more interest or more need we'll take it from there...For the next year or two or three years it is a transition period and there is gonna be a lot of learning that the districts have to do and there will be a change in demands on the people.

MacMillan Bloedel's GIS is housed in the Nanaimo regional office (where strategic planning occurs). It is not currently designed to be directly used by personnel involved in tactical planning. Whitehead and MacDonell explain:

(Whitehead): Our original system design, rightly or wrongly, evolved from the old mapping days. In '79, when it first came out, you didn't have graphics terminal capabilities other than a special graphic screen so the idea of having on-line terminals where you could get graphic output was not feasible. So, when we moved into ARC/INFO, we kept the system structure that was already in place. So, right now, it is not designed as an on-line inquiry system, it is designed more as an analytical database.

(MacDonell): I would like to be able to use GIS but it is unavailable to me. I have to go through the programming high priest to get anything out of it so it is out of my control. I don't know if it is user friendly enough and we certainly don't have the hardware for anybody just to walk up and ask a question...It is frustrating because you can just sort of go to a drawer and pull out a file and add it up yourself unless you have a report so you gotta go to these guys and give them some sort of project plan and eventually the thing comes back weeks later, wrong, and so you have to go check it all over. Brad [Whitehead] has his pressures and there is a huge amount of data to be processed. And priorities seem to change from week to week.

(Whitehead): One of the objectives this year is to try to take some of the production responsibility away from my group and move them into the digitizing area. That will free us up to start developing the user interfaces so that Pat [MacDonell] will eventually be able to sit and [use the system].

GIS may be heading to the division in the future. The Cowichan Logging Division of MacMillan Bloedel was the first, and so far only, division to acquire GIS. The acquisition of a micro-based ARC/INFO system was a bottom-up decision pushed by Jack Lavis, Division Logging and Woodland Superintendent. Lavis explains:

We never used Intergraph [the old GIS system] [Intergraph Corporation]. All we did every year is our inventory revisions, sent them off, sometimes a year, two years later, new maps came back, went off in the drawers. We just used our own stuff and kept going. The [Vancouver] Inventory Division was only something

like a necessary evil we had to do every December and January. [In 1985] we flew off to New Brunswick and visited the Frazier Company to look at the [ARC/INFO] system. The first day I saw that I thought, 'I know that is what I want, but how do I get there?' ...so I worked on our boss and the regional manager...and we put together a game plan to get to a finished product with our GIS by September of 1989...So we started on our journey of putting things together and just working very slowly with software, hardware, inventory, data, updating...And it was four years to just piece things together and get things where we wanted to...The thing is if you rush it you're going to get screwed up...Our company decided last year that we were going to be a test division because we were so far ahead...It's up to the division [whether they acquire GIS or not]. Everyone is kind of run off on their own kind of string...

When the GIS is operational (slated for September, 1989), Lavis will use it to analyze inventory to assist in logging planning, reforestation, spacing, thinning, fertilization, site prep, and brush control.

The Olympic Region of Washington DNR, as a pilot region, acquired GIS at the same time as did headquarters in Olympia. Vaughan explains:

We had it the same time Olympia did...In the fall of '83 we were the first pilot area for GIS and we were actually the only region with the hardware and capabilities to run GIS for about two years.

The original concept of GIS was to have stand-alone mini [main-frame] computers in the regions and have a main frame in Olympia that did some of the caretaker work...That didn't work very well...In '84 the mini main-frames weren't that great. So processing with ARC/INFO was too slow. The next step was to say, 'let's make a network; let's get a supercomputer in Olympia, with dedicated 9600 baud hookups so you have a legitimate remote work station...We tested the minis for about 18 months and then went over to a full network in the fall of '84.

Under this present scheme, regional offices, like the Olympic region in Forks, are basically remote ARC/INFO work stations with the main computing done in Olympia. Headquarters must load data for the regional office to work with.

At this time, the Olympic region's GIS is run as a service bureau; users request products from the GIS staff. Flanigan and Vaughan explain:

(Flanigan): I'm not a direct user. I make requests and then somebody figures out how to get it out of the system.

(Vaughan): We want to move beyond that--[to a] dial-up link with the laptops [for district managers]. As far as producing a map, I think that it is too soon right now. Maybe in a year or two or three years that is going to be more available for them to do only from the aspect of easy to follow programs. Developing a map is a pretty complex set of functions. Getting the report, on the other hand, is very simple. So macro-wise, they can take their laptop and get a report. We want to get to that because I think it is imperative for buying those people into GIS and letting them feel as though they are a part of it as opposed to being a slave to it.

3. GIS products are more readily usable in tactical rather than strategic planning.

Simpson Timber's GIS products are generally operations oriented.

(Naccarini): More recently we've had more planning type things. But generally, we still put these products together that people can use daily...Our products are operations oriented.

One of the things we use [GIS] for is to keep track of all the silvicultural history...We also put together a cost analysis system that keeps track of all

the costs on managed stands. It gets entered into a program that interrelates with the mapping portion in the GIS.

We have done a really good job of all the areas that have slash that is unabated and where we have actually gotten rid of it and burned it. There are even rules now that you can't have more than 800 acres of contiguous slash; without GIS, that would be hard to map.

(Wing): When there is a plan for the coming season, in the forest management program we get a request to produce a list or some maps showing the potential stands. That is the sort of thing that saves 20 or so people in our department.

(Naccarini): One of the latest projects is a new inventory system we call the MULT [Management Unit Layout Program] system. (Simmons): The MULT information gives us an idea of what's ahead of us, where it is located, where we have roads and where we don't have any roads, where expected log yield recovery should be in the future.

Simpson Timber is moving toward using GIS for the broader picture.

(Simmons): GIS helps us react to a lot of political things such as buffer strips along streams. If political legislation encumbers our ownership, we can run it through our GIS and put a dollar value to the species mix we have in our land. Otherwise, you're talking about somebody sitting down with a map, drawing some lines, trying to estimate what's in here.

(Naccarini): We have done a lot of work on the Candy Creek drainage. We do a lot of buffer zone analysis and we're trying to project the volume of timber lost or gained depending on the strip.

We get involved in a lot of land acquisition. We had one with the State of Washington, a multi-million dollar land exchange and [GIS] more than paid for itself just to come a few dollars closer to your final cost or the value of your land you are exchanging.

We did a project with a lot of polygon overlays dealing with spotted owls.

British Columbia Ministry of Forests primarily produces enhanced maps but it is moving toward broader applications:

(Wiart): Before [GIS], our data was hard copy maps, like mylar maps. In '78 the decision was made to go to a CAM system, because of ease of access, manipulation, updating and to just be able to carry that number of maps. In the province we have over 6600 1:20,000 map sheets. [GIS] enables us to call up and produce maps with various features, the standard GIS sorts of tools-combining different levels to make up themes or overlays or the like.

(Prelusky): We can add in the local resource uses in the levels and customize your map and it's geo-referenced whereas previously you had a data file in your computer and it wasn't geo-referenced.

We can color theme our operable land base and present it; that was impossible before. We can show trends over the province and that was never possible before. You had to have a person sitting down and coloring a map sheet. And if you wanted a copy you'd color another one.

(Wiart): With remote-sensing images we can locate areas of change. We can update for forest cutovers. So if you want to determine all the cut from one year to another year we can do some sleight of hand with the imagery and have that show up.

MacMillan Bloedel has been, up to this point, working primarily on inventory. They are now beginning to move into other areas:

(Whitehead): The biggest use so far has been updating inventory. We have done a variety of projects where we've produced maps showing all the NSR (non-suitable regeneration) stands and certain age classes fated for somebody to use. Then we get into our five-year plan and our twenty year plan. There is sort of a standard set of products that come out of that and we set up maps, or a set of reports that list volumes and grades...We can now start looking at the second phasing of GIS evolution which is analysis.

Something else is digital terrain modeling. Landscape management is a very big issue. One of the

things we do is to visualize the impact of logging certain areas.

One such area is the Carmanah Valley, an exceptional spruce forest located on the west coast of Vancouver Island. Due to public pressure, MacMillan Bloedel reconsidered its original plan to log the valley. Whitehead used GIS to produce three dimensional views of different management scenarios for the Carmanah. These "viewsapes" have been used at public meetings set up to decide on a management plan for the Carmanah valley.

Washington DNR uses GIS primarily during the intensive management phase of stands, up through commercial thinning. Flanigan and Vaughan explain:

(Flanigan): Right now I use GIS for this whole range, including map and tabular data with my timber action plan. I'll use GIS tabular data for location of different stand types; I don't ask for maps every time I have a request for a particular stand combination, because there is a time problem. To produce the tabular data I can get it quick. Sometimes I have to wait for the map.

