MAKING GIS WORK IN FOREST MANAGEMENT

Glen A. Jordan, RPF

Faculty of Forestry
University of New Brunswick
Fredericton,
New Brunswick E3B 6C2

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ABSTRACT

It is not particularly difficult, in today's climate, to justify acquisition of a GIS in most forestry organizations, since the technology offers great upside potential and apparently very little downside risk as an aid in forest management decision making. However, the processes of acquiring and implementing a GIS are far more difficult rows to hoe. Although there is great opportunity, there is also great risk of error and waste of large amounts of money and time. This paper exposes those considerations, issues and questions most crucial to the successful acquisition and implementation of a GIS for forest management.

Keywords: forest management, GIS, implementation, pitfalls
INTRODUCTION

Forest management is held out as the solution to a future shortfall in Canada's forest growing stock and geographic information systems (GIS) are currently the darlings of the forestry profession. That the convergence of the two on the forestry scene is more than coincidence could be debated but, that design and implementation of the former could be greatly facilitated by implementation of the latter is fact. However, both are relatively new commodities and as a result not only their implementation but their relationship as well are poorly understood. This paper will concentrate on geographic information systems and their implementation for forest management decision making.

A reasonable starting point would seem to be with definitions of forest management and geographic information systems. Forest management involves the design and implementation of a plan of actions (and inactions), sequenced over time and geographic space in order to control the future forest in terms of its, structure (distribution of the forest over age classes and geographic distribution of age classes) and thus a desired flow of benefits. A GIS, on the other hand, is computer-based technology characterized by specific hardware and software that permits the simultaneous storage, management and analysis of data along with its geographic location. It is, in other words, a spatial database management system.

It is not difficult to make a case for GIS technology as the basis of an information system for decision support in forest management. Forest management has both temporal and spatial dimensions involving decisions of not only what, how much and when, but also where. Since a GIS is unique among information systems in that it accommodates spatial data, thus permitting the management of resources over time and space, it seems logical that GIS technology should form the basis of a decision support system in forest management. There is very little risk that making a decision to implement a GIS will be a wrong one; in fact, it's fair to say that forest companies who ignore GIS technology risk being taken over by competitors who take advantage of it. However, the real risk, of which there is plenty, arises in attempting to achieve a successful GIS implementation. In addition to meeting specific organizational objectives, a successful GIS implementation will be one characterized by at least:

(i) being on schedule,
(ii) being within budget,
(iii) giving reasonable response times to user queries,
(iv) meeting or exceeding user and management expectations,
(v) providing forest management decision support at intended levels of application (policy, management and/or operating), and
(vi) obtaining support of key personnel - managers, users and technocrats.

GIS IMPLEMENTATION PLANNING

The approach to implementing a GIS should not really be any different from the generally accepted approach to designing and implementing forest management. Clearly and quantitatively stated objectives (including intermediate milestones) must be present and the best possible plan of action for reaching those objectives must be identified. The success of a GIS implementation will be measured, like forest management, in terms of its achievements and not in terms of good intentions and valiant efforts (Wellar 1982).

The only way that success can be gauged is for achievements to be measured against originally identified milestones and objectives. Generally, a GIS implementation plan must address the following technical, financial, and institutional considerations:

(i) system acquisition tactics and costs,
(ii) data requirements and costs,
(iii) database design,
(iv) initial data loading tactics and costs,
(v) system installation tactics, timetable and costs,
(vi) system life cycle and replacement costs,
(vii) day-to-day operating procedures and costs,
new staffing requirements and costs,
user training and costs, and
application development and costs.

The mere presence of an implementation plan, however, does not guarantee success. There is ample evidence that GIS implementation planning is fraught with many pitfalls. Keeping in mind the aforementioned planning considerations, this paper will expose those technical, institutional and financial pitfalls that are most likely to contribute to the failure of a GIS implementation for forest management decision making. The pitfalls have been gathered from several sources: including, journal articles, conference and symposium proceedings, personal experience and from conversations with experienced individuals.

GIS IMPLEMENTATION PLANNING PITFALLS

Pitfall #1: Failure to Identify the Users
Ultimately users determine what data a system should maintain, how it should process the data and the form that it should be presented in for decision making. It would seem to be obvious then that users needs should receive due attention in any implementation plan. However, it's a focus that's made illusive by the nature of forest management decision making. Users in a forest management environment are spread over three different levels of decision making: policy, management, and operations. Information requirements are very different at each of these levels. The trick, "...is to design and implement an information system that maintains information consistency across all levels of decision making, while still providing each level with information at the scope and resolution that it requires," (Baskerville 1988). This is not to say that all GIS implementations must serve all three levels of decision making to be successful.

However, a failure to recognize the hierarchical nature of forest management decision making and differing information needs will result in a GIS implementation that lacks user focus and serves neither policy, management nor operations decision making.

It is, therefore, crucially important to know who the intended users of a GIS are to be designers of policy, management and/or operations.

Pitfall #2: Failure to Involve Managers and Users, as well as Technocrats
A GIS will impact significantly on an organization. In particular, it will introduce new information gathering procedures, new processing requirements, new output products, new staff responsibilities and, perhaps, new approaches to forest management decision making itself. People in an organization will be affected! A basic management tenant introduced to students of management early in their studies is that participation is a key to success. If the people in an organization that will be affected by a new initiative are not involved in its design, their crucial input will be missed, their support lost and failure of project implementation ensured.

It is, therefore, important that GIS implementation involve representatives from various levels within an organization: decision makers, managers, technocrats and, most importantly, forest managers (Baskerville 1988)(Newton 1986).

Pitfall #3: Failure to Match GIS Capability and Needs
Today, unlike the situation just five years ago, GIS hardware and software choices are many and varied. There are presently dozens of systems being marketed in North America. They cover the cost/performance spectrum; ranging from microcomputer configurations of relatively low cost ($15,000) and performance, up to minicomputer configurations of much greater cost ($250,000+) and performance. A buyer is presented with a significant challenge making the right choice. The right choice will be the GIS that provides the needed performance no more, no less for the minimum investment (Burrough 1986).

GIS implementation success is particularly sensitive to the right hardware and software choices. Specifically, selected hardware and software must satisfy capacity, i.e. specific data needs and volumes, and function, i.e.
specific data processing needs associated with anticipated application development. Identification of capacity and functional needs can be difficult and even frustrating but, failure to do so will result in one of two outcomes. In the worst case the selected GIS will never get past the data loading stage of its implementation. In the best case, the GIS implementation will be retarded in its evolution and fail, or be slow, to achieve its intended place as a forest management decision support tool (Crain 1983).

It is, therefore, important for a GIS implementation plan to initially specify a requirements and assessment study to guide GIS selection.

**Pitfall #4: Failure to Identify Total Costs**
GIS acquisition cost is relatively easy to identify; involving essentially the initial purchase price of GIS hardware and software. Although seemingly large, it will in fact represent a very small fraction of the total cost of implementing a GIS. Significant, ongoing costs will include hardware and software maintenance, system infrastructure construction, staffing, system administration, initial data loading, subsequent data updating, system programming, eventual system hardware replacement, and perhaps consulting fees. A failure to identify all costs, up front, will result in the need to repeatedly requisition additional unexpected funding. An organization’s financial planners are intolerant of such surprises (Brown 1986).

It is, therefore, important that a GIS implementation plan incorporate accurate, relatively long-term, cost projections for all aspects of GIS operation, if project credibility is to be maintained and GIS implementation allowed to evolve fully.

**Pitfall #5: Failure to Conduct a Pilot Study**
A GIS implementation plan must deal with many technical and administrative issues and their related cost impacts. Three of the most crucial issues, in terms of failure sensitivity, are database design, data loading and maintenance procedures, and day-to-day operating logistics. Resolution of database design issues, data capture tactics and costs, data needs and storage amounts, processing needs and times, manpower time and costs, and administrative logistics will require the collection of detailed information. The time-honoured pilot study has considerable merit in this regard. The idea is to gather detailed observations from a test of sufficient duration, size and complexity to be representative of operational conditions. Failure to do so will guarantee implementation foul-ups.

It is, therefore, important in a GIS implementation plan to spell out design specifications as well as time and cost forecasts.

**Pitfall #6: Giving GIS Implementation Responsibility to the DP Department**
Spatial data handling is not even close to running a payroll system or, even a forest inventory of the past; it has special problems which depend upon a unique body of knowledge for solution (Marble 1982). Although an organization’s Data Processing Department will ultimately provide some technical staff, the GIS implementation team is best staffed, at least at the top, by non-data processing types. This would include a manager who falls somewhere in the cracks between forest manager and GIS analyst. To do otherwise will ensure failure (Brown 1986).

It is, therefore, important that GIS implementation not be managed by an organization’s Data Processing Department.

**Pitfall #7: Failure to Consider Technology Transfer**
As stated earlier, spatial data handling represents an unique body of knowledge with its own problems and solutions. GIS technology is also relatively new and it is unlikely that personnel within an organization will have a great deal of understanding and appreciation of it. A GIS implementation plan should, logically, identify and address training needs on two fronts: (i) targeted users, i.e. forest managers, and (ii) technocrats. The education of either group is not a one-shot, quick and dirty affair. Spatial data handling is not only an unique body of knowledge, it is also a very large and complex one. While failure to educate in-house technicians will merely necessitate hiring new college or university educated individuals (likely in any event), failure to educate targeted users will ensure that a GIS implementation becomes an end in itself; failing to generate applications characteristic of a forest management decision support system.
It is, therefore, important that a GIS implementation plan budget time and money for the education and training of the principal users of the technology the forest managers. To a lesser extent, training of in-house technicians is important as well.

SUMMARY

While it may not be difficult to justify the acquisition of a GIS for support of forest management decision making, successful implementation requires great care and attention. To have a chance at success, GIS implementation must be a controlled undertaking; planned to serve the design and implementation of forest management. A plan's ultimate success, regardless of how it is decided to measure it, will depend upon the degree to which it addresses, in as comprehensive and quantitative manner as possible, an array of technical, financial and institutional questions while avoiding some known pitfalls and oversights.

REFERENCES


APPLICATION OF GIS AT THE DIVISIONAL LEVEL
Geographic Information Systems
or
Garbage Induction Systems?

Jack Lavis
Superintendent, Forestry and Logging
MacMillan Bloedel Ltd.
Cowichan Logging Division
PO Box 630, Chemainus
British Columbia, V0R 1K0

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ABSTRACT

MacMillan Bloedel acquired their first GIS in 1980. The system has been primarily used for forest inventory and fibre supply analysis at the corporate level. Over the past year the Cowichan logging division of MacMillan Bloedel has been using a microcomputer-based GIS for silviculture record-keeping and development planning. The system is linked to the corporate GIS. This paper will discuss the division's experience with GIS and provide some insight into how a GIS might be justified at the operational level.
INTRODUCTION

One of the most important pieces of information for the foresters and engineers at the Division is the inventory. Three factors which make the inventory workable are:

- reliability
- date last revised
- ease of access

In our particular case in the past all three items above were serious problems.

a) Reliability - last cruise conducted on our second growth which represented 65% of our holdings was 1969.

b) Date last revised - normally our inventories were three to four years behind with respect to current information, (logging, roads, planting, etc.).

c) Ease of access - all queries were made through our Inventory Section in Nanaimo and handled on a "time available" situation. Therefore very little was asked for.