One thing about the GIS system, rather than having a bunch of printouts which would baffle anyone, they have this nice map, which is simple and easy to use by a lot of people.

(Vaughan): From a silvicultural end it runs the entire intensive management program for our region. It schedules and produces products, both report and mapping products that will tee off a certain project that happens annually. For example, doing our reproductive surveys, we planted trees and now it is time to survey it to test our success. The computer knows that and knows when each unit's time is up as far as when it is time to do a survey on your initial regeneration prescription. It will produce a map report of where that unit is at.

With the spotted owl controversy in the Pacific Northwest, DNR has found a new use for GIS:

(Vaughan): We've produced nine different scenarios of how the Old Growth Commission would allocate remaining old-growth and how we develop spotted owl habitats and how the other timber types could integrate into that preservation versus fifteen year planning back and forth, new AACs. The overlays that we used were both elevation modeling for flight paths for spotted owls as well as just different variations of where the old growth set asides will be and how that will affect road system uses, harvest patterns.

The nine scenarios were produced in three days. As Vaughan states:

That is a real positive when dealing with the public, to say, three days later, boom, here's our scenarios.

4. GIS has potential to help bridge the gap between tactical and strategic planning.

British Columbia Ministry of Forests has officially recognized the dichotomy between long-term strategic planning and short-term operational planning. Further, they have proposed the GIS-based Forest Resource Analysis System (FRAS) for TSA planning.

Analytic support for forest planning is required for both long term and short term functions. Long term analyses are required to determine long term sustainability for various management and harvesting options including silvicultural investment strategies. These can remain strata based. Short term analyses are needed for allocation and scheduling in a manner which will be sensitive to availability of timber based on economic operability, other resource values, losses to fire and pests, and harvest scheduling concerns. Short term analyses need to be area based. Currently, only the analyses relating to long term sustainability are well developed, other analyses either need to be

refined or newly developed.

FRAS is an area based planning support system, meaning that the basic resource data will be accessible and maintained on an area specific basis and that planning processes and models will consider the geographic location of stands and the spatial relationships between stands...The primary focus of FRAS is the short term planning problem of determining a 20-year harvest schedule that is geographically locatable..Short term planning will be linked to long term sustained yield strategies through a process of reconciling multipass harvest models, forest planning models, and scheduling and allocation models (Williams et al. 1988).

The system is scheduled to be operable by the end of 1991.

Washington DNR's Vaughan thinks that GIS will expand its role in the planning process:

I think the next big step for GIS is comprehensive planning, getting all people involved, counties, private timber companies, private individuals. When we have the comprehensive planning plus the modeling that is integrated, then I think [GIS] will take a giant leap forward and be recognized as this is the tool that we will always use.

HYPOTHESES NOT RELATED TO FOREST PLANNING

1. GIS update and maintenance is a larger proportion of the workload than organizations originally conceive it will be.

Simpson's Naccarini explains:

A lot of it is getting the time to do something. We [Naccarini and Wing] do the programming and updating of inventory and databases.

British Columbia Ministry of Forests update, with 6600 maps covering the province, is a multi-year chore. Wiart explains:

One of the directions of the branch is to update our maps on a two year cycle. So that means we would be updating 2700 maps a year as well as reloading 600 maps a year on a ten year cycle.

MacMillan Bloedel staff has to this point spent most of its time updating inventory. Whitehead explains:

Updating has been our biggest demand; [we are almost current on update], now we can start looking at the second phase of our GIS evolution which is analysis.

Washington DNR's Flanigan has an analogy for update:

Data-input is like a black hole. It is a never ending thing. There's a large expense that you have to put into it before you get a dime out.

2. The greatest limitations are related to personnel rather than technical matters; many of the early technical problems have been solved.

Simpson Timber's Naccarini states:

There are a lot of things that would be nice to computerize, to put in the GIS. But it is just being able to have the time and the people to do it.

Simpson has run into other problems as well.

(Wing): Our biggest problem is something that appears to be working and then it quits and it will start working again...You get a lot of digitizing errors that you don't even realize are errors until you try to run the software and it doesn't work.

(Naccarini): One of the greatest limitations is linking everybody's databases together in a smooth manner. That is one of the things that slows us down; we end up keypunching things over again that one person might produce.

(Simmons): We need to increase the interactivness with other people, tie PCs into a networked database so everybody could use the same database and all be using the same information. Right now everybody is kind of

doing their own thing.

For Simpson, the limiting equipment factor has thus far been that they are using an old Intergraph system; many of the equipment problems stem from the fact that the system is out-of-date. The system was scheduled to be replaced during the summer of 1989; most of the problems should be solved with the new system. The plotter may still be a problem; it is slow and complicated to set up, and is not scheduled for update.

British Columbia Ministry of Forests found training to be the slow part of implementation. Prelusky explains:

The machines were quickly operational. The training of the people was a long learning period. We took draftsmen who don't have any forestry background and basically made them forest technicians and they had to learn what the inventory was about. So that took us about a year to get people up to speed to do the application part of it.

Washington DNR also found personnel to be a hurdle.

Vaughan explains:

The major problem with GIS right now is finding qualified people to run it and then keeping the people...Salesmanship really comes into dealing with GIS. It is new technology. There are foresters in the field that are used to keeping books; that is what they've done, it works fine for them. [The attitude is] 'its wonderful to have this new machine but it is just more work for me to feed it.' Especially if we are feeding it, feeding it, feeding it and we don't see a thing come back. That is probably the toughest part of implementation for that kind of a system. It is tough for managers as well as the workers.

Data is another limiting factor. Vaughan and Flanigan state:

(Vaughan): The current limitations on our GIS are data limitations. For example, someone will come in and say they want to see all my stands over 2500 foot elevation. That is tough to do because we don't have elevation data in. We have the software to do it but we don't have the data.

(Flanigan): The question for us right now is how do we digitize all that topographic data and get it into a GIS system. Right now it is a money consumer and it takes a lot of time and resources to come up to speed. And for that reason there are a lot of people that are getting turned off in our organization.

Plotter technology is also acknowledged by Washington DNR as a limiting technology. Vaughan states:

One of the major hangups we had initially wasn't with the software, it was more hardware dependent, like plotters. Plotter technology was way behind the GIS technology but we are doing better now...We now have one of the newest plotters made and it was bug city when we got it. As nice as that plotter is you need to go electrostatic for production use because it is faster.

NEW HYPOTHESIS GENERATED FROM PRIMARY CASES

1. Early players in GIS have had to grow with system development, changing and updating systems. This has led to problems in implementation and personnel support.

Simpson Timber began planning for GIS in 1974; acquisition and implementation was not easy.

(Wing): We contracted with a consultant to build a GIS in 1974. After two years, the company decided it couldn't fulfill the contract. At that time, Simpson decided to go with Intergraph.

(Simmons): Some of our people had the idea that [GIS] was a good idea but I think they were ahead of their time. The software and the hardware were not really available [in 1974] and after signing the

contract [with the private contractor] it became quite apparent that the contractor could not perform on the contract. [After that], we worked with several vendors. We put together test databases for them to work off of and told them what we wanted to do. We ended up with Intergraph. They were just taking a look at the use of their system in industries like ours. I think we were one of their first or second customers and basically we played guinea pig for about two years. Some of the stuff they promised was not readily available. It was in 1978 that we got our first GIS and it took us about three years to get that up and running before we could phase out the [old inventory system].

(Wing): The equipment was delivered in the fall of 1978. We got a new computer [upgraded from a PDP 11/34 to a PDP 11/70] in 1981 because as the software was developed they realized it wouldn't work on the original computer. Immediately after we got it it was obsolete. It was limited to small areas with polygon overlays because you can't get over ten to fifteen polygons on a level. The problem with [the newer] machine is that it is finicky. You can tell someone to run these ten commands to get it out but invariably something goofy goes wrong...We have actually written programs that take the place of some of the Intergraph stuff that didn't work.

(Naccarini): Like the database report writer was extremely slow. And the DMRS database (Intergraph's attribute database) is just a son of a gun. It is terrible syntax. For making queries it is awful. You have to keep up with it all the time.

(Wing): Overlaying is an involved process. The data that you are interested in has to be plotted off to a second work file to run the overlays. If you want to maintain some of it you have to file it back. It is because of this software that you can't operate on a large file for the analytical portion of the work. It is slow.

(Wing): The equipment is breaking down, and the repair parts are recycled. The PDP 11/70 itself has been fine but the peripherals have been a mess. The plotter and the tape drive and the work station have had massive [problems], all the time stuff going wrong with them. All the equipment is several years out of date; they just recycle the parts. The problem we have is that they fix the part that fails but there is something that gets jostled in the shipping and it gets

back here and it is broken.

(Simmons): The problem we are having is that we haven't outgrown the capabilities of the system it is just that you can't get support for the hardware.

Simpson was slated to replace the out-of-date Intergraph system in the summer of 1989, soon after these interviews were conducted. The new system, the Intergraph Clipper system, will be state of the art. Wing and Naccarini explain:

(Naccarini): When a person buys a GIS you have to put in a life expectancy.

(Wing): This [old] system was put in on a ten-year plan and we are a little overdue...We are trying to buy the latest thing now so we can at least be a little further up the scale in terms of obsolescence.

British Columbia Ministry of Forest's requirements have changed since first acquiring GIS in 1978. They have responded by adding systems rather than replacing systems.

(Wiart): We got into GIS in 1978. We had an Intergraph system. No real smarts but it did the job for digitizing maps. We went to increased demands and they facilitated interactive manipulation in the graphic element and designs...We are still using Intergraph to load the maps. But we use PAMAP GIS for creating grids in our overlays and we are also getting in to a Terrasoft system for different uses. A lot of GIS systems do different things and they do different things better than other systems. In general, any one system does eighty percent of your work. For that last twenty percent, you need a specific system...It is really hard in a governmental situation to align yourself with any one company because there are good features in all these different GIS systems and we are getting a lot of different maps from a lot of different sources. So it ties in that we should be a multi-vendor. In the next twelve months we will be getting ARC/INFO on our mainframe.

Frank Hegyi writes: ...user needs are changing

constantly concerning the functionalities required of the system and the number of resource overlay levels needed to be processed. Hence, GIS with high quality cartographic capabilities may encounter operational problems as the number of levels of overlays increases. Secondly, the introduction of PC-based GIS significantly reduced the unit cost of production. However, the PC-based systems also encountered operational problems as the desired level of throughput of digitized maps increased. Thirdly, GIS functionalities have not completely satisfied client needs...The operational life of GIS systems will be reduced from the current five years to three. That is, the rate of enhancements is expected to be such that after three years a particular hardware/software configuration may become counterproductive compared to new alternatives (Hegyi 1989).

Hegyi feels that, despite having to acquire new systems, British Columbia Ministry of Forests made the right decision in acquiring GIS:

...the most progress appears to have been achieved by agencies who have made a major commitment to the technology, plunging in, rather than awaiting its gradual evolution. Delays in decisions to acquire GIS have prolonged the continuation of tedious and costly manual systems, and have prevented the use of current information by resource managers in a flexible and timely manner. Further, the impact of these delays has often been to incur costs far in excess of the proposed acquisition (Hegyi 1989).

MacMillan Bloedel acquired an Intergraph system in 1979; that was scrapped in 1986 in favor of ARC/INFO.

(Whitehead): The Intergraph system was installed in 1979...The company purchased a DEC computer and Intergraph software with the idea of developing a GIS; I think a little bit ahead of its time in terms of the whole GIS concept. Intergraph was able to do the mapping fairly well but the database side of GIS it couldn't handle at all... They were not keeping up with the analytical capabilities. It was a case where things were promised 'next year.' So in 1986 we made a switch from Intergraph to ESRI's ARC/INFO trying to get into a modern GIS concept.

As with a lot of organizations, MacMillan Bloedel's GIS has been both a blessing and a curse. Whether it has been more of a blessing or a curse is in the eye of the beholder.

(MacDonell): Really, from '78 until ['88], we haven't done a hell of a lot that we couldn't have done by hand cheaper and faster. This has been ten years of absolute disaster behind us. Did GIS meet our expectations? No, it didn't. And it certainly didn't exceed expectations. We put in the application to our own outfit to go buy the thing in '78; we put in another [one] about two or three years ago that said exactly the same thing and got an upgrade and we are bringing another one saying exactly the same thing. We don't know if we are going to get it. It is almost like we just pulled out the old one and put a new date on it. It is not quite that simple, but in a sense it is kind of sad that we are still asking for more money and more money so we can do what we said we were going to do in '78. These things aren't easy. Was GIS quickly operational? Well, it has taken ten years to get it to do half of what we want it to do.

(Whitehead): I think we have to look at it in two phases: the Intergraph phase and the ARC/INFO phase. Up until this year, the inventory was never up to date...We didn't run a parallel system at all, we just switched from one to the other and things went downhill for a very long time in terms of quality of maps and quality of information. [We wouldn't have been better waiting for ARC/INFO, however,] because the conversion over couldn't have been done and we wouldn't be current into 1989, it just wouldn't have been physically possible.

(MacDonell): Up until the last year or so it has been an absolute disaster. But we were on the leading edge of technology and the technology wasn't there and we had to take our bumps. But I think we made the breakthrough and hopefully it will work out. But basically, the maps had gotten to the point that they were, for a stage, totally unreadable, unusable. The data was so untimely it was embarrassing. We have got a hell of a lot of fences to mend before we have any credibility around here. And it was all the GIS. So we are poised to get into new and better things but then we are always poised for that.

Washington DNR has also changed systems since they

first acquired GIS. Flanigan and Vaughan explain:

(Vaughan): The first automated system was called GRIDS; [we used it from] '75 through '83. So in '82, '83 this technology was starting to come to the point where we could get better definitions spatially. Larry Sugarbaker was brought on board to totally design a new system because definitely the field had convinced executive management that this GRIDS system was money down a rat hole...Conceptually the system was okay. It is just that there wasn't the technology to do what we wanted done. We kept doing it by hand, too, so during that seven to ten year period it was a real bugger because you are doing two systems. It was not financially feasible because we were doing it by hand plus we were feeding and automated system that most people felt really negative about because it wouldn't give outputs that were useful.

Through competitive bidding and product demonstration we ended up with the ESRI [ARC/INFO] system. So in the fall of '83 we were the first pilot area in this region for the GIS...we had it the same time as Olympia...we tested the minis [mini main frames] for about 18 months and we went over to a full network out of Olympia in the fall of '84.

After the new GIS was installed, there were still problems with implementation. People's interest began to wain.

(Flanigan): Well, this [GRIDS] system has been out of business for about 8 years now and for that long we haven't had any new information. In fact, we are just now putting another inventory system into the GIS. We thought we'd be up and running in three years, and we are still not 100%. It has been eight years and there still aren't a lot of products that are coming back out. What we have now is a pretty good database in the system, mostly timber and roads, water, soils, and land sections...I think GIS has a lot of potential but we have to start getting something out of it.

It [ARC/INFO GIS] is not user friendly and if we don't start getting outputs that people can readily get there will be a lot of them that will write it off. They won't care about the data they are feeding in. That happened to our previous system, the GRIDS system. Field people never got what they needed out of it so they didn't bother keeping it up or they did it

haphazardly and the thing deteriorated real quick. And if GIS doesn't start producing products that are useful for the field users I'm afraid it is going to meet the same fate. So that is where the outfit is. And we are trying to correct that. But we are right on the edge, I'd say.

(Vaughan): We have a huge area to deal with, 360,000 to 370,000 acres of data, and we started from a core and moved out. So what we do for this person, we can't do for that person up in Port Angeles. It's frustrating for them.

CHAPTER 7

FINDINGS

This final chapter presents theory developed from and illustrated with the data. The theory, presented as six hypotheses, is useful in explaining the behavior of the organizations involved in the study and predicting how GIS will be integrated into forest land owning organizations in the future. These hypotheses can also be used as the basis for other GIS-related studies.

Hypothesis 1: In the foreseeable future, GIS will be most useful in three forest planning situations:

- a. Site-specific tactical planning.*
- b. Political planning (planning for restrictions imposed on the organization from outside interests, e.g. government regulations or pressure from private groups).*
- c. Strategic policy analysis (assisting with strategic decision making; answering technical strategy questions, but not actually engaging in strategic planning modeling, e.g. long term sustained yield modeling).*

GIS is a useful tool in forest planning. The most immediate use is in site-specific tactical planning. Three of the four primary organizations use GIS in tactical

planning. Simpson Timber uses GIS to produce maps showing harvestable stands for their annual plan. MacMillan Bloedel uses GIS to produce maps and reports for their five- and twenty-year plans. And when the Cowichan Logging Division finishes installing GIS, their whole range of tactical planning will be GIS-based. Washington DNR uses GIS to produce maps and reports for their timber action plans. Tactical forest planning relies on maps and GIS is an excellent map-producing tool.