Our inventory presently breaks down as follows:

<table>
<thead>
<tr>
<th>Mature 101+ yrs</th>
<th>Immature 1-100 yrs</th>
<th>Deciduous Alder/Maple</th>
<th>N.S.R.</th>
<th>N.P. rock/swamp/alpine</th>
<th>N.S.F. farm/roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>.12,181</td>
<td>46,186</td>
<td>2,388</td>
<td>1,603</td>
<td>6,027</td>
<td>3,023</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71,408 ha</td>
</tr>
</tbody>
</table>

How did we end up with our GIS and what do we intend to do with it?

THE BACKGROUND

So how did we proceed to get a good "GIS" in place with the following points in mind:

- reliable, accurate information
- current updated inventory
- compatible software/hardware with our Nanaimo section
- user friendly

During 1985 our company decided to expand on the "Intergraph System" it was using as a computer aided mapping system to a graphics information system. The two systems looked at were:

- update of Intergraph
- E.S.R.I.

Early in 1986 our company made the decision to go with the E.S.R.I. geographic information system. We then decided to become totally compatible with our Nanaimo end and also work towards being self sufficient.
THE PLAN

To eventually end up where we would feel we had a good workable system required the following:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CORPORATE COST</th>
<th>DIVISIONAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Hardware/Software</td>
<td>$35,675</td>
<td></td>
</tr>
<tr>
<td>- New updated Second Growth Inventory</td>
<td>325,598</td>
<td></td>
</tr>
<tr>
<td>- Updated 1-20 year old inventory</td>
<td>48,000</td>
<td></td>
</tr>
<tr>
<td>- Totally updated Div. Inventory</td>
<td></td>
<td>$149,000</td>
</tr>
</tbody>
</table>

Dec. 31, 1988
- Software Programming
  8,000
- Digitizing 1:5000 topog. maps
  6,000
- Digitizing Forestry area openings
  3,500

$426,773 $149,000

If you have any knowledge of being in the forestry department at a logging division you will understand what the reaction would be from your manager coming forward with the above request.

Therefore we put together the following time frame that would see us totally operational by August 1989 and add to the data base during 1990.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
<th>TIMING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namtec ATP Computer (1.2 floppy)</td>
<td>2,999.00</td>
<td>Feb/87</td>
</tr>
<tr>
<td>40 meg hard drive</td>
<td>1,760.00</td>
<td>Feb/87</td>
</tr>
<tr>
<td>80.287 math co-processor</td>
<td>495.00</td>
<td>Feb/87</td>
</tr>
<tr>
<td>Tecmar EGA Master</td>
<td>495.00</td>
<td>Feb/87</td>
</tr>
<tr>
<td>Datatrain DC350 Monitor</td>
<td>729.00</td>
<td>Feb/87</td>
</tr>
<tr>
<td>Roland PR 1012 Printer</td>
<td>379.00</td>
<td>Feb/87</td>
</tr>
<tr>
<td>Tektronix 4696 Colour Copier</td>
<td>3,153.00</td>
<td>May/87</td>
</tr>
<tr>
<td>Arc Info &quot;Starter Kit&quot;</td>
<td>3,600.00</td>
<td>Feb/88</td>
</tr>
<tr>
<td>Parallel Switch - Printers</td>
<td>100.00</td>
<td>June/88</td>
</tr>
<tr>
<td>Arc Plot software Package</td>
<td>1,800.00</td>
<td>June/88</td>
</tr>
<tr>
<td>Updated Second Growth Inventory</td>
<td>325,598.00</td>
<td>Jan-Dec 88</td>
</tr>
<tr>
<td>150 Meg. Hard Drive</td>
<td>2,350.00</td>
<td>Jan/89</td>
</tr>
<tr>
<td>Digitizer (Edit Maps)</td>
<td>4,000.00</td>
<td>Mar/89</td>
</tr>
<tr>
<td>Plotter &quot;Calcomp 1023&quot;</td>
<td>8,415.00</td>
<td>Mar/89</td>
</tr>
<tr>
<td>Arc Edit Overlay</td>
<td>5,400.00</td>
<td>Apr/89</td>
</tr>
<tr>
<td>Updated Divisional Inventory</td>
<td>149,000.00</td>
<td>Aug/89</td>
</tr>
<tr>
<td>Software Programming (User interface Menus)</td>
<td>8,000.00</td>
<td>Jun-Dec 89</td>
</tr>
<tr>
<td>Updated 1-20 Year Inventory</td>
<td>48,000.00</td>
<td>1986/87/88/89</td>
</tr>
<tr>
<td>Digitize 1:5000 topog. maps</td>
<td>6,000.00</td>
<td>Mar-Jun 90</td>
</tr>
<tr>
<td>Digitize Forestry Openings</td>
<td>3,500.00</td>
<td>Jul-Sep 90</td>
</tr>
</tbody>
</table>

THE COST $575,773.00
THE USE
One of the most important uses of the GIS will be to analyze the inventory of our operation to assist in:

- logging planning (species, markets, time of year, systems)
- reforestation
- spacing
- thinning
- fertilization
- assessments
- site preparation
- brush control
- etc.

We will also totally update our inventory with current information every three to four months depending upon workload.

EXAMPLES
I have several slides and mapsheets to show you some of the uses we will be getting from our system.

- Specific mapsheets can be queried to illustrate spaced areas and parameters can be given to highlight areas of potential spacing.
- Specific parameters can be fed in on a mapsheet basis to interrogate thinning potentials.
- Specific areas can be blown up for better viewing.
- N.S.R. areas can be highlighted and printed on forest cover maps to facilitate planting and stocking assessments.
- Old growth stands can be queried for high value species (Cypress), and a map produced to facilitate ground reconnaissance.

SUMMARY
There are several GI Systems on the market. Each system has its own specific process of integrating forestry data into a management package. The decision as to which system to use is sometimes determined by cost, compatibility with other company systems etc.

We are very excited at the prospect of working with and growing with our GIS management package. We feel our data base is accurate and will allow us to feel confident with any analysis conducted. The system will definitely save time and all new additions (layers) will be analyzed as to cost/benefit.
SO YOU BOUGHT A GIS - NOW WHAT?

Allan G. Levinsohn
A.G. Levinsohn Consulting Inc.
Suite 1560, 10303 Jasper Avenue
Edmonton, Alberta
(403) 428-7773

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ABSTRACT

Many organizations begin implementation of a geographic information system (GIS) with the selection of GIS hardware and software. The necessary planning and design required for successful implementation is rushed or never performed. As a consequence, many technical, institutional and personnel issues are not dealt with and the systems fail to live up to expectations. Adequate experience with GIS implementation exists to identify aspects of project planning and organization that can help to ensure successful GIS implementation. These include comprehensive project planning, appropriate staffing and training, formalized application selection and design techniques and executive commitment to system implementation.
INTRODUCTION

Most automated information system projects do not fail because of a lack of technology or technical failures. They fail because of poor project planning and management.

The cost of the project is underestimated losing management support prior to completion, or inadequate time is allocated for staff training and the projected productivity is not achieved, or worse, there never was a project plan. Applications for use of the system were not selected and designed, they just happened.

The selection of geographic information system (GIS) hardware and software should occur toward the end of the implementation process, but more often then not, it is the starting point for GIS implementation. Once the system is in-house, the pressure to produce something is on. Planning and organizational issues become dealt with in an ad-hoc, reactive manner rather than in a well conceived proactive plan. How often is the phrase "let's quit talking about it and get on with it" heard? This statement may result from ignorance of the "pitfalls" in implementing automated information systems, past frustrations with previous poorly organized planning exercises, or unrealistic commitments made to management in order to sell them on the GIS. Often it is said that "we don't have time to go through all this planning, we have to have this system implemented right away." The importance of effective planning increases with the pressure for speedy delivery of the completed system. It is when a truly tight schedule must be met that we must learn to do work less of the time and to plan more of the time.

Clearly the size and scope of the system governs the size of the project, the amount of staff, and the complexity of the plan. However, unless you will forever be the only user of the system, unless you never plan to leave, and unless no-one else will ever be interested in the outputs of your system; at some point your work will have to be integrated with that of others. How well that occurs is a function of how well thought-out the process for accomplishing integration was.

This paper presents some aspects of planning and organization management essential for successful GIS implementation.

BACKGROUND

In a recent study involving case histories for about 500 system development projects since 1977 it was found that fifteen percent of studied projects were aborted in progress or delivered products that were never used (DeMarco and Lister, 1987). Twenty-five percent of major projects (lasting 25 work-years or more) failed to be completed (Jones, 1981). In the overwhelming number of these projects there were no technological issues to explain the failures. It was found that most failures could be attributed to the sociology of the project team; "the major problems of our work are not so much technological as sociological in nature" (DeMarco and Lister, 1987).

Examples of sociological and institutional problems that may be encountered are: communication problems during system design, resistance to technological change from perceived personal threats to job or power, lack of executive commitment, under estimates of required resources, over estimates of returns, inadequate integration of the system with business functions, and a lack of will to make the institutional changes required to derive cost-effectiveness from the system.

Even with adequate planning significant problems can result from poor communication between the end-user and the system designer as to what is required and what can be delivered. The process of design and implementation often changes the user's perception of his needs. What was asked for may not be what is needed after the system has been implemented. Many processes that support decisions, particularly senior level ones, are based on the decision makers mental image of the problem relying on information gathered through a variety of personal experiences. Such a process is not explicit or easily quantifiable and is difficult to support with an automated information system.

Implementation of new technology leads to changes in the organization. Systems that have been designed to meet needs specific to the current operations of an organization may not meet the needs of the changed organization.
Most existing functions have been based on techniques and information that could be provided prior to the introduction of automated systems. The introduction of automated techniques changes the scope of what is feasible and many old processes are reconceptualized within the new bounds of what is feasible. Systems designed too closely to current procedures may prove to be inadequate within the new realms of what is feasible.

Many early system development projects promised more than could be reasonably delivered, or cost significantly more than planned. Often management has become appropriately sceptical of new system projects and claims of enormous gains in efficiency and effectiveness.

Project planning cannot eliminate these problems but it can develop specific strategies for dealing with them and reducing their impact on the success of the GIS.

**PROJECT PLANNING**

Effective project planning begins with well defined goals and objectives. Only a clear definition of mission and purpose of the business makes possible clear and realistic business objectives (Drucker, 1973). The business objectives of the company are the foundation for strategies, priorities, plans and work assignments. Managerial jobs, organizational structure and the company's business strategy are all governed by the business objectives. An automated information systems strategy should support the needs of the organization as defined by its business objectives. The information systems strategy identifies what business activities will be affected by implementation of the strategy and how they will be affected.

Ideally, GIS planning is performed within the framework of an overall corporate automated information systems strategy of which GIS only forms a part. The GIS should be designed to support related business objectives and the implementation plan should identify the means for integrating its use into the overall stream of day-to-day business activities.

When the purpose of the GIS has been established, implementation planning can proceed. There are many structured approaches for design and implementation. Regardless of the approach used, system development can be considered to occur in four phases:

- **Conception**
  
  the process that leads to the initiation of the GIS project. The political, administrative and monetary commitments are obtained and the general system philosophy and scope are determined.

- **Design**
  
  the general philosophy developed during the first phase is translated into a precise definition of the system, within the scope and monetary constraints identified in the conception phase.

- **Implementation**
  
  the process of constructing the design created in the second phase.

- **Operation and Maintenance**
  
  making the system available to users and satisfying the objectives identified during conception. It includes day-to-day technical management, enhancements, and performance evaluation.

The design and implementation phases can be further subdivided into: conceptual design, strategic planning, application selection and design, database design, system acquisition, installation and training, and data capture/conversion. Often the tasks are not as distinct as presented here, and frequently early tasks are revisited during actual implementation.

The principal objective of the process is to build a technically successful system that is utilized by the end-user and that satisfies the organizational objectives. Successful implementation is in part measured by the long term
usefulness of the system. The completed system should be capable of being modified to accommodate growth and organizational change.

Structured techniques for system design and implementation are well defined in a considerable number of works, including that of Booth (1983), Martin and McClure (1985) and Yourdon (1986), and will not be dealt with in this paper. However, a set of generalized tasks can be derived from these to serve as context for the discussion in the next section of this paper.

The significant data that is used to support decision making at various levels such as the TFL, the compartment, the stand and the cut-block must be determined. To organize the data it is necessary to determine the "procedural context" of the data. That is, how the data are used in the company - who collects it, analyses it and uses it in making decisions. The sources of the data can then be determined. Does the data originate in company, or is it received from a government department, and so forth. Related technical issues must also be dealt with - such as content, requirements for special formats, timeliness, and exchange standards.

Within this context it is possible to define appropriate roles and responsibilities for data collection and maintenance, the setting of standards and policies and for resolving issues related to processing and dissemination. The result should be an understanding of current information use in the company. This must then be adjusted to account for planned changes identified in the strategic plan, above.

With an understanding of information use in hand, it is possible to determine the appropriate type and amount of technology to support the company's information handling requirements. The component technologies needed for each part of the identified process can be determined. Other issues that must be dealt with at the same time are: integration of component technologies, location of the equipment (degree of decentralization), responsibility for management (maintenance, etc.), and the "upgrade path" for the system (how to accommodate new needs).

At this point, institutional impact issues should be revisited. The requirements for training, new staff, changes to organization structure and procedures should be reviewed and a plan for change management determined.

If the preceding process is performed well, realistic costs and schedules for implementation can be determined. It is also possible to predict what changes are likely to occur and what will need to be done to deal with or take advantage of them.

PROJECT ORGANIZATION

The previous section dealt with the planning process. The intent of this section is to provide some general points with respect to the administration of GIS implementation and operation.

Some of the issues raised may seem to be obvious and the resolution of them natural. However, first-hand and documented experience in system development have shown these issues to be major causes of system failure. The following paragraphs present some of the key issues in ensuring successful system implementation.

Executive commitment for the project is essential to ensure that adequate resources are provided and that necessary policy issues will be dealt with. Management must be well informed by the project team at the outset of the phases of development and the amount of time and effort required to develop the system. An honest assessment and characterization of the project at the outset will prevent many later problems.

A high degree of end-user involvement in all aspects of system development builds commitment to the system, establishes credibility of design, and ensures the system will be used and meet user's needs.

The use of technical consultants for analysis and design tasks will speed implementation by shortening learning curves and provide needed on-site experience prior to company staff having attained it.
Contracting-out large easily defined tasks (e.g. large data conversion efforts) that draw heavily on internal resources, while producing little in the way of user satisfaction, or technical tasks that require sophisticated expertise for short periods, will reduce pressure on company staff and accelerate system implementation.

A multi-year system implementation plan should identify the requirements, resources, and responsibilities of departments and individuals involved in the project. The plan should identify the operational goals, objectives and policies; document existing capabilities, define the specific needs; and state the design methodology, and work schedule for the project.

All aspects of the project should be well documented to speed user and new technical staff training, to establish and communicate standards, to eliminate the dependence on individual personalities, and to facilitate staff transfers.

The implementation of new technology provides an opportunity for re-evaluation of organizational structure, mandates and information flows. A properly coordinated project will have the representation and management support necessary to evaluate opportunities for beneficial organizational change. A project committee structure should be established to facilitate the necessary coordination. The number and size of committees and the frequency of meetings will depend on the organization culture of the company and the size of the project.

There should be a senior management committee comprised of the senior managers of departments involved in the system implementation chaired by the CEO or his designate. This committee should review project progress, and set policy and budgets. The head of organizational unit responsible for the GIS implementation reports to this committee.

Complementing the senior management committee should be a project management committee comprised of middle managers or senior professionals of the departments that will be using the GIS, including service departments responsible for accommodation, telecommunications and so forth. This committee monitors progress of the project, reviews recommendations from the project manager, approves expenditures within budget, and ensures adequate cooperation from participating departments. The project manager reports to this committee.

In larger companies and for larger projects it may be beneficial to have one or more end-user working group(s). These are comprised of senior working staff from departments that will be or are planning to implement GIS applications. These can be chaired by the Project Manager. They provide access to the information and data required for application design and implementation, review the application designs and prototypes, and facilitate training and analysis sessions. Such committees are good vehicles for building the end-user involvement and commitment essential for successful system implementation.

Another optional committee, again depending on project size and complexity, is a technical advisory committee. It is comprised of technical staff and consultants. Chaired by the Project Manager, it provides the expertise for system analysis and design, technical direction, and recommendations on necessary standards, procedures and so forth.

It is very important that the group or individual best qualified to deal with a specific issue be allowed to decide. In many instances the roles of each group become confused with disastrous results for the project.

**PROJECT STAFFING**

A successful self sustaining system requires knowledgable committed staff. Experience with many system implementations has identified several key positions and the associated necessary skills for a successful system. These positions are based on tasks and functions that have to be performed. How many of these positions exist for any project is determined by the size of the project, the volume of work, the extent to which staff have other duties, and the skills of the staff.
Vendor training covers the software operation but does not deal with other equally important functions of a GIS. The following outlines five key positions, and areas of expertise, recommended for implementing and operating a GIS facility. As projects and systems increase in size, these positions may be split to create more specialized positions.

**GIS MANAGER**

Overall responsibility for the GIS facility rests with a GIS manager. The manager should have a broad understanding of the GIS system, its capabilities, its applications, and the product types which can be generated. The person should ideally have an information systems management background, be skilled in personnel management and possess an understanding of geographic data and its applications. However it is best if the GIS manager is an existing staff member well experienced with the company’s functions trained to become familiar with the GIS software. Knowledge of the business is of greater significance than technical computer knowledge, but prior computer system experience will reduce the learning period. The GIS manager is responsible for administration and planning, budgeting and schedules, and coordination of the user community for their geographic information needs.

GIS line management should not be confused with project management. Line management is business management. It involves all aspects of the business including personnel, finances, and ensuring profitability. The line manager views the GIS project as one among many in the company. The project manager’s only focus is the successful implementation of the system. Special project management and systems analysis skills are required for success. Project management can be frustrating and the position requires considerable skills in negotiation, inter-personal communication, and past experience in the design and implementation of automated information systems. The project manager must plan what is to happen, obtain agreement, and ensure that what has been planned happens. For these reasons, project management is often contracted out.

**GIS SYSTEMS ANALYST**

A geographic information system analyst aids users in identifying and defining GIS products to be generated for each application, performs planning of processing steps for GIS applications, directs in-house software training, and performs data base design and organization. The person should have specific knowledge of the selected GIS software and how it can be used, GIS concepts, data base design principles, application design principles, an ability to communicate and plan specific work tasks for data base creation and management, analysis, and product generation, and a good knowledge of the computer operating system.

**PROGRAMMER**

For successful operation of a GIS it is essential to have a programmer with specific knowledge of the GIS software and how to combine various commands into macros (strings of GIS commands). The person should also have extensive experience with the selected computer operating system including the operating system’s command language, graphics drivers and programs.

The principal responsibility of this person is the writing and testing of macros, isolating software problems and debugging the site-specific software. However in smaller installations, this person is often responsible for backups and other general system maintenance as well. The GIS programmer can be an existing staff member with the appropriate computing skills trained to perform the required functions. However, given the time required to become knowledgeable, it will be more cost-effective to hire a programmer, if there is no one in the organization well versed in the operating system and programming languages of the selected hardware.

The programmer may also act as a senior processor generating GIS products. In that case, a knowledge of map projections, scale and other aspects of cartography are required for processing cartographic files for map production. Other duties include managing project directories, performing complex processing functions such as spatial analysis and plot creation.
COMPUTER SYSTEM ADMINISTRATOR

The system administrator must have an understanding of software system directories, organization and use of the computer operating system, the GIS software, other installed peripheral software. Other required knowledge includes: knowledge of on-site hardware, including graphics devices and digitizing tables, and an intimate knowledge of the computer operating system.

This position is responsible for systems management including performing data backups, and installing and maintaining hardware, designing and setting up disk file organization.

The tasks can be performed by the Programmer if he has adequate technical knowledge and if the system is not too large and the development tasks are too numerous, as to affect proper system administration. The person for this position is usually best hired, given the large amount of technical knowledge/experience required. It is not practical to train marginal internal staff.

CARTOGRAPHIC TECHNICIAN

This position is responsible for a wide variety of tasks such as photo and map interpretation, drafting, digitizing and mapping requirements for a particular set of applications.

This position can be filled by an existing staff member trained to perform the required functions. The training requirements are not as extensive as for some of the other tasks; about 2 weeks formal training and 1 - 2 months of work experience to become proficient.

To economize, it is possible to hire a cartographic technician who can also perform routine system administration tasks and some programming (especially new macros). The GIS Manager can also perform some system administration tasks, depending on technical expertise and workload. However, it is essential that the system administration tasks are properly and routinely performed, therefore, although it may be possible to share the work and save on staff, it must be a top priority for the staff responsible - the entire investment in the system depends on it.

For some positions, such as the Programmer and the Cartographic Technician it is useful to have highly experienced help immediately upon installing the system. There are several options for obtaining good technical support. Although good staff are scarce and may be expensive, hiring for a longer term position such as the Cartographic Technician is usually the best approach. Experienced staff can be contracted from a consulting firm to undertake the front-end development and provide in-house training of permanent staff. A contract programmer can work on-site for a year or so as part of the purchase agreement with the GIS vendor.

End-user training is usually provided by the GIS software vendor. If possible, this training should be taken in stages to permit practice and familiarization prior to proceeding with more complex uses. This is particularly significant for the Cartographic Technician, Programmer and System Administrator.

The system can also be implemented so that most of the user access is through menu-driven interfaces to custom applications. This reduces the amount of end-user training required, but increases implementation costs and the need for an experienced programmer at the outset of implementation.

CONCLUSION

In summary, don't begin GIS implementation by buying a system, but if you have, take the time to deal with planning and organization issues anyway; only limited success is possible without doing so.

Make sure the following are in place: executive commitment for the project, a multi-year implementation plan based on a comprehensive system design, a staffing and training plan, and an organizational structure that will ensure good communication and support.
REFERENCES


GIS: PICTURE OR PUZZLE PIECE?

Jim McDougall
Manager
AT Product Development Automation Technology Division
H. A. Simons Ltd. 401 W. Georgia St.,
Vancouver
British Columbia V6B 5A1

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS and its forerunners have traditionally operated as a stand-alone system to provide long-term forest management planning as well as short-term operating plans for operations. With the building today of large information databases through the integration of financial and production reporting systems, is it still appropriate to treat GIS as a stand-alone or does it really belong as another piece of the business's information base?
INTRODUCTION

Good afternoon ladies and gentlemen, I am pleased to have been invited to talk to you this afternoon. In an environment where, with some justification, MIS people have been considered the enemy, I consider this an important opportunity to show that MIS does have a significant role to play in relation to GIS.

As the world shrinks and third world countries, whose resources have been largely untapped, start to develop these resources, the markets which our forest industry supplies grow in competitive intensity. Cheaper labour rates, faster growing forests and other less expensive operation costs give these countries a competitive edge in the market place. While we currently enjoy the advantage of higher quality products because of the inherent characteristics of our forests, the difference in selling price, if it continues to grow, will persuade our customers to find ways of adapting his processes to use the cheaper products.

The onus is on us, the forest industry, to be as effective a competitor as we possibly can GIS on its own, is in itself, a tool that aids competitive effectiveness. There is, however, a much more powerful tool created if GIS becomes a piece of a much larger system.