GIS is beginning to make inroads into political planning, that is, planning for restrictions imposed on the organization from the outside, either through government regulation or public pressure. MacMillan Bloedel used GIS to help decide the fate of the Vancouver Island's Carmanah Valley, an exceptional spruce forest whose management has been the topic of intense public debate. GIS-produced "viewsapes"--3-dimensional views of different management scenarios--were used at public meetings to obtain input on management alternatives.

Both Simpson Timber and Washington DNR have used GIS to answer questions about spotted owl habitat on their lands. Simpson Timber used GIS polygon overlays to summarize covertime distribution for a one mile square area around possible owl sites. Washington DNR created nine different scenarios allocating remaining old growth timber as part of a regional planning committee, the Old Growth Commission.

The turnaround time was only three days, which Vaughan stated, "[was] a real positive when dealing with the public."

Both the Carmanah Valley and the spotted owl controversy are examples of "wicked" political problems. Allen and Gould (1986) state:

Solutions [to wicked problems] are generally good or bad rather than true or false; their validity cannot be tested objectively. There is no single correct formulation for wicked problems, only more or less useful ones. Wicked problems are almost never successfully solved by selecting the rationally best solution but more often by choosing the emotionally satisfying one.

Forestry organizations, even private organizations managing private land, are increasingly finding themselves involved in wicked problems. While GIS cannot solve wicked problems, it can help formulate the problem and offer different scenarios from which to make decisions.

Political planning is also necessitated by government regulation. Simpson has been tracking slash abatement on GIS; complying with new state regulations prohibiting more than 800 acres of contiguous slash would be difficult without GIS. Simpson has also used GIS to project the volume of timber affected with different size buffer zones in response to new streamside management regulations.

Neither Simpson, Ministry of Forests, or MacMillan Bloedel has tried to calculate the annual allowable cut by linking a strategic planning model to GIS. But GIS is useful in the broader facets of strategic planning. Simpson

uses GIS to help make land acquisition and exchange decisions. Naccarini states:

[GIS] more than paid for itself just to come a few dollars closer to the final cost of the land you are exchanging.

British Columbia Ministry of Forests uses GIS integrated with remote sensing images to track forest cutovers. They also use GIS to show trends over the province by color theming the operable land base map with GIS. MacMillan Bloedel uses GIS to track stands that do not meet regeneration standards.

Washington DNR's GIS experience seems to reject a portion of the hypothesis: they calculate sustained yield cut with a model linked to GIS. But tying the model to GIS was personal initiative (on the part of biometrician Charles Chambers) rather than department policy. Vaughan states, "...it's kind of his baby. No one messes with it." No other organization has even attempted to integrate a strategic planning model into GIS; in fact, few models of any kind have been integrated into GIS.

Hypothesis 2: *There is a logical progression from entering basic inventory data and spatial information through tying in more and more complex models. Strategic planning models, one of the most complex models, will naturally be one of the last models to be integrated.*

Ministry of Forests' Wiart explains the process that

most organizations follow when implementing GIS:

We [are] not going headlong into an application, we are evolving in applications...One definite phase might be data input. The next phase might be applications. The next phase might be integration.

Creating a GIS database is difficult and slow.

Simpson's Simmons states:

It probably took us three or four years just to get the database mature enough to get acceptance by people.

Washington DNR's Flanigan explains:

Data-input is like a black hole. It is a never ending thing. There's a large expense that you have to put into it before you get a dime out.

Large ownerships compound the problem. For example, it has taken Ministry of Forests, with over 6600 map sheets for the province, ten years to input them all into GIS.

None of the organizations have fully achieved their goals relating to integrating models. MacMillan Bloedel has not integrated models into the system yet, but expects to in the future. Whitehead explains:

None of the supporting systems that we have around now are directly tied into our GIS. When we transfer information to growth and yield models it is a file transfer over..We'll get to the point where the models are built [into GIS] or they'll be integrated, probably by establishing more work stations, so a model will run on a work station, but that work station will have access to all our database.

Washington DNR also wants to integrate models into GIS.

Vaughan explains:

It's not a direct link, i.e. pull this data and plug it right in [to a model]. It won't do that yet. We are working toward that.

The Simpson GIS staff would like to link their growth model to the system, but have not yet found the time. Ministry of Forests is still working toward full integration of models with GIS.

Once again, the fact that Washington DNR does have a strategic planning model integrated into GIS seems to reject this hypothesis. Yet the organization as a whole is tending to follow the evolutionary pattern; the integration of Washington DNR's planning model is more of an aberration than a pattern.

Hypothesis 3: Most organizations either already have, or are trying to get, GIS to the tactical or field level. This is the level where the people 'know' the data. If people at this level do not buy into GIS, the database may never be good enough to use.

Washington DNR's Flanigan explains the importance of selling people at the field level on GIS:

If we don't [get] outputs that people can readily get there will be a lot of them that will write [GIS] off. They won't care about the data they are feeding in. That happened to our previous system, the GRIDS system. Field people never got what they needed out of it so they didn't bother keeping it up or they did it haphazardly and the thing deteriorated real quick.

MacMillan Bloedel's Lavis explains the field perspective on the company's previous GIS:

We never used Intergraph. All we did every year was our inventory revisions, sent them off, sometimes a year, two years later, new maps came back, went off in the drawers. We just used our own stuff and kept

going. The [Vancouver] Inventory Division was only something like a necessary evil we had to do every December and January.

Simpson's Naccarini adds:

One focus on justifying the cost of [GIS] is to give upper management all this information. But if you focus on this too much, it falls on its face. If you don't have the support of the key [field] people, you don't know if the data is any good.

Simpson Timber, with only two people dedicated to the GIS, tries to involve field people in the operation as much as possible. The system is designed so field people can input and retrieve data, at least the simple, everyday things. Wing and Naccarini's time is already stretched thin; they depend on the field people to take on some of the work load.

British Columbia Ministry of Forests GIS has already filtered down from its headquarters branch to the regional offices. District offices are now getting GIS; within two years all the districts should have a micro-based GIS. The districts will initially be updating forest cover inventory maps but will eventually move beyond the inventory update to applications.

MacMillan Bloedel's GIS was not originally designed to be used by field personnel. But the Cowichan Logging Division put together a proposal to acquire micro-based ARC/INFO and has steadily been working to become fully operational. The program has been successful to the point that MacMillan Bloedel has made Cowichan a test division

with an eye toward acquiring GIS in the other divisions.

The regions were included in GIS acquisition from the start for Washington DNR. The districts do not currently have GIS, but the Olympia region is pioneering a program to provide laptops with modem hookups to district managers.

Vaughan states:

We want to get to that [the laptop hookup] because I think it is imperative for buying those people into GIS and letting them feel as though they are a part of it as opposed to being a slave to it.

There are caveats to implementing GIS at the field level. Hardware and software shortages can become even more acute. MacMillan Bloedel's MacDonell explains:

I think you want to keep everybody off GIS as much as possible because it is [already] so overloaded.

Database integrity is another concern. MacMillan Bloedel's Whitehead explains:

One of the things we have to address is the whole data security issue. Once you set up a network that has easy access to databases you have to make sure [the original database remains intact].

Hypothesis 4: After basic inventory data is loaded into the computer, necessary update and maintenance is a time consuming venture that can impinge on producing advanced applications.

Once basic inventory data is input into the system, the data must be maintained and updated. MacMillan Bloedel staff has to this point primarily been working on inventory update. Whitehead explains:

Updating has been our biggest demand; [we are almost current on update], now we can start looking at the second phase of our GIS evolution which is analysis.

British Columbia Ministry of Forests, with 6600 maps covering the province, schedules update as a multi-year chore. Wiart explains:

One of the directions of the [headquarters] branch is to update our maps on a two year cycle. So that means we would be updating 2700 maps a year.

While Simpson Timber has tried to make data input and retrieval available to field personnel, Wing and Naccarini update the inventory and databases. When asked about additional applications, Naccarini responds, "a lot of it is getting the time to do something."

Most of the database maintenance for Washington DNR is done by the headquarters staff in Olympia. This setup frees the regional staff to work on applications. Vaughan explains:

The positive end is we don't have to worry about backups. We do the work and they do the backups. I love that.

Hypothesis 5: GIS limitations are primarily personnel limitations, but include hardware and software limitations. Hardware limitations seem to be primarily with plotters. Software limitations are primarily due to older versions of GIS software with glitches or current versions that are not user-friendly.

Simpson's Naccarini explains his company's personnel

limitations:

There are a lot of things that would be nice to computerize, to put in the GIS. But it is just being able to have the time and the people to do it.