GIS - A HISTORICAL PERSPECTIVE

In order to look ahead, it is useful to stop and look behind. GIS in the forest industry, has gone through several phases in its evolution to reach the point it is at today. While the following phases and their time frames have varied from company to company and by region in Canada, they can be viewed as reasonable norms.

FIGURE 1

Figure 1 represents the general level of mapping up to the early 1960's. It contained nothing more than topographic and notable terrain information. The average forest company maintained relatively little information on their cutting licenses beyond these maps.
By the mid 1960's most companies had added, as illustrated by Figure 2, another type of data to their knowledge base. Stock and stand tables had been generated for the various species on their limits. Concurrent with this, companies and governments had started to cruise the forests to develop timber inventories to determine what the real available resource was and how much could be harvested in order to balance replenishment.

Late in the 1960's as interest, both public and governmental, began to focus on the forest industries' use of the "RENEWABLE RESOURCE", most forest companies added another piece to the forestry knowledge base. They began to collect regeneration data on the areas that had been harvested in the past. At this point in time, information existed as paper maps and manually kept books of tables.
As Figure 4 illustrates, by the early 1970's, in response to the needs of forest management agreements dealing with allowable cuts and in response to operational needs for a more effective method of identifying areas to cut, and the planning for cutting, the concepts of logging chances were implemented. These chances, contained in a logging chance bank, broke the licence up into harvesting blocks. In this process, additional information, as well as the existing information in the manually kept books on timber inventory and stock and stand tables now had a common reference point. Chance bank maps identified not only topography and terrain, but also cover type, stands, swamping, rockiness and other factors which related to the degree of difficulty in working in the area. These factors began to provide significant assistance to the operations personnel responsible for production planning.

In the mid 1970's, another milestone was reached with the formulation of the LOGPLAN production model as shown on Figure 5. This computer simulation attempted to model the forest harvesting process to facilitate operational planning and scheduling. Although it had the potential for significant benefits, it was only utilized by very few companies. A number of factors worked against its widespread use. Most woodlands operations lacked some of the key data required by it. They had neither the computer personnel or hardware to be able to run it in-house. Finally, many operations lacked the management expertise to make use of what it could provide.
As Figure 6 indicates, by the mid 1980's computers had finally found a home in the forestry group. Many companies had transferred their mapping to computer-based environments. The tables, that were some of the first areas to be put on the computer in the late 1970's/early 1980's, had been integrated with the mapping.

Today, as shown by Figure 7 we have expanded out from simple mapping and applied various rules which allow the computer to generate road plans and cut layouts. The industry has come a long way but where do some of the more substantial paybacks for GIS come from? In the words of a song, "Is that all there is?" To look forward, it is necessary to look at what has been happening in the downstream operations, the pulp and saw mills.
GIS AND PROCESS CONTROL

One might note, as they viewed the previous diagrams, that each one has been enclosed by a picture frame. This is symbolic of the fact that GIS, in the course of its evolution, has existed as a stand alone system servicing the forestry department and providing assistance to operations. This is very analogous to the development over the same historical time frame, of process controls within the mills that woodlands deliver their product to.

During this timeframe, control of operations in the mill has evolved from manual control, through pneumatic and electrical control, programmable logic, and into the world of digital control systems employing advanced control strategies. Like the evolution of GIS, they have continually improved our ability to produce. But as we reach the 80/20 rule, we find that we can run our operations better, but have not accomplished a lot relative to managing them more effectively. This resulted in taking a closer look at what was needed and as a result, some new concepts were defined.

In the discrete industries the term “CIM - Computer Integrated Manufacturing” and in pulp and paper the term “MWS - Mill Wide Systems” were coined. They described an environment where the tying together of both process and MIS systems created an information base which would allow the development of management information systems which would give a comprehensive view of the total business. This would give management the information tools they needed to make better decisions.

In the world of woodland operations management, the same problem of getting answers to key questions exists. Like the mill, the answers to the questions requires information from both the traditional MIS-based systems as well as information from the GIS-based systems combined together.

TYPICAL PROBLEM

In order to illustrate this point, I would like to follow through a simplified but typical scenario where this would occur. Assume for the moment, that you are the woodlands manager in an operational group that includes woodlands, pulp mill, paper mill and converting operation. It is March and you are running well and successfully relative to both budget and forecast. You are just sitting down to a management meeting that has been called on relatively short notice. Around you at the table so far, are the managers of the other mill facilities in the group. You start getting a nervous feeling as the group manager walks in with the divisional Vice President and the Vice President of Marketing and Sales.

This nervous feeling develops into a definite sinking feeling as over the course of the next two hours, you hear how a new product that was developed has been a run-away success in its test market. Since the converting operation in this group is the most suitable facility in the group to produce this product, the total group operation is to be swung over to produce this product. Nausea envelopes you as the impact of this is translated back through paper making to pulp requirements and then back to fibre. The bottom line is, there is going to be a significant change in the softwood/hardwood ratio to be delivered to the mill. Since the operation has to submit a new budget for the balance of the year based on the changed operation within a month, when this is backed from converting through the paper and pulp mill, you now have four days to put together a new operating plan and cost it. As the meeting breaks up, the group manager and divisional V.P. indicate to you their confidence that you will be able to hold the line on the cost of delivered fibre near to the current budgeted cost in order to minimize the downstream financial impact on the rest of the operations. You leave the meeting and head for the first aid post for a needed plop-plop, frizz-frizz.

If we were to follow this woodlands manager back to his operations and watch what happened, in order for him to submit his revised plan, we would typically see the following process. The weight of fibre of hardwood and softwood would be converted back to cords or cubic metres and serve as the input to the Chance Bank component of the GIS system. Out from this would come a series of sets of logging chances that would satisfy the volumetric requirements. Forestry would then eliminate those sets that fall outside their government submitted plans. Next, forestry and operations would convene to review the remaining sets. The first round of elimination would kick out
those sets that are not at all feasible due to access to the existing road system, or because of seasonality for cutting and hauling. At this point in time, they are now down to three or four sets of ten or more chances that meet basic acceptability criteria.

Now operations has to sit down and try to develop a harvesting plan for each of these sets, trying to balance cutting seasons, hauling restrictions, manpower, and machine resources, as well as determine the best harvesting method for each chance in each set. Given the time constraints and the amount of work involved in going through this process, it is likely that operations will find enough reasons to reduce the number of sets to no more than two. After two late nights, operations delivers to the costing group, a plan involving one set for final costing work-up with the hope that the delivered cost will be close enough. On the fourth day, the woodlands manager presents the new plan to the area manager and hopes that his boss doesn't ask too many questions. The delivered cost is significantly different from his prior budget and the only response available is that it is the result of a change of plan.

In summary, the process starts with a set of volume requirements that flows into a part of a GIS. The output from this flows through an educated guessing process and then finally through a part of the financial system. One would think that there must be a better way!

**DATA RELATIONSHIPS GIS-MIS**

Since we know what we have available from the GIS side, the key for finding a better way must lie over on the MIS side of the house. A good labour and production reporting system in this area would have been capturing a significant amount of information about our operation. This information would include labour hours and dollars, machine hours, production, maintenance and other costs relating to each area we have harvested. This would be broken down by the various functions such as road building, harvesting method, conversion method and delivery method. This information was needed in order to produce the typical management and financial reports. If we take this information base and try to align it with our GIS information base, we are likely to arrive at something that looks like Figure 8.

![Figure 8: GIS vs. MIS](image_url)
One can see that if we align the two information bases, a bridge relationship can be built between them because chance bank is a common reference to both environments. The question then becomes "What is the value of building this bridge and integrating GIS with MIS?" To find an answer to this question, let us mate the GIS system with the MIS system and develop a system on top of them which encompasses the new capability. With this enhanced GIS/MIS system we will revisit the problem the woodlands manager faced and follow the process as this system tackles the challenge.

The process starts in the same manner as the volumetric requirements are entered into the system. The system starts out as before, by first developing a series of sets of chances that met the volumetric requirements. Rather than simply kicking them out for human analysis, it would follow down a logical process. It would determine whether or not these areas were available to it by examining the forest management plan. Next it would examine road building and hit road building requirements against road building resources availability. Any solution that required significantly more road building capability than was allowed would be eliminated. In the process, the system would look back at other logging chances with similar terrain characteristics and then hit against the MIS historical data to determine productivity, to arrive at resource constraints as well as costs. In the same manner it would work its way through the various harvesting methods, and then conversion and delivery methods, eliminating sets that fail to pass resource availability requirements. In the end, a few hours later, a set of reports would be available to operations for review. Each of the alternative sets would be fully cost estimated and the reasons for a given set failing the system's criteria would be documented. As well as viable sets, the system has tried to optimize a production schedule since it can look at the actual experience for similar areas cut in different seasons.

At this point, operations can use their experience to factor in elements that have not been quantified in the MIS system. Potentially, the system could facilitate playing "what if" games, allowing operations to change resourcing requirements to see what the costs would look like for sets that failed resource requirements. The final product would be a group of production plans detailing costs and fibre deliveries to the mill. Pulp mill inventory requirements for production could now be logically evaluated. Overall delivered costs versus making up short-term inventory short-falls by outside purchases could be balanced. The net result is a plan which the woodlands manager could present to the area manager, backed up by sufficient information to justify costs and schedules, as well as alternative plans that might reduce his delivery costs but cause significant problems for the pulp mill.

In this example, the system was volumetric driven. Conceptually, the system could be driven in reverse by using manpower and machine availability to determine production output, generating chances, volumes and schedules as its output. In either case we are using GIS/MIS as a high powered planning tool. For those who have had some familiarity with the old LOGPLAN model, you will see many similarities with what LOGPLAN was trying to accomplish. The concept is basically the same but the execution is drastically different. The integration of GIS with MIS allows the building of a new type of model which overcomes the major obstacles LOGPLAN faced.

The GIS/MIS system can be used in other ways. With GIS's display capabilities tied to the MIS information base, many types of management information can be presented in a geographical context rather than the tabular form most managers are faced with. This type of picture format would allow managers to quickly key in on problem areas that require their attention without sifting through mounds of numerical information. The sooner management's attention is focused on these problems, the more likely they are to be solved quickly and profitability improved.

**SUMMARY**

In summary, it becomes clear that GIS is an important piece of the overall business information system. The synergy created when GIS and MIS are integrated gives rise to the development of a very powerful competitive weapon. Companies who integrate these puzzle pieces together and effectively use the results will have the competitive edge required to remain viable in the marketplace.

Integration is not a trivial task. It requires a high level of commitment to make it happen. GIS and MIS must be joined to work together, a task that compares in difficulty with getting process and MIS personnel working to-
gether. In many cases either MIS and/or GIS systems will need to be updated. In some instances GIS itself will have to be put in place. In some organizations, GIS has not happened because management has loudly asked “Where’s the beef?” and the GIS proponents have been unable to generate sufficient financial justification. The one pound burger comes about as a result of the integration of GIS and MIS. These benefits alone justify having GIS. It will take time and money to develop the integrated environment but the competitive benefits are clear.

In the puzzle of the business information system, a piece of a puzzle has been sitting on a corner of the coffee table and the puzzle itself has a missing piece. GIS is that piece and it clearly belongs in the puzzle in order to complete it.
GIS, AN EVOLVING TECHNOLOGY:
WHEN DO I JUMP IN?

Alex Miller

President,
ESRI Canada Ltd.,
Don Mills, Ontario

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS technology is evolving rapidly. New hardware and software are announced regularly. There are always some new improvements in the works. Since none of the existing systems are perfect the temptation is to wait for the next improvement. This paper will explore some of the areas in which changes have occurred and are anticipated. It identifies the issues that are relevant to acquiring a GIS. It also discusses strategies for keeping informed of the technology and avoiding hardware and software obsolescence.
HARVEST PLANNING ON A MICRO-BASED GIS: A DESCRIPTION OF THE MINISTRY OF FORESTS' "HARVEST MANAGEMENT SYSTEM"

Andrew Mitchell R.P.F.,
Planning Forester,
Integrated Resources Branch,
Ministry of Forests, Victoria, B.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
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ABSTRACT
A user friendly program which operates in conjunction with a microcomputer GIS has been developed for operational use in harvest planning and management. It provides detailed information on costs and log values by harvest block. One, five, ten, twenty-five year harvest plans, total chance development plans, economic feasibility analysis, development and capital cost amortization, future timber growth projections, and harvest scheduling based on harvest chance are some of its applications. It is integrated with a digital terrain model for landscape management and it can interact with other forest information on GIS to facilitate integrated planning.
INTRODUCTION

The Ministry of Forestry's "Harvest Management System" is a comprehensive tool for planning and managing harvest. It can be used for economic feasibility analyses on large areas of forest, for total chance harvest development planning on a drainage, or for operational harvest planning and management. The need for a special treatment during harvest to protect other forest resources can be identified. A forester can use the tool and interact with other layers of forest information on the GIS.

GIS is a site-specific tool. It provides information on a defined space on the ground. A harvest tool in GIS deals with information on harvest of the site. Road costs, haul times and costs, the method of logging and expected productivity on the site are some of the main items. Other information on the date of logging, environmental concerns regarding fish habitat, landscape aesthetics, etc. is important but highly variable according to the situation. The program enables a list of these items to be created to suit local needs.

The following diagram is a section of a total chance harvest development plan. Data on harvesting a block can be entered while the GIS displays the harvest plan or map on the computer screen.

![Diagram of harvest plan](image)

Block 25 is designed to be logged by short distance cable or highlead machine. Expected productivity on the site is entered. Costs of the men and machines employed are kept in a series of tables elsewhere in the program. Different tables can be created. One may contain cost estimates for a future time period to apply to the blocks to be logged at that time. Information pertinent to the harvest of block 25 shown previously is entered in the following table.
Map name : 92F004
Block Name : 25
Project : LUCKYCRK
Trip time (min): 185
Load size (m³): 33
Truck cost ($/hr): 70 (6.54 $/m³)
Rehab cost ($/ha): 0
Road cost ($): 270000
Fixed cost ($): 0

<table>
<thead>
<tr>
<th>System</th>
<th>-- Production --</th>
<th>-- Shifts required --</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC</td>
<td>fall yard load</td>
<td>fall yard load</td>
</tr>
<tr>
<td></td>
<td>110 270 480</td>
<td>251 102 58</td>
</tr>
</tbody>
</table>

Key Definitions
YEAR : 2016
HARVEST SEQUENCE : 2
DEV BY MAIN RD : N

The key definitions at the end of the table enable user defined information to be entered for each block. Blocks can be included or excluded or sorted on the basis of this information to produce summary reports. A five year plan for blocks to be harvested between 2011 A.D. to 2015 A.D. can be produced by sorting for these dates.

An overlay process in GIS is employed to provide timber volumes by species for each harvest block. Ministry of Forests' digital inventory maps or generic inventory information from another source or cruise can be used. The "Harvest Management System" can report on expected future volumes based on growth equations if Ministry of Forests' inventory data is used. Estimated log grades and values can be entered in a table. These could come from a cruise of the area or they may be based on previous experience in the general area. Another table provides for selective logging of a block. Any percentage of each species can be removed. This facility can be used to reduce volumes to account for decay, waste or breakage.

Areas, volumes, species percentages, log grades and values and logging costs are calculated. The results for harvest Block 25 are shown in the following tables.

<table>
<thead>
<tr>
<th>VOLUMES BY SPECIES</th>
<th>Species</th>
<th>% Logged</th>
<th>Volume Logged</th>
<th>-- Grade 1 --</th>
<th>-- Grade 2 --</th>
<th>-- Grade 3 --</th>
<th>-- Grade 4 --</th>
<th>-- Grade 5 --</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>% name</td>
<td>% name</td>
<td>% name</td>
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<td>% name</td>
<td>% name</td>
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</tr>
<tr>
<td>Ba</td>
<td>100</td>
<td>645</td>
<td>H</td>
<td>5 1</td>
<td>30 J</td>
<td>30 X,</td>
<td>30 Y</td>
<td>5</td>
<td>31,110</td>
</tr>
<tr>
<td>Ow</td>
<td>100</td>
<td>15,720</td>
<td>H</td>
<td>5 1</td>
<td>30 J</td>
<td>30 M</td>
<td>30 X</td>
<td>5</td>
<td>765,736</td>
</tr>
<tr>
<td>Yc</td>
<td>100</td>
<td>648</td>
<td>H</td>
<td>10 J</td>
<td>40 X</td>
<td>40 i</td>
<td>10</td>
<td>0</td>
<td>57,672</td>
</tr>
<tr>
<td>Hw</td>
<td>100</td>
<td>10,442</td>
<td>H</td>
<td>30 J</td>
<td>30 H</td>
<td>5 X</td>
<td>30 Y</td>
<td>5</td>
<td>381,310</td>
</tr>
<tr>
<td><strong>TOTALS:</strong></td>
<td></td>
<td>27,655</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$1,235,829</strong></td>
</tr>
</tbody>
</table>

- 147 -
Falling cost : $100,400
Yarding cost : $168,300
Loading cost : $51,794
Logging fixed cost : 0
Rehab cost : 0
Haul cost : $180,864
Fixed cost : 0
Road cost : $270,000

Actual volume : 27,655 m³
Logged volume : 27,655 m³
Area : 84.90 ha
Average log vol/ha : 325 m³/ha
Total cost : $771,358
Total log value : $1,295,829
Average cost : 27.89 $/m³
Average value : 44.69 $/m³

A total chance development plan for harvest of an area such as a drainage needs to account for many logging blocks. Capital costs of main roads, bridges, sorting yards and dumps need to be considered. There will be overhead and other cost items. The "Harvest Management System" has a series of capital and operating cost tables that can be applied to a harvest development. A sample table follows:

COST TABLE 1
PROJECT: LUCKY

<table>
<thead>
<tr>
<th>Capital Costs</th>
<th># Description</th>
<th>Cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>(lump sum)</td>
<td>1 ROAD TO ELLISWICK LK</td>
<td>227000</td>
</tr>
<tr>
<td></td>
<td>2 ROAD AROUND TWOLAKES208000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 BRANCH ROAD</td>
<td>100000</td>
</tr>
<tr>
<td></td>
<td>4 3 BRIDGE CULVERTS</td>
<td>75000</td>
</tr>
<tr>
<td></td>
<td>5 LUCKY CREEK BRIDGE</td>
<td>60000</td>
</tr>
<tr>
<td></td>
<td>6 1KM ROAD DOWN LUCKY</td>
<td>150000</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating Costs</th>
<th># Description</th>
<th>Cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>(per cubic m.)</td>
<td>1 OVERHEAD</td>
<td>8.85</td>
</tr>
<tr>
<td></td>
<td>2 TOWING</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>3 DUMP, BOOM, SORT, SCALE</td>
<td>4.22</td>
</tr>
<tr>
<td></td>
<td>4 ROAD MAINTENANCE</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>5 CREW TRANSPORTATION</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>6 ACCOMMODATION</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>0.00</td>
</tr>
</tbody>
</table>
More than one table is available for each development to enable analysis of alternatives. Capital costs are amortized against the volume available for harvest in the development. A flexible reporting system permits the forester to examine and analyze the harvest development under a variety of circumstances. Harvest blocks can be included or excluded based on logging costs, harvest method or for millions of reasons based on user defined information. Harvest plans for different time periods in the future can be extracted. If a major branch road within the development is to be constructed in 1990 to service several harvest blocks along the road from 1990 to 1995, a summary report can be produced to provide costs and road amortization for this development within the larger area. The summary report for a harvest development plan lists all the blocks that have been selected, summarizes areas and volumes by harvest method. Species grades and values are listed and capital and operating costs are outlined. The summary concludes with an economic summary for the development as shown in the following table.

<table>
<thead>
<tr>
<th>Total logging summary for forest unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total falling cost : $3,872,200</td>
</tr>
<tr>
<td>Total yarding cost : $7,338,650</td>
</tr>
<tr>
<td>Total loading cost : $2,100,511</td>
</tr>
<tr>
<td>Total logging fixed cost : 0</td>
</tr>
<tr>
<td>Total rehab cost : $10,650</td>
</tr>
<tr>
<td>Total haul cost : $5,749,129</td>
</tr>
<tr>
<td>Total fixed cost : $149,000</td>
</tr>
<tr>
<td>Total road cost : $7,085,004</td>
</tr>
<tr>
<td>Total capital cost : $820,000</td>
</tr>
<tr>
<td>Total operating cost : $17,777,446</td>
</tr>
<tr>
<td>Total cost : $44,902,590</td>
</tr>
<tr>
<td>Total value : $41,077,550</td>
</tr>
<tr>
<td>Total volume : 942,101 m³</td>
</tr>
<tr>
<td>Total area : 2,362 ha</td>
</tr>
<tr>
<td>Average volume/ha : 398.86 m³/ha</td>
</tr>
<tr>
<td>Average cost : 47.66 $/m³</td>
</tr>
</tbody>
</table>

A development can be analysed under a variety of different circumstances and the results compared. The software enables data from many harvest development plans to be combined for analysis and scheduling of timber harvest over large areas of forest.

Harvest has a major impact on the forest. It can affect other forest values and resources. The "Harvest Management System" facilitates planning and management of harvest and it provides necessary cost and value figures. The tool can be enhanced if it is used interactively with other information and facilities in GIS. The "Harvest Management System" operates in conjunction with the Terrasoft GIS developed by Digital Resource Systems of Nanaimo. A digital terrain model attached to this GIS enables the landscape effects of proposed logging to be ameliorated. The following diagrams illustrate the modification of a proposed harvest block to reduce the visual impact.
Although the harvest block on the second diagram is larger than the first one, it is more compatible with the landscape.

In the previous example a harvest plan was modified because the visual impact was assessed on a digital terrain model. Development of forest management software for GIS to aid silviculture, watershed, recreation, forage, fish, wildlife and pest management would assist harvest planning. The forest management community should develop software for GIS that handles all aspects of the forest cycle.
GEOGRAPHIC INFORMATION SYSTEMS
IN DEVELOPMENT PLANNING:
A WORLD BANK PERSPECTIVE

Glenn Morgan
World Bank Environmental Department
Washington, D.C.

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT
This paper examines the opportunities and constraints facing developing countries in the adoption of GIS technology in natural resource development sectors. The author reviews the current experiences of the World Bank, a leading international development agency, in the introduction and use of this technology for the promotion of more effective approaches to natural resource development planning and management. The paper covers the role of the Bank in natural resource development sectors; the constraints imposed by lack of accessibility to high quality land resource information; the Bank's current strategy for GIS implementation; and the prospects for widespread adoption of GIS in World Bank supported activities.
INTRODUCTION

The purpose of this paper is to describe the context in which Geographic Information Systems (GIS) and related technologies (remote sensing, resource survey/inventory etc.) are used by the World Bank. The paper examines the opportunities and constraints facing developing countries in the adoption of GIS technology in natural resource development sectors and reviews the current experiences of the World Bank, a leading international development agency, in the introduction and use of this technology for the promotion of more effective approaches to natural resource development planning and management. The paper covers the role of the Bank in resource development sectors; the constraints imposed by a lack of high quality land resource information; the Bank's current strategy for GIS implementation; and the prospects for widespread adoption of GIS in World Bank supported activities.