Wing adds:

There is no way you can justify putting a bunch of people dedicated to a computer. We've tried to make [some of the simple stuff] available to other people...but it varies a lot between people. Some have the potential for using the system. It is not something you can force on people.

British Columbia Ministry of Forests found training to be a hurdle. Prelusky explains:

The machines were quickly operational. The training of the people was a long learning period. We took draftsmen who don't have any forestry background and basically made them forest technicians and they had to learn what the inventory was about.

Washington DNR found another type of personnel hurdle.

Vaughan explains:

The main problem with GIS right now is finding qualified people to run it and then keeping the people. I think from the concept of hiring people that most organizations, including ours, tend to devalue [the GIS operator]. And with that in mind, their GIS [operator] is doomed to failure because they are not looking for a high-level person. That can make or break this \$5 million investment. When they skimp on an operator they totally blow out their GIS plans.

Vaughan still finds he has to sell the system to keep support:

Salesmanship really comes into GIS. It is new technology. There are foresters in the field that are used to keeping books; that is what they've done, it works fine for them. [The attitude is] 'its wonderful to have this new machine but it is just more work for me to feed it.' Especially if we are feeding it, feeding it, feeding it, and nothing comes back. That is probably the toughest part of implementation for that kind of a system. It is tough for managers as

well as the workers.

MacMillan Bloedel's GIS limitations are primarily due to lack of hardware. Whitehead explains:

We are 90 - 95% CPU utilization and it is just killing the system. If we went back to straight inventory maintenance we could probably handle it but we have had a lot of special projects come in.

MacMillan Bloedel's MacDonell would like to use GIS but hardware limitations make that impossible:

We certainly don't have the hardware...for anybody just to walk up and ask a question.

Simpson's hardware limitations are primarily due to having an out-of-date system. Wing explains:

The equipment is breaking down, and the repair parts are recycled. The PDP 11/70 itself has been fine, but the peripherals have been a mess. The plotter and the tape drive and the work station have had massive [problems], all the time stuff going wrong with them. All the equipment is several years out of date; they [Intergraph] just recycle the parts. The problem we have is that they fix the part that fails but there is something that gets jostled in the shipping and it gets back here and it is broken.

Simpson was scheduled to replace the old system in the summer of 1989, soon after these interviews were conducted.

Plotters are the piece of hardware most universally cited as being inadequate. Simpson's plotter, which causes problems because it is slow and complicated to set up, is not scheduled for replacement. Whitehead describes MacMillan Bloedel's two-pen plotter, which doesn't have color capabilities, as "very limited." Washington DNR's Vaughan also acknowledges that his plotter is a limiting factor:

One of the major hangups we had initially wasn't with the software, it was more hardware dependent, like plotters. Plotter technology was way behind the GIS technology but we are doing better now...We now have one of the newest plotters made and it was bug city when we got it.

Software can also limit GIS usefulness. Simpson's current system has out-of-date software as well as hardware.

Wing explains:

I think the last upgrade we had was in '85 so there really hasn't been any changes in software other than our own applications programming that we've done since '85...The problem with this machine is that it is finicky. You can tell someone to run these ten commands to get it our but invariably something goofy goes wrong.

Naccarini adds:

And the database is just a son of a gun. It is terrible syntax. For making queries it is awful. You have to keep up with it all the time.

Another problem was that some of the software modules, when loaded in 1985, did not work. Wing and Naccarini have worked around the problems, either by discarding unusable modules or writing their own programs for the modules that they need but that do not work.

Lack of user-friendly software is a common complaint.

MacMillan Bloedel's Whitehead explains:

Most of the sophisticated GIS packages don't come in a good user friendly package and there's a fair amount of programming that goes on.

As time permits, MacMillan Bloedel is developing interfaces so field personnel can sit down at the machine and use the system.

Washington DNR's field personnel also rely on GIS

operators for products. Flanigan states flatly: [ARC/INFO] is not user-friendly.

Hypothesis 6: GIS has, until recently, produced a lot of unfulfilled promises. The experience has not been completely negative, however, because a) the value of the learning experience is unquantifiable b) databases are more mature, and c) the GIS industry has developed. Thus high expectations for the utility of GIS remain. But GIS must start to fulfill promises or it will lose support from the organizations.

GIS development has been a long, involved process for the "early players." MacMillan Bloedel and Washington DNR have completely changed GIS systems; Simpson Timber is totally replacing its original system with a newer one from the same company; British Columbia Ministry of Forests has added new systems to complement the original system. As Simpson's Simmons states, "Some of our people had the idea that [GIS] was a good idea but I think they were ahead of their time." MacMillan Bloedel's Whitehead adds:

In 1979, the company purchased a DEC computer and Intergraph software with the idea of developing a GIS; I think a little bit ahead of its time in terms of the whole GIS concept.

The GIS experience to this point has often led to disappointment. MacMillan Bloedel's MacDonell explains:

Really, from '78 until ['88], we haven't done a hell of a lot that we couldn't have done by hand cheaper and faster. This has been ten years of

absolute disaster behind us. Did GIS meet our expectations? No, it didn't. And it certainly didn't exceed our expectations. Was GIS quickly operational? Well, it has been ten years to get it to do half of what we want it to do.

Though some of the early players have taken some hard knocks, jumping into GIS in the early stages of development has had advantages. The organizations that chose not to wait and developed GIS are farther along the learning curve. As Simpson's Simmons states:

[Implementing GIS] was long and laborious, but it allowed us to learn how the system works.

British Columbia Ministry of Forests has evolved with their GIS. Wiart states:

It is a dynamic system so where we started to where we are now to where we are going to end up I think is going to be totally different.

MacMillan Bloedel's Whitehead thinks the years of implementing GIS have been valuable:

I think the forest industry is ahead of everybody else [in utilizing GIS] because we started a little more early.

Washington DNR learned how not to implement GIS with their first system. When Larry Sugarbaker was brought in to design a new system, a group of people involved with the old system convened to brainstorm ideas to incorporate in the new design. Vaughan explains:

We had a team of people, about six or seven people statewide, that say 'this is the kind of products we want to see, this is the kind of data that we keep now, this is what we want to use it for. Now you give us a system that does that.'

Another advantage of buying into GIS early is that databases developed on the early systems are now more mature. British Columbia Ministry of Forests' Wiart states:

We were the first to get into digital mapping and computer mapping which means that we have a lot of information that people want to make use of.

MacMillan Bloedel was able to transfer data when they switched from Intergraph to ARC/INFO in 1986, which helped them become current with their inventory update. Whitehead explains:

[We wouldn't have been better off waiting until 1986 to acquire GIS] because the conversion over couldn't have been done and we wouldn't be current into 1989, it just wouldn't have been physically possible. It was a foul conversion process but it was a lot better than having to redigitize all the maps.

Washington DNR, on the other hand, was not able to transfer data when they changed systems. This caused credibility problems. Flanigan explains:

[The GRIDS] system has been out of business for eight years and for that long we haven't had anything. WE couldn't [use the] information. In fact, we are just now putting another inventory system in the GIS. Credibility in the data in the GIS is vital but [the data] is not always adequate.

Finally, because there were customers, the GIS industry, in the form of vendors, developed into a viable concern. All four organizations now use GIS systems provided by vendors. British Columbia Ministry of Forests is a multi-vendor organization. GIS vendors, unlike the first consultant hired by Simpson Timber, now have the

knowledge to put together a working system and the desire to work with clients to meet their needs. For example, Washington DNR is an alpha and beta test site for ARC/INFO.

The maturing of the GIS vendor industry also allows organizations to contract out work ranging from digitizing to applications development. Ministry of Forests already contracts out much of their GIS work. Wiart explains:

We have a number of contractors that work for us. As there is work that we can contract out and expertise that is shown in the private sector we contract out. There is lots of competition and it is bringing the cost down.

Yet, for all of its promise, GIS must begin to deliver or risk losing credibility. MacMillan Bloedel's MacDonell states:

Up until the last year or so [GIS] has been an absolute disaster. But we were on the leading edge of technology and the technology wasn't there and we had to take our bumps. But I think we made the breakthrough and hopefully it will work out. But basically, the maps had gotten to the point that they were, for a stage, totally unreadable, unusable. The data was so untimely it was embarrassing. We have got a hell of a lot of fences to mend before we have any credibility around here. And it was all the GIS. So we are poised to get into new and better things but then we are always poised for that.

Washington DNR's Flanigan adds:

I think GIS has a lot of potential but we have to start getting something out of it. If we don't start getting outputs that people can readily get, there will be a lot of them that will write it off...We are right on the edge, I'd say.