BACKGROUND

The World Bank is, arguably, the leading multi-lateral development Bank. As such, the Bank maintains an influential profile in the economies of the developing world. A short list of objectives of the Bank would certainly include accelerating growth in economic output, expanding employment opportunities, reducing malnutrition and disease, slowing population growth and improving public sector program management capacity. These goals are pursued through a vast number of interventions and programs. Indeed, through its project lending operations, country economic and sector policy work, the Bank makes significant contributions to public sector development priorities of its borrowing member nations.

For example, in Fiscal year 1988, the Bank approved 221 loans totalling 19.2 Billion Dollars (US) for its less developed member nations. Many of these Bank projects, particularly in agriculture, forestry, manufacturing and rural development schemes both directly affect, and are affected by, the assured availability of natural resources. Since its inception the Bank has lent over 202 Billion Dollars for all projects a large percentage of them integrally linked to the sustained productivity of the natural resource base of the nation. In the forestry sector alone, the Bank approved projects totalling 167.5 Million Dollars in FY88 and over 1.5 Billion Dollars since lending operations began. From the figures presented in Table 1 we can see that the Bank's operational program continues to have a substantial focus on agriculture and rural development projects which today account for nearly 25% of all operational lending in FY88.

The Bank also plays an important, though variable, role in policy formulation in its member countries with regard to long range strategies within resource utilizing sectors. New types of development programs are emerging which will have subtle but potentially far ranging impacts on national economies. As structural adjustment lending programs receive increasing attention in coming years and as developing economies change and adjust to new initiatives, unforeseen and unintended pressures will no doubt emerge on the natural resource foundation upon which economies are based. It is in this development environment that the Bank strives to evaluate all projects and programs to ensure that they incorporate longer-term sustainable use of natural resources as a fundamental element in development objectives.

WORLD BANK INVOLVEMENT IN
NATURAL RESOURCE INFORMATION MANAGEMENT

Because of the long term implications of project and policy initiatives on a country’s resources, the Bank is concerned that national, state, and local governments are adequately prepared to design, evaluate, implement, and supervise large scale development projects. But it is not unusual for long term resource allocation decisions to be made in a resource information "vacuum". Comments made by Simonett several years ago still ring true for many developing countries today:

"Decisions on capital investment and resource development are made in an atmosphere of greater or lesser uncertainty. The uncertainty is almost always greater in the developing than the developed world because of the weaker information base. As a result many projects in the
| TABLE 1 |
|-----------------|--------|--------|--------|--------|--------|
| Sector          | IBRD   | IDA    | TOTAL  | IBRD   | IDA    | TOTAL  |
| Agriculture and Rural Development | 3,761.7 | 1,015.7 | 4,777.4 | 1,946.3 | 984.0 | 2,930.3 |
| Development Finance Companies | 1,324.7 | 124.5 | 1,449.2 | 2,204.9 | 93.0 | 2,297.9 |
| Education       | 577.7  | 251.5  | 829.2  | 173.5  | 266.3 | 439.8  |
| Energy          | 213.0  | 18.1   | 231.1  | 605.4  | 82.0 | 687.4  |
| Oil, Gas, and Coal | 2,423.2 | 363.7  | 2,786.9 | 2,857.0 | 159.9 | 3,016.9 |
| Power           | 757.2  | 63.9   | 821.1  | 411.4  | 7.0  | 418.4  |
| Nongovernment Project | 900.0  | 421.0  | 1,321.0 | 1,790.0 | 647.1 | 2,437.1 |
| Population, Health and Nutrition | 166.6  | 252.9  | 419.5  | 33.3   | 20.8 | 54.1   |
| Small-scale Enterprises | 264.5  | 10.0   | 274.5  | 405.5  | 16.0 | 421.5  |
| Technical Assistance | 60.1  | 77.8   | 137.9  | 15.0   | 88.9 | 103.9  |
| Telecommunications | 24.5  | 25.9   | 50.4   | 654.5  | 27.8 | 682.3  |
| Transportation | 1,255.8 | 244.4 | 1,499.2 | 1,145.8 | 600.1 | 1,745.9 |
| Urban Development | 945.5  | 173.0  | 1,118.5 | 1,234.6 | 234.5 | 1,469.1 |
| Water Supply and Sewerage | 567.3  | 97.5   | 664.8  | 711.0  | 258.4 | 969.4  |
| TOTAL           | 13,178.8 | 3,139.9 | 16,318.7 | 14,188.2 | 3,485.8 | 17,674.0 |

| TRENDS IN LENDING, IBRD AND IDA, FISCAL YEARS 1986-88 (percentages) |
|-----------------|--------|--------|--------|--------|--------|
| Agriculture and Rural Development | 28.5  | 32.3   | 29.3   | 13.7   | 28.2   | 16.6   |
| Development Finance Companies | 10.1  | 4.0    | 8.9    | 15.5   | 2.7    | 13.0   |
| Education       | 4.4    | 8.0    | 5.1    | 1.2    | 7.6    | 2.5    |
| Energy          | 1.6    | 0.6    | 1.4    | 4.3    | 2.4    | 3.9    |
| Oil, Gas, and Coal Power | 18.4  | 11.6   | 17.1   | 20.1   | 4.6    | 17.1   |
| Industry        | 5.7    | 2.0    | 5.0    | 2.9    | 0.2    | 2.4    |
| Nongovernment Project | 6.8  | 13.4   | 8.1    | 12.6   | 18.6   | 13.8   |
| Population, Health and Nutrition | 1.3   | 8.1    | 2.6    | 0.2    | 0.6    | 0.3    |
| Small-scale Enterprises | 2.0   | 0.3    | 1.7    | 2.9    | 0.5    | 2.4    |
| Technical Assistance | 0.5   | 2.5    | 0.8    | 0.1    | 2.6    | 0.6    |
| Telecommunications | 0.2   | 0.8    | 0.3    | 4.6    | 0.8    | 3.9    |
| Transportation | 9.5    | 7.8    | 9.2    | 8.1    | 17.2   | 9.9    |
| Urban Development | 7.2   | 5.5    | 6.8    | 8.7    | 6.7    | 8.3    |
| Water Supply and Sewerage | 5.8  | 3.1    | 3.7    | 5.0    | 7.4    | 5.5    |
| TOTAL           | 100.0  | 100.0  | 100.0  | 100.0  | 100.0  | 100.0  |

Note: Details may not add to totals because of rounding.
developing world have unexpected and usually undesirable outcomes... economically, socially, and environmentally. Since the major bases for economic development in developing nations lie in their natural resources improved information on these resources will reduce some of the uncertainty in decision making." 

Information on the nature, extent and productive potential of natural resources in developing nations is typically incomplete or out-of-date. Consequently, many agencies in developing countries are unable to monitor land resource changes; evaluate natural system dynamics; predict impact of proposed actions; or evaluate development alternatives. The implications for technically sound and economically sustainable resource exploitation are staggering. As environmental and natural resource management issues move to the top of the international agenda the impact of decades of neglect regarding the maintenance of land resource information will be strongly felt.

There seems to be an unquestionable need for better management of the world’s natural resources and ecologically sensitive areas and the Bank's recent initiatives in the area of environmental assessment reflect a growing international concern. Within the Bank there is an implicit awareness that better approaches to natural resource information acquisition, management and dissemination are both required and desirable. Following a major institutional reorganization in 1987, the Bank made its first major step forward in the area of international environmental management in many years. These initiatives have raised the Bank’s profile in the international environmental community and coincidentally the expectations of those who look to the Bank for leadership in this field.

The purpose of Bank’s re-orientation with respect to environmental issues is to demonstrate the importance and pervasiveness of environmental issues in development work. The broad objectives of the Bank’s Environment Department are threefold: improve the ways environmental aspects of individual Bank projects are addressed; encourage increased investment in programs directly addressing major environmental issues; and establish an institutional foundation for integrating environmental and natural resource management into the highest levels of national economic planning.

The range of responsibilities of the Bank’s central environmental department include institutional environmental policy formulation, scientific and technical research, economic analysis, country environmental assessment, environmental management task forces and the establishment of a modest unit for technical assistance in the field of GIS/LIS, resource survey and inventory.

GIS IN THE CONTEXT OF BANK PROGRAMS

To promote and strengthen its technical contribution in this field, the Bank has developed internal capabilities in the fields of GIS, digital image processing, resource survey techniques and digital database design. Within the Environment Department the unit is known as the Center for Earth Resource Assessment (CERA). CERA has two broad operational objectives:

i) improve the extent to which information about the nature and geographical extent of natural resources and environmentally sensitive areas is used in the identification, preparation, appraisal and supervision of Bank projects; and

ii) promote the widespread use of cost-effective methodologies and technical innovations for natural resource survey, inventory, baseline and database development programs of the Bank’s borrowing members.

Within the Environment Department we believe that GIS and supporting technologies such as satellite remote sensing can and should provide valuable decision support functions at local, regional and national levels.

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1. From paper by David Simonett, citation unavailable
To address these goals CERA has developed a work program which focuses on three interrelated sets of activities:

i) development of internal GIS, Image Processing, CAD/CAM capabilities;

ii) incorporation of these technologies into the Banks lending program; and

iii) development of collaboration between the Bank and external scientific bodies, international agencies, bilateral donor programs, and the private sector.

INTERNAL GIS CAPABILITIES

The Bank’s Environmental Operations and Strategy Division (ENVOS) has established a Geosystems facility which functions primarily as a demonstration or “proof of concept” center where Bank staff can, with the assistance of systems specialists, learn about the strengths and weaknesses of a number of different GIS hardware and software workstations. The objective of the Bank’s internal capability is not to establish a fully developed GIS production facility nor to compete with private sector contractors. Rather our aim is to serve in an educational way, helping staff appreciate the contribution of GIS. Currently the Center for Earth Resource Analysis (CERA) maintains in-house demonstration and research facilities for automated GIS, Image Processing, and CAD/CAM.

One example of a GIS study the Bank has recently completed is a Soil Erosion modelling exercise for the Indonesian island of Java where polygon overlay techniques were used to generate erosion risk assessment maps for the entire island. The resulting analysis was used as direct input into an economic model which attempted to calculate approximate dollar cost of soil erosion to the local economy. CERA has also recently completed a household energy supply study in Pakistan where GIS modelling capabilities were used to identify the number and location of settlements which could be efficiently serviced through the introduction of solar energy. Yet another example is a simple land cover and land use database development activity for Western Bhutan to illustrate the utility of GIS for land use planning and management studies throughout the country. The CERA Geosystems laboratory conducts about 10 such demonstration activities per year. The Bank’s CERA lab facility is not intended as site for the systematic development of large global databases on the state of the world’s natural resources. Rather, we see our role as a node in a larger “network” of information centers world wide.

PROJECT LENDING EXPERIENCES

A second element of the ENVOS strategy to operationalize GIS is to encourage the incorporation of GIS as components of Bank funded projects. From our perspective, GIS is seen to provide four levels of information management and analysis. These functions can be summarized as description, diagnosis, prediction, and prescription. The simplest functions of GIS are related to technical record management functions. They tell us the physical extent and nature of the information stored in the database. The diagnostic functions of a GIS should tell us what is wrong. For example it may, as in the Java soil erosion model, help to explain why a situation has occurred. GIS can also help in predictive analysis to answer “what if” scenarios. These capabilities can help to examine the impacts of decisions made today on the quantity and quality of resources available in the future. The final function of GIS in operational lending is the prescriptive function. This function describes what should be done to help ameliorate or mitigate.

Incorporation of GIS into Bank projects is primarily a capacity building exercise typically focusing on the introduction of GIS into line agencies such as Department of Agriculture, Forestry, Soil Conservation, or Watershed Management. To date there have been no “free-standing” GIS or resource mapping projects financed by the Bank. Rather, our approach has typically been to include these capabilities as part of a larger, sector specific loan. Countries where the Bank has or will soon support GIS programs include Brazil, Indonesia, Papua New Guinea, China, India, and Pakistan, to name a few. While the number of projects with GIS components has been a very small proportion of Bank lending in resource sectors, the interest is growing and requests for assistance are increasing steadily. Several lessons have emerged from our practical experience in the developing world and these are summarized in the following sections.
COLLABORATIVE EXTERNAL PROGRAMS

To date, it has been the international development agencies which have been the principal moving force behind the introduction of GIS technology into the developing world. For this reason, ENVOS actively pursues co-operative natural resource and environmental database development programs with many international agencies and non-government organizations. We feel it is important that efforts be made to pursue joint, collaborative efforts with other agencies to ensure that the development community’s message regarding natural resource information management systems is consistent and technically sound.

In particular the Bank has developed joint programs with UNEP, FAO, the International Geographical Union (IGU), and SIDA (Sweden). The Bank has also assisted in the development and execution of numerous joint projects with the United Nations Development Program (UNDP) in the field of national mapping and database development activities.

In addition, the Bank has also proposed a plan for establishing a network of national environmental information centers which would be built around GIS technology. These centers would act as clearinghouses for available information on a nation’s natural resources by collecting and disseminating information which is dispersed throughout many agencies. They would also act as centers of excellence for resource survey design, database development planning, and professional education and training.

The Bank’s efforts are representative of a wider recognition within the development assistance community that resource information management programs are an important development activity with implications across many sectors. Initiatives similar to the one evolving at the Bank are well established or are merging within such agencies as the United States Agency for International Development (USAID), CIDA (Canada), SIDA (Sweden), United Nations Environmental Program (UNEP), the Food and Agricultural Organization of the United Nations (FAO) and the Organization of American States (OAS) to name a few.

Still, the impact of the Bank’s operational lending program on the promotion of GIS should not be overestimated. The Bank, for example, has no explicit policy on the development of natural resource information systems.

In terms of operational lending the actual amount loaned for GIS development is very small, much less than 1% of total Bank financial commitments.

The real impact of resource information however can be seen when one considers the problems created for project design, implementation, and supervision activities where information is unavailable. A 1986 internal Bank study indicated that the preparation and implementation of projects totalling nearly $800 Million (US) was delayed due to lack of adequate land records. This figure has surely risen since then and will continue to increase as Bank lending for environmentally oriented programs increases.

While the prospects for GIS adoption in developing nations are strong, the reality is that routine applications of the technology may be further off than one might expect. Within the development community several different constraints to successful project implementation typically merge. These include institutional, technical, and fiscal constraints. These issues apply equally to efforts designed to promote information system development and should be considered before any GIS project is undertaken.

INSTITUTIONAL ISSUES

Perhaps the most important constraints to successful project implementation are institutional in nature. Generically, institutional problems relate to considerations such as how program priorities are determined; how government is organized to manage and implement programs; how staffing needs will be met; and how organizations with similar mandates interact; how access to information is guaranteed; and so on.

Clearly, developing countries have no shortage of high priority problems. The management of natural resource information, unfortunately, does not frequently rank highly as a priority for many developing countries. At the
risk of making gross generalizations and oversimplifications, governments typically lack the commitment and the resources to maintain current environmental and natural resource information at even minimally acceptable standards. It has been estimated that on average African countries are spending less than 1/10 of one per cent of GNP on generating information related to the status of their natural resource base.

Perceptions are critical in the public sector and, in general, GIS has been regarded as a sophisticated, costly, and unjustifiable expenditure. Consequently most nations in the developing world have not significantly transformed or improved the institutional apparatus for dealing with terrestrial or aerial surveys, mapping and resource information management. Many would argue that the international community of bilateral development agencies and multi-lateral development Banks have a special obligation to assist in the development and maintenance of the information databases.

Other institutional limitations are related to shortages of trained staff, unpredictable data availability, and a lack of a strong planning tradition. GIS programs will often not meet expectations because we overestimate the impact of planning in the context of developing economies. In far too many situations the incremental value that improved information management makes is unperceived. All of these factors will limit the potential contribution of geographic information systems to development activities in the short-term. But pointing out these problems is only accentuating the obvious. All projects in developing countries face these types of constraints. They are not unique to the GIS and Resource Information management field.

Critics of GIS, remote sensing and resource information management in the Bank maintain that GIS and Remote sensing technological diffusion is largely supply driven as opposed to being demand driven. In developing countries, almost without exception, GIS are conceptualized and supported by outside donor programs. Those who make decisions about introducing GIS are often from cultures different from those whose lives are being affected and the success of “technology transfer” is frequently defined in the innovators terms while the value to the receiving beneficiaries remains questionable.

There are many in the Bank who would suggest that the technologies of GIS and more specifically satellite remote sensing are “cures looking for an illness”. In far too many cases, they maintain, GIS implementation has been as a result of a technology push rather than serving an articulated or felt need on the part of the user. Like so many technologies developed for industrialized economies, systems introduced in this way are rarely self-sustaining and remain a bad technological “fit”.

Our experiences with national remote sensing centers, for example, has indicated that many line agencies consider the contribution of such centers to be marginal. Large centers typically have not interacted with the day-to-day managers of natural resources and are seen as ivory tower, hi-tech gurus. It is far too typical to encounter systems which have been justified on the basis of ill defined user needs. Usually, users of the GIS are identified simply as development planners or policy decision makers. Data requirements for national resource management programs are likewise generically defined. Seldom have systems met their stated objectives because the data or processing capabilities often do not meet specific needs of specific users. Consequently the many capabilities remain underutilized and the products of the information system make no lasting contribution.

Many institutional issues raise the question of whether or not GIS can be considered appropriate technology for developing countries. While an often used phrase in the development literature, appropriate technology means different things to different people. An important issue from the Bank’s perspective is whether the transfer of any technology increases or reduces the levels of technological dependency. If the implementation of GIS greatly relies on expatriate expertise for hardware, software, equipment maintenance, and training to remain viable then it could be considered inappropriate. Of course, there are trade-offs to be considered. Obviously we invite difficulties when indigenous technologies are promoted which are obsolete. This is frequently the case in data processing and computer applications.

Another institutional issue related to technological innovation is the degree to which the new technology will cause institutional distortions. New technical approaches almost always affect many workers and can lead to job displacement and modified responsibilities at all levels in an organization. We have seen many examples where
the use of GIS and Remote Sensing technologies have led to intense interdepartmental rivalries and personal jealousies. The introduction of automated data processing facilities - a source of pride and a sign of accomplishment in many agencies - has, in some cases, resulted in the "modernized" departments becoming quite isolated from their counterparts with a consequent reduction in effectiveness.

FISCAL ISSUES

Another set of implementation problems arise due to government fiscal constraints. Few Governments in the developing world systematically and consistently fund mapping and surveying programs. This is especially true with respect to land use and land capability mapping programs. Part of the explanation lies in the poor understanding of how mapping and database programs can make a difference to development planning.

One of the major challenges facing the expanded use of GIS technologies beyond the demonstration project phase is the problem of identifying clear-cut financial benefits from GIS use. The GIS community currently lacks unambiguous, empirically based accounting data on both cost reductions or the value of improved decisions. This is currently a bottleneck which has led to reluctance among development practitioners to push hard for its implementation.

From the Bank's perspective we see relatively little consensus in the GIS community as to how costs are to be derived. There is a poor definition of what the GIS "product" actually is which has led to a dearth of meaningful cost comparators. We perceive an even larger gap with respect to benefits assessment. This is because natural resource information is an intangible asset. By this it is meant that resource information has different value to different users; that the value of data changes over time depending on the urgency of user needs; and land resource information has an unpredictable life expectancy because land use changes can be swift and unanticipated.

Demonstrating the financial benefit of GIS is not as straightforward as it may appear on the surface. In general, we could state that the value of GIS is the value of the change in decision behaviour which it leads to, less the cost of acquiring and storing the information. In other words, the value of the information is in effecting changed behaviour. Typically this connection is not strongly made or perceived. Most GIS demonstration projects simply illustrate how the GIS might be used in a given management or planning scenario but few examples actually show how a different decision was made through the use of the technology. For these reasons, many governments have been reluctant to invest heavily in information system development programs.

TECHNICAL ISSUES

Finally, the Bank perceives that many institutions face substantial limitations with respect to the level of technology that can be absorbed in the GIS field. Despite a growing experience base in the developing world with computers and automated data processing the vast majority of developing countries have no formal training programs at technical schools or universities in the GIS field. Though this situation will be somewhat ameliorated by the ease of use of many GIS packages available today we still anticipate a substantial shortages of trained staff.

Other important technical issues relate to the need for standardization both in terms of procedures used by national, State and Local government but also in terms of the products supplied and used. This will become an increasingly difficult problem as the PC revolution leads to greater decentralization in database development. Service and maintenance contracts, reliability in power supply, provision of proper physical facilities, patents, copyrights and licensing regulations are important technical issues when working in developing countries. Each affects the productivity of the information system in its own ways.

CONCLUDING REMARKS

Despite the issues which we have addressed above the GIS community should not be discouraged by the factors working against successful implementation of GIS programs. Financial, institutional, technical and logistical problems are common in the developing world, and they are not unique to GIS implementation projects. And
after all, working to change these environmental constraints is what development work is all about. This GIS community should be prepared to play its role. Our goal as advocates of improved information availability and management should not be to remove all uncertainty in development planning but rather to accommodate it more effectively. The question should be “How can GIS programs be designed to achieve its goals more efficiently and with less risk to the supporting government.”

The present position of ENVOS is that GIS, while a potentially valuable tool, should be introduced incrementally in a fashion which explicitly recognizes the institutional, fiscal, and technical constraints and tackles them head-on. Clearly, GIS is finding a place in the information management needs of developing countries. This has been due in a large part to the dramatic reduction in start-up costs for GIS workstations. (Incidentally, we generally support the view that PC based work stations are the preferred data processing environment to achieve the goal of incremental change. We are convinced that desk-top workstations should be widely promoted because, in addition to their ease of use and growing availability, they permit selective decentralization to regions or agencies which are capable of absorbing the technology now.)

In order to effectively disseminate GIS technologies in the developing world the GIS industry must continually strive to highlight its operational relevance. We must be seen as more than a “cure looking for an illness”. We must be seen to understand the problems of the developing world and be precise about the role of spatial information in addressing those pressing needs. Within the development community there is still considerable skepticism regarding the role of resource information surveys, baseline environmental studies, and especially digital databases.

The connection between better natural resource information management and improved decisions is not clearly perceived in the developing world. Relatively few examples exist of how the use of GIS has actually led to different decisions or made significant impact on the policies of governments at any level. This means that as a discipline we need to be more explicit about where GIS has been used and how it has made a difference.
DATA INTEGRITY - MANAGING DATA FOR THE FUTURE

Reeler, E.C., M.Sc.E., P.Eng

Applications Engineer,
Universal Systems Limited,
Fredericton, New Brunswick

Masry, S.E., Ph.D., P.Eng

President,
Universal Systems Limited,
Fredericton, New Brunswick

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
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ABSTRACT

Users of geographic information systems are becoming more concerned with data integrity, particularly now that they are moving towards integrating different systems in distributed networks. This paper highlights many of the integrity concerns which users now face at this point in the evolution of geographic information systems.
INTRODUCTION

According to the Webster dictionary, definitions of the work "integrity" include:

1. soundness
2. incorruptibility
3. the state of being undivided
4. a firm adherence to a code

These apply particularly well to the concept of data integrity in a geographic information system.