Ministry of Forests' Hegyi feels, despite the problems,

those that acquired GIS early made the right decision:

...the most progress appears to have been achieved by agencies who have made a major commitment to the technology, plunging in, rather than awaiting its gradual evolution. Delays in *decisions to acquire GIS* have prolonged the continuation of tedious and costly manual systems, and have prevented the use of current information by resource managers in a flexible and timely manner. Further, the impact of these delays has often been to incur costs far in excess of the proposed acquisition (Hegy 1989. Emphasis added).

MacMillan Bloedel's Whitehead adds:

I look at [GIS] quite positively in that I can see the potential there. GIS, [within] the computer world, is one of the new developing technologies where a lot of the standard computer things have reached a plateau. MacMillan Bloedel has an accounting/payroll system... that [has] reached a plateau in computer technology where GIS is really just starting to take off. The possibilities are unlimited. The difficulties are going to be trying to pull all the resources together to make it happen.

GIS is making inroads into forest planning, most immediately at the tactical level, but also at the political and strategic level. It does not appear that sustained yield strategic planning models will be integrated into GIS at a fast rate. Strategic planning models are already complex, there are too many other pressing needs, and they are generally perceived to work fine in the role they play (when that role is well understood and not exceeded).

GIS is not without problems. Data maintenance and update is time consuming; problems with personnel, hardware, and software have limited the usefulness of GIS; and GIS has, for several years, had "teething problems". The early

players had to bear some high costs for pioneering GIS. But all in all, GIS is still the most promising technology on the horizon.

Appendix A
Original and Revised Interview Questions

ORIGINAL QUESTIONS (USED DURING THE POTLACH INTERVIEWS)

Questions for the Planning Expert

1. What are the objectives that drive your timberland management?
 - A) What is the overall goal/mission statement in managing your timberlands?
 - B) What are your strategic objectives?
2. What sort of planning process do you follow?
 - A) Where do "planners" fit into your organization?
 1. Do planners have authority?
 2. Are plans strictly adhered to?
 3. If plans are adhered to, what are the control mechanisms? Reports?
 - B) Is planning a multi-stage process--strategic to operational?
 - C) How structured is the process?
 - D) Where does quantitative modeling fit into the process?
 - E) Do you publish (at least internally) a formal planning document?
3. Where does mathematical modeling fit into your planning process, and what type do you use (linear programming, integer programming, graph theory, simulation)? Optimization vs. non-optimization.
4. What constraints must you consider (Best Management Practices, State Forest Practices Acts, water quality regulations, cumulative effects regulations)?
5. Do you plan for multiple resource outputs; if so, what are the resources you plan for?
6. Trace the development of your planning model. How fast is your planning process developing? What models did you use two years ago? Five years ago? Ten years ago? Twenty years ago? What forces caused you to change what you were/are doing?
7. Trace the history of your organization's decision to acquire a GIS. Why did you want to purchase/build a system?
8. What planning needs did you think GIS would fill?
9. From a planning standpoint, what can you do with GIS?
 - A) Did GIS meet/exceed expectations?
 - B) Was it quickly operational?
 - C) Did implementing GIS involve personnel changes? Organizational changes? Re-evaluation of your work environment?
 - D) What level are the experts on? Local? Regional? National? How do you relate to them?
 - E) What would you like to do with GIS but can't? Is it hardware limitations? Software? Personnel? Are you restricted from doing certain things?

10. Does GIS have a major impact on your planning system?
 - A) Has GIS already had a major impact?
 - B) Do you foresee a major future impact?
 - C) Do you use GIS to explain "policy" type questions or only for operational questions?
 - D) Do you foresee GIS following a pattern of evolution similar to the one operations research models have in forest planning?
11. How automated is your planning process? Where does "machine control" end and "human control" begin?
12. How does GIS effect the relationship between "top-down" and "bottom-up" planning?
13. If GIS were to dramatically alter the present planning process, what would the model be?
14. How do you manage your inventory information?
 - A) How often do you collect field data? Is your inventory maintained on a GIS? Do you aggregate plot data before entering it into a GIS?
 - B) How have your inventory/data needs changed since acquiring a GIS?
 - C) Can you retrieve inventory data to answer questions?
 - D) How often do you update your inventory on the computer? Continuously? Do you "freeze" your data between updates so you are sure of the source? Who updates the data: field personnel? data entry specialist? How does the update system work?
 - E) What standards and guidelines does your organization have for information management?
 - F) What problems do you encounter in the present system?
15. How do you handle data uncertainly in the planning process? When you present your results?
16. Is your GIS cost effective?
 - A) Is someone responsible for keeping track of hours spent/cost to do a study?
 - B) What sort of monitoring/evaluation systems are in place?
 - C) What are the results: costs up/better info? costs up/worse info? costs down/better info? costs down/worse info?
17. What research needs can you identify? Planning? Modeling? GIS?
18. What skills do forestry graduates need to be effective planners?
 - A) Do you hire specialists?
 - B) Do you offer in-house training?
 - C) Do you see a need for a University short course in forest planning?
19. Are you glad that your organization acquired a GIS? How did the majority of impacted employees react?

Questions for the GIS expert

1. Trace the development of your GIS from the beginning to the present. What forces caused the system to change?
2. Where does the GIS section fit into the organizational hierarchy?
 - A) Do specialists do all the "hands on" work?
 - B) Do field personnel actually sit down and work on the system?
 - C) How well is GIS received by foresters/field personnel?
3. Where do you fit into the organization's planning scheme? How closely do you work with the planners?
4. In what areas has GIS greatly improved your operation? Moderately improved? Not helped?
5. What can GIS NOT do?
 - A) What questions can you not answer that you are asked?
 - B) What new equipment have you acquired in the last 12 months?
 - C) What new equipment do you hope to get in the next 12 months?
 - D) Do you foresee new capabilities in the near future?
6. How do you manage your inventory information?
 - A) How often do you collect field data? Is your inventory maintained on a GIS? Do you aggregate plot data before entering a GIS?
 - B) How have your inventory/data needs changed since acquiring a GIS?
 - C) Can you retrieve inventory data to answer questions?
 - D) How often do you update your inventory on the computer? Continuously? Do you "freeze" your data between updates so you are sure of the source? Who updates the data: field personnel? data entry specialists? How does the update system work?
 - E) What standards and guidelines does your organization have for information management?
 - F) What problems do you encounter in the present system?
 - G) Can you acquire data in a digitized format?
7. What direction do you see GIS taking? Fully automated? Where do people fit into the system? What things can you do in "real time".
8. What GIS research needs can you identify?
9. What skills do people coming out of forestry school need to have to be effective with GIS?
 - A) Do you mainly hire specialists?
 - B) Do you offer in-house training courses?
 - C) Do you see a need for University GIS short courses, and what should they concentrate on?

10. What GIS configuration do you use? What software is imbedded? Linked? How do you incorporate models into the GIS environment?
11. What differences do you find between planning applications and other applications? What are the other applications?
12. How "user friendly" is your GIS?
13. Have people accepted GIS? Why or why not?
14. How much support have you received from upper management? In money? Encouragement? Has this support changed over time?
15. How long did it take to get your GIS operational? How did you keep interest/support high during this time?
16. How are decisions about changes/additions to the system made? Generated from below or above?
17. Is your GIS cost effective?
 - A) Is someone responsible for tracking hours spent/cost to do a study?
 - B) What sort of monitoring/evaluation systems are in place?
 - C) What are the results: costs up/better info? costs down/better info? costs up/worse info? costs down/worse info?
18. Did implementing a GIS involve personnel changes? Organizational changes? Re-evaluation of your work environment? What level are your GIS experts on: Local? Regional? National?
19. Did Minn/Ark divisions implement GIS? Other Id areas? Local decision?

REVISED QUESTIONS (USED DURING INTERVIEWS AT THE PRIMARY CASES)

Questions for the Planning Expert

A. Description of the Planning Process

1. What is the overall goal/mission statement for managing your forest lands?
2. What are your specific objectives?
3. What legal or formal administrative constraints must you consider?
4. What sort of planning process do you follow?
5. Where do planners fit into your organization?
6. Is planning a multi-stage process? If yes, please describe the stages.
7. Do you publish, at least internally, planning documents? If yes, please list titles and dates.
8. Where does quantitative modeling fit into the planning process? Where does mathematical modeling fit into the planning process?
9. Please outline the basic planning models you have used during the last 20 years.
 - a. 1969
 - b. 1979
 - c. 1984
 - d. 1989
 - e. What forces caused you to change your planning process?
10. How do you plan for individual and multiple resource outputs?

B. Geographic Information System (GIS) Implementation

1. Trace the history of your organization's decision to acquire a GIS. What planning needs did you think GIS would fill?
2. From a planning standpoint, what things has GIS enabled you to do?
3. Did GIS meet/exceed expectations?
4. Was it quickly operational?
5. What changes did implementing GIS involve?
6. Are the GIS experts accessible?
7. What would you like to do with GIS but can not do currently? Is it a hardware limitation? Software? Personnel?
8. Impact of GIS on your planning system:
 - a. Has GIS already had a major impact?
 - b. Do you foresee a major future impact?
 - c. Do you use GIS to explore "policy" type questions, operational questions, or both?
 - d. Do you foresee the spatial analysis

capability of GIS changing the fundamental nature of the planning process?

9. In what areas has GIS greatly improved your operation? Moderately improved? Not affected?
10. How does GIS affect the relationship between "top-down" and "bottom-up" planning?
11. How do you handle entry errors in the planning process?
12. How do you handle sampling errors in the planning process?

Questions for the GIS Expert

1. Trace the development of your GIS from your earliest system to the present system. What forces caused the system to change?
2. What GIS configuration do you use? What software is imbedded? Linked? How do you incorporate models into the GIS environment?
3. How long did it take to get your GIS operational? How did you keep interest/support high during this time?
4. What are your GIS applications? What are the differences between planning and other applications?
5. Where does GIS fit into the organizational hierarchy?
 - a. Do specialists do all the "hands on" work?
 - b. Do field personnel actually sit down and work on the system?
 - c. How well is GIS received by the foresters/field personnel?
 - d. Do you have software engineers/programmers or do you rely exclusively on the vendor for these skills?
6. How much support have you received from upper management? In money? Encouragement? Has this support changed over time?
7. How are decisions about changes/additions to the system made: generated from below or above?
8. Current limitations of your GIS?
 - a. What questions can you not answer that are asked?
 - b. What new equipment have you acquired in the last 12 months?
 - c. What new equipment do you hope to get in the next 12 months?
 - d. Do you foresee new GIS capabilities in the near future?
9. Do you attend GIS meetings: Local? Regional? National?
10. What do you do to keep up with changes in GIS technology?

Questions for both the Planner and the GIS Expert

1. Inventory Information Management:
 - a. How often do you collect field data? Is your inventory maintained on a GIS? Do you aggregate plot data before entering it into a GIS?
 - b. How have your inventory/data needs changed since acquiring a GIS?
 - c. Can you retrieve inventory data to answer questions?
 - d. How often do you update your inventory on the computer? Do you "freeze" your data between updates so you are sure of the source? Who updates the data?
 - e. Do you mix hard and soft information in the database? If so, do you keep track of the source of the information? If yes, how?
 - f. What standards and guidelines does your organization have for information management?
 - g. What problems do you encounter in the present inventory data management system?
2. To what extent does GIS automate your operation:
 - a. How "user friendly" is your GIS?
 - b. Where does "machine control" end and "human control" begin?
 - c. What things can you do in "real time?"
3. Changes resulting from implementing a GIS: Did implementing GIS involve.
 - a. Personnel changes?
 - b. Organizational changes?
 - c. Re-evaluation of your work environment?
4. GIS cost effectiveness accounting:
 - a. Is someone responsible for tracking hours spent/cost to do an accounting study?
 - b. How is overhead accounted for?
 - c. What sort of monitoring/evaluation systems are in place?
5. What research needs can you identify? Planning? Modeling? GIS?
6. What skills do forestry graduates need to be effective:
 - a. Do you hire specialists?
 - b. Do you offer in-house training?
 - c. Do you see a need for a University short course in forest planning? GIS? Both?
7. Are you glad that your organization acquired a GIS? How did the majority of the affected employees react?

Appendix B
Case Study Histories

POTLACH CORPORATION**PRIMARY SOURCES OF EVIDENCE**

Interview with Jim Newbury (Forest Economist), April 24, 1990

Interview with Steve Smith (Inventory Group Leader) and Dennis Murphy (Systems Analyst), April 25, 1990

SECONDARY SOURCES OF EVIDENCE

Potlach 1988 Annual Report

Potlach Mapping Project and ESRI System Demonstration
(Photocopies of a presentation developed by Steve Smith)

Harvest Plan Map generated by ARC/INFO

Potlach Intra Company Memo on the advantages of the ESRI system

SIMPSON TIMBER COMPANY**PRIMARY SOURCES OF EVIDENCE**

Interview with Paul Wing (Forest Inventory Supervisor) and Mike Naccarini (Biometrician), May 22, 1989

Interview with Keith Simmons (Harvest Planning and Road Construction Supervisor), May 23, 1989

SECONDARY SOURCES OF EVIDENCE

Simpson Timber Shelton Cooperative Sustained Yield Unit Progress Report 1986 and 1987

Special Report--Simpson Timber Company and the Shelton Cooperative Sustained Yield Unit: Planning Their Future in a Changing World

Collins, C. 1971. 25 years later: the circle that still works. Reprint from American Forests, October 1971.

A Walk on the Waterfront, Simpson Timber Company Open House pamphlet. Held May 14 and 15, 1986.

Simpson Timber Product Sheets: Guardian Siding, Regular HDO

(High Density Overlaid plywood), Overlaid plywood sign panels, Mezzdek (mezzanine floor panel), A-MATE (plywood concrete form panel), TUF-TRED SKIDGUARD (textured, polyglass overlaid panel).

MACMILLAN BLOEDEL LIMITED

PRIMARY SOURCES OF EVIDENCE

Interview with Pat MacDonell (Manager, Inventory Section) and Brad Whitehead (Coordinator-Information Services), May 29, 1989

Interview with Jack Lavis (Superintendent, Forestry and Logging--Cowichan Logging Division), May 30, 1990

SECONDARY SOURCES OF EVIDENCE

Lavis, J. 1990. Application of GIS at the divisional level. p. 121-124 in GIS '89: A Wider Perspective. Symposium held in Vancouver, B.C. 7 - 10 March, 1990.

MacMillan Bloedel Facts and Figure, Issued March 1989.

"About MacMillan Bloedel" Information brochure printed by MacMillan Bloedel.

MacMillan Bloedel Annual Review, 1988.

PROVINCE OF BRITISH COLUMBIA MINISTRY OF FORESTS

PRIMARY SOURCES OF EVIDENCE

Interviews with Allen Prelusky (Timber Supply Forester) and Raoul Wiart (Remote Sensing Officer), May 26, 1989

SECONDARY SOURCES OF EVIDENCE

Hegy, F. 1990. The role of GIS in provincial inventories. p. 85-88 in GIS '89: A Wider Perspective. Symposium held in Vancouver, B.C. 7 - 10 March, 1990.

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Mitchell, A. 1990. Harvest planning on a micro-based GIS: a

description of the Ministry of Forests' "Harvest Management System" p. 145-150 in GIS '89: A Wider Perspective. Symposium held in Vancouver, B.C. 7 - 10 March, 1990.

Williams, D., L. Dellert, and P. Bunnell. 1988. Proposed Forest Resource Analysis System (FRAS): Problem Analysis and System Concept. British Columbia Ministry of Forests, 13 p.

British Columbia Terrain Resource Information Management Program: A new dimension in mapping information. Ministry of Environment and Parks, Victoria, B.C.

FOREST ACT (RS 1979, chapter 140) Consolidated August 16, 1988

Morice Timber Supply Area: Timber Supply Analysis Report, October 15, 1987.

Overview of the Inventory Program, Ministry of Forests, Province of British Columbia, Two page information paper.

Forest Inventory Manual, BC Ministry of Forest
 Chapter Two: Public Involvement (1984)
 Chapter Three: Resource Management Plans for Timber Supply Areas
 Chapter Eleven: Forest Resource Geographic Information System (1989)
 Chapter Twelve: Map Overlays (1989)

Forest Planning Framework, Ministry of Forests, 36 p.

LRSY Calculation History, Two page information paper, Ministry of Forests.

Maps: The Sunshine Coast Planning Project (Sunshine Coast Timber Supply Area)--Three 8.5 X 11 color maps.

Remote Sensing for Inventory Update, One page information paper.

WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES

SOURCES OF PRIMARY EVIDENCE

Interviews with Al Vaughan (GIS Coordinator, Olympic Region) and George Flanigan (Hoh District Manager), June 2, 1989

SECONDARY SOURCES OF EVIDENCE

TOTEM, Washington DNR bi-monthly publication
 Forest Practices (December 1985)

Special Lands (Summer 1988)
San Juan Islands (August 1986)
Urban Forestry (Spring 1987)
Aquatic Lands Enhancement Account (Summer 1987)
Timber, Fish and Wildlife (Fall 1988)
Timber Sales (August 1985)
Fiscal Year 1987 Annual Report (Spring 1988)

Gregg, T.W.D., L.J. Sugarbaker, E.W. Barthmaier, R.B. Scott, and R.A. Harding. 1980. Development of a Statewide Geographic Information System in Washington. Washington DNR. 135 p.

FY 1987- FY 1988 Biennium Report, Washington DNR 48 p.

Organization Chart, Washington DNR. 1 p.

State Forest Board Lands: A Report to the Counties 1987, Washington DNR. 45 p.

Five Million Acres: The Public Lands Story, Washington DNR, 10 p.

Forests for the Future: The Renewable Resource, brochure.

Appendix C
Organization Profiles

POTLACH CORPORATION

Potlach is a publicly owned, diversified forest products company with 1.5 million acres of timberland in Arkansas, Idaho, and Minnesota. The company manufactures primarily bleached fiber products and wood products.

Potlach is decentralized, so the three divisions essentially act as separate companies. This case study includes only the Western Division, headquartered in Lewiston, Idaho.

The Western Division has extensive manufacturing facilities in Lewiston, including a tissue and toweling mill, a polyethylene extruder, a bleached paperboard mill, a bleached kraft pulp mill, and a sawmill. Other manufacturing facilities include sawmills in both Santa and St. Maries, Idaho; a plywood plant in Jaype, Idaho; and a particle board plant in Post Falls, Idaho. Potlach owns approximately 600,000 acres of timberland in Idaho; in addition, the company deals with an additional 1.5 million acres of land in other ownerships in Idaho.

Potlach's Wood Products Division is headquartered in Lewiston, Idaho. Potlach's GIS is situated in the Inventory Systems Section in Lewiston. In addition to the Lewiston staff, Potlach has the Clearwater Woodlands staff located in Headquarters, Idaho, and the Northern Woodlands staff, located in both St. Maries and Bovill, Idaho.

SIMPSON TIMBER COMPANY

The Simpson Investment Company is headquartered in Seattle, Washington. It is the parent company to three operating units, including the Simpson Timber Company, Simpson Paper Company, and Pacific Western Extruded Plastics Company. It is a privately owned, decentralized organization.

The Simpson Timber Company, which is the focus of this study, is headquartered in Shelton, Washington. Manufacturing facilities include the Olympic Panel Products Plant and a sawmill in Shelton, and a sawmill in Dayton, Washington. The Simpson GIS is located at company headquarters in Shelton, Washington. Simpson invested \$24 million in a restructuring program between 1985 and 1986. The restructuring goal was to make Simpson competitive by focusing on those businesses which have the greatest economic potential.

Simpson timber has a unique 100 year sustained yield

contract with the U.S. Forest Service, signed in 1946 under Public Law 273 of the 78th Congress.

The agreement, which created the Shelton Cooperative Sustained Yield Unit (CSYU), combines 351,000 acres of Forest Service and Simpson Timber land under common management. The purpose of the CSYU is "to promote the stability of forest industries, of employment, of communities and of taxable forest wealth..." (Collins 1971). The Shelton Unit is the only cooperative program established under the 1944 legislation.

Simpson Timber's Olympic Peninsula's activities have been substantially governed by the CSYU agreement for more than 40 years. Under the agreement, Simpson timberland and adjacent Forest Service timberlands are managed as one unit. The CSYU agreement has 3 basic provisions:

1. Management and harvesting from Simpson and Forest Service lands are coordinated through jointly prepared plans;
2. Simpson has the exclusive right to buy, at the appraised price, all timber sold by the Forest Service within the CSYU boundaries; and
3. A volume equal to 80% of all timber harvested in the CSYU must be processed in the Shelton/McCleary areas.

Simpson is currently attempting to amend the CSYU agreement so that no more than 50% of the volume harvested from the CSYU must be processed locally.

BRITISH COLUMBIA MINISTRY OF FORESTS

The Ministry of Forests administers approximately 52 million hectares of Crown lands in British Columbia. The Ministry of Forests is headquartered in Victoria, British Columbia. The two Ministry branches responsible for forest planning are the Planning Branch and the Inventory Branch. The Planning Branch is responsible for developing planning policy and procedure, directing the ministry's public involvement program, providing technical support for planning throughout the Ministry, and monitoring regional planning activities. The Ministry GIS is located in the Inventory branch, thus this case study concentrates on that branch.

The Inventory Branch is responsible for the Inventory program, which includes the compilation and maintenance of

forest inventory on all Crown lands in British Columbia. Other responsibilities, besides maintenance of the database, include the annual update of resource maps and associated data files, the collection of growth and yield statistics, the estimation of decay, waste and breakage, and the continuous monitoring of forest depletions. In 1986, the mandate of the Inventory Branch was expanded to include both range and recreation inventory.

Besides the Branch staffs, there are six regions in the province and up to seven districts within each region. Regional staff prepares Timber Supply area plans, and District staff implements plans.

The Ministry adheres to the principle of integrated resource management, thus its planning is a comprehensive process for developing a mosaic of land use that reflects "optimal allocation and management." To develop this mosaic of land use, they follow a rigid planning process which includes information assembly, analysis, evaluation of options (including public input), selection of an option, implementation, and monitoring.

The Ministry involves the private sector in data collection, analysis, and applications on Crown lands. The Ministry administers two types of units: Timber Supply Areas (TSAs) and Tree Farm Licenses (TFLs). Planning and administration of TSAs is the responsibility of the Ministry of Forests. After the Ministry completes a TSA plan, the wood to be harvested is sold through licenses to small companies. The area of the TSA is allocated to those companies as twenty year operating areas. There are 35 TSAs in the province.

Larger private companies, such as MacMillan Bloedel, lease TFLs through the Ministry. The private companies are responsible all aspects of managing a TFL, including calculating AAC and writing plans. The plans are reviewed by the Ministry of Forests.

The Ministry GIS is located at the Inventory Branch Office in Victoria. In addition, each of the six regional offices has a micro-based GIS. The Ministry is in the process of getting GIS to the district level.

MACMILLAN BLOEDEL LIMITED

MacMillan Bloedel is one of North America's largest forest products companies with integrated operations in Canada and the United States as well as major investments in Canada, the United Kingdom, and Continental Europe. The

Company manages 1.5 million hectares of productive timberlands which supply most of its total fiber requirements. Of these timberlands, one million hectares are in British Columbia where the Company's head office is located and approximately half of its capital is invested. The products of MacMillan Bloedel and its affiliated companies are marketed throughout the world and include lumber, panelboards, kraft pulp, newsprint, groundwood printing papers, fine papers, containerboard and corrugated containers.

MacMillan Bloedel was decentralized in early 1982 into separate management units. The new organizations consists of five primary operating units: Alberni Region, Nanaimo Region, Powell River Region, the Containerboard and packaging Group and the Marketing Group. Each of MBs operating units is run much like an independent forest products company, with one man in charge and responsible for the unit's results.

This case study concentrated on the Nanaimo Region in British Columbia. Interviews were conducted at both the regional office in Nanaimo, where the primary GIS is located, and at the Cowichan Logging Division, which has acquired a micro-based GIS. The Nanaimo Region also includes the Queen Charlottes, Northwest Bay, and Stillwater logging divisions. MacMillan Bloedel administers both Tree Farm Licenses leased from the provincial government and private lands.

WASHINGTON DEPARTMENT OF NATURAL RESOURCES

The Washington Department of Natural Resources is a state agency that manages five million acres of state land. The Department's mandate is to preserve the land and keep it productive. Where appropriate, they also generate dollars to support the state's schools and other institutions.

The state lands managed by DNR are varied. The lands are administered to provide opportunities for people to purchase resources such as timber, minerals, and gravel, lease or rent land for agriculture, grazing, aquaculture and commercial uses, lease land for mineral and oil and gas exploration, and use the land and water for recreation.

As Trust land asset managers, DNR manages about three million upland acres for the financial support of public schools, state universities, county governments and other institutions. Revenue is primarily earned from timber sales and land leases.

DNR also carries out a variety of natural resource service and regulatory duties. They fight fires on private and public lands and regulate forest practices; advise small tree farmers on the best forestry practices; operate recreation sites; regulate oil and gas drilling and surface mining; and provide geological information.

Washington DNR is headquartered in the state capital of Olympia. There are seven regions throughout the state; each region contains one or more districts.

This case study concentrates on the Olympic Region, headquartered in Forks, Washington. The Olympic Region is the lead region for GIS within Washington DNR. Region GIS staff participated in the interviews to explain the GIS perspective. The manager of the Hoh District was also interviewed to obtain the user's perspective.

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