Up until the present, the users of geographic information systems have successfully been able to merge spatial data from many sources and to edit and maintain the resultant databases in order to allow the user to access and process spatial information in a multi-user environment.

Present needs are now requiring users to extend their current spatial database capabilities in order to efficiently share data with other organizations. This has involved the integration of many different databases using different hardware and software and containing data formatted in many different ways. The future needs of geographic information systems users will be to maintain and extend these interconnected databases in an environment of rapidly evolving hardware and software.

These situations have posed many problems in terms of data integrity. This paper highlights many of the concerns which users now face at this point in the evolution of geographic information systems.

1. DATA INTEGRITY IN COMPILATION

"Data integrity" refers to the soundness of spatial and attribute data in a geographic information system. A primary consideration should be whether data integrity has been established in a database in the first place, namely at the data compilation stage. This is not only an issue involving the hardware, software and data structure, but also one which involves the management of the quality control process. Data which is "clean", in the sense that it conforms to data structuring rules, may not necessarily be useful or even correct.

Modern technology has enabled the merging of data sets of different spatial accuracies from maps of different scales containing data collected over different periods of time. Data collection is expensive and users often have to use data sets which were originally collected for some other purpose. This situation can lead to the danger of data conflicts and inconsistencies between data sets of differing age and accuracy.

Accuracy requirements are entirely application dependent, for example, property applications may require more accurate data than resource applications. Also revision cycles depend on the type of data being collected, for example, natural features such as rivers and relief are more stable over time than man-made features such as roads or buildings.

Nevertheless, the user must be aware of the spatial accuracy of different data sets in the system, when they were collected and the purpose for which they were originally collected. Both the accuracy and the age of data depend on data collection, however integrity can still be established in the system if each item of spatial data has an associated age and accuracy which are readily accessible by the user and by the system software. These properties can then be used to colour code different data sets in the same area of interest or to weight calculations performed by the system software.

Other ways of ascertaining data integrity within a system are by using software to perform internal data consistency check within a database as well as consistency checks between corresponding data records in separate databases to detect whether there are data conflicts or redundant records.

There are other integrity issues which are more of a data structure and systems software policy concern, for example, the resolution at which spatial data can be stored in the system, whether calculations are performed with single or double precision and whether figures are rounded off or truncated. Although these issues do not substantially affect data accuracy, they may affect the matching of data at map edges and the connectivity of lines on a map and lead to troublesome inconsistencies between adjacent data in the database.
2. DATA INTEGRITY IN ACCESS AND UPDATE

"Data integrity" also refers to the incorruptibility of spatial data in a geographic information system. Data could be corrupted by situations such as unauthorized editing, or system breakdown during a transaction. There are also dangers of corruption in a multi-user environment when two users are performing updates on the same data or during two simultaneous transactions when one user is updating data used by the other user.

At present these problems can be overcome through data security software and procedures. There are rollback facilities to recover from a system breakdown and data locking procedures to protect data during simultaneous transactions. This is known as concurrency control. There are also transaction verification procedures which allow the user to abort a transaction if desired.

Problems in ensuring incorruptibility can be further compounded when there are distributed databases and networks of interconnected systems. Usually each department in an organization is placed in charge of its own specific data and data security is implemented to prevent any unauthorized updates. This is done by permitting other users to access the data but not to update it. This type of data security needs to be implemented across systems in a network. Some users achieve this by sending a set of update instructions to other sites in a distributed database while others prefer a centralized database concept.

However, when complex configurations of databases are involved, it is clear that in order to preserve the incorruptibility of the data and still have flexibility in a network of systems, it is also a necessity to have systematic update procedures and sound data organization across systems in the network, as well as efficient system management.

3. DATA INTEGRITY BETWEEN SYSTEMS

"Data integrity" also refers to the wholeness of spatial data in a geographic information system and more particularly in a network of different systems.

Many users need to closely interrelate the data contained in several different databases, but require the network to respond and function as if it was a single database. A typical example of this is a geographic information system whose graphic elements possess associated textual attributes contained in several textual databases. For the network to function as a single system reliable links need to be established between elements in the geographic information system and records in the textual database. There should also be checks to detect redundant records and missing records as well as procedures for concurrency control and recovery after a breakdown of any one of the components of the network.

Threats to data integrity also include incompatibilities caused by new hardware and software which are both rapidly evolving in the geographic information systems industry. More robust data structures, software which is upward compatible and software which is portable between databases on different hardware have definite advantages in such a rapidly evolving industry.

There are also integrity concerns about the loss of data when translating between incompatible data formats on different systems. Here the solution may be to encourage interdepartmental cooperation in adhering to agreed upon compatibilities, standard data formats and translation procedures.

4. CONCLUSION

In past years, geographic information systems have been used for merging and maintaining spatial information for data processing and access in a multiuser environment. At present there is increasing emphasis on data sharing and the networking of existing systems. Consequently data integrity control, which was manageable in a single system is now becoming more of a concern to users.

There are many solutions to problems of data integrity in terms of data structure, software and integrity mechanisms. However all of them depend very strongly on the initial existence of data integrity in the network. It is clear that to achieve this, the organizations and departments involved in sharing this data have to first agree on compatible data accuracies, data structures, formats and standards. In other words, data integrity must first be established and can more easily be maintained by the "firm adherence to a code" of standards compatible with and agreeable to all concerned.
CREATION OF FOREST INVENTORY MAPS USING AIRBORNE DIGITAL IMAGERY AND GIS

N. Reid
MONITEQ Ltd.,
Concord, Ontario

J. Fisher
Marshall Macklin Monaghan Ltd.,
Don Mills, Ontario

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VANCOUVER, BRITISH COLUMBIA
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ABSTRACT OF POSTER

The management of forest resources requires timely and accurate information in a format providing ease of manipulation for those involved in the decision making process. One approach to managing these resources is the Ontario Forest Resources Inventory which provides a database of forest resources, updated on a twenty year cycle, available to forest managers for planning and decision making.

In the current work, recent technological advances in the fields of Airborne Digital Imaging and Airborne Image Registration were used to create a Forest Resources Inventory database and input it to a Geographic Information System (GIS). An area equivalent to two Ontario Base Maps (OBMs) was surveyed using 5 metre resolution airborne imagery. The airborne imagery was geometrically corrected, registered to UTM co-ordinates and classified for tree species, maturity and stocking. An automated process was developed to convert the classified imagery to a polygon vector coverage. Examples of unclassified imagery, classified imagery, and the polygon coverage of the test area are presented.
TRAVELING DOWN THE YELLOW BRICK ROAD
TOWARDS
INTEGRATED RESOURCE INFORMATION SYSTEMS

Don Reimer, Ph.D.
President
D.R. Systems Inc.
Nanaimo, B.C. V9R 5B3

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

GIS consists of three components or functions; data loading or conversion, maintenance of graphics and attribute databases and applications or analytical capabilities. The real benefits of GIS come from industry, and even company, specific applications. Unfortunately the economic reality of the GIS software industry dictates that the applications provided by the GIS vendors be generic to a number of industries. As a result, the forest industry and individual users must develop applications suitable to their own requirements. This paper discusses the integration of GIS with simulation models used for analyzing fibre supply strategies over the near and long term.
INTRODUCTION

When Alice in the story "Alice in Wonderland" asked for directions, she was asked where she was going. When she replied she really didn’t know, the answer was given that it didn’t really make any difference which road she took as they obviously all went somewhere.

It has been my experience that this general lack of knowing where you wish to go has been one of the basic problems in the implementation of GIS-based information systems. While a GIS is a key component, a GIS package is only one item that is needed in a resource information system. You will also need software, and a methodology, for controlling and updating your basic resource inventory information. Similar needs apply to the growth projection system used to forecast the future inventory and to the planning systems used for making short-term, operational and longer-term, strategic plans.

All of these components are essential parts of any resource information system, and, in the case of the newer GIS-based approaches to information management, must be fully interfaced and integrated with each other before full benefits of an expensive GIS system will be realized. By carefully defining the objectives of the new information system (i.e. which management teams is it going to support and what applications will they be using it for), and by using an integrated approach to the implementation of the various components of such an information system, it is possible to purchase, install and successfully implement a GIS-based resource information system within a realistic budget and time frame. The key phrases are defining objectives and integration of components. Failure to do a good job in either of these areas makes it difficult to make much progress down the yellow brick road.

Given the above context, I will discuss my experience in integrating and implementing forest growth models into today’s GIS-based information systems.

FOREST GROWTH MODELS

One critical component of any forest-resource based information system is the forest growth projection sub-system. As we move towards a second-growth forest economy, growth and yield models become critical tools in the planning and scheduling of silvicultural treatments and harvests.

In order for a given growth model to be useful in this work, it must be fully compatible to and integrated with not only the forest inventory database, but also with the stand history records and silvicultural treatment codes and databases. In addition, the output data generated by the growth model(s) must be compatible with the requirements of the particular forest planning models being used. At the moment, very few, if any, growth models have been developed with any consideration at all for the types and reliability of data which is normally collected in forest inventories. Considerations relative to the utility of the output from growth models for use in planning models and scenario generators has had even less attention.

This current state of affairs is slowly changing.

However, given the information requirements of forecasting tree and stand growth, and the increasingly sophisticated requirements of land managers, there will have to be some changes and additions to the information collected in forest inventories before direct and full integration will be achieved at the general level.

I recently attended a growth and yield workshop where one topic of discussion was the expected characteristics of future growth and yield models and the type of information which will be necessary to drive them. These growth models are being and will be used to help develop increasingly sophisticated forest management plans. Information requirements for forest management planning now include a wide range of environmental and aesthetic impact analyses, in addition to the more normal descriptions of tree sizes and volumes available at various times in the future.

One way to look at these future forest inventory and growth model information requirements is to look at these information requirements as part of a larger corporate information need. For example, if corporate objectives
include mill modernization or expansions, then it will be necessary to be able to forecast future piece sizes, and possibly expected ring widths, in addition to the normal information on volumes and dbh class ranges. Past and future silviculture practices will have to be tested in order to develop a proper forest management scenario which in turn will be tested against corporate objectives.

If pest management is a serious consideration, then some means of incorporating information which will allow forecasting of probabilities of pest infestations and intensities will be needed and will have to be included in the forest inventory database. The USFS is currently linking one of their growth models to a range of post processor models to predict big game cover and habitat, disease and pest impacts, water yields, recreational and aesthetic impacts, etc. These requirements all add complexities to the forest inventory databases as well as to the output requirements from the growth models.

Growth models which can begin to supply the basic information for these requirements will most likely be single-tree, distance independent models. Such models can handle mixed species, multi-age stand projections, can handle changes in stem form due to silvicultural practices, can handle changes in merchantability limits, and can provide future forecasts of forest stands by species, dbh class and log quality class. These models all require some estimator of inter-tree competition, usually based upon some simple assumptions about crown form and length. While these models are developed using permanent plot data, some of which must be stem-mapped, the only additional inventory information required should be information on length of live crown for each species present.

Information required for wildlife management, recreation and aesthetics, and water are currently based upon normal stand characteristics such as stocking, species, volume per hectare, habitat or ecozone characteristics, etc.; information items which most current inventories contain. Information necessary for pest management includes the normal information on stand and site characteristics plus some information on the occurrence of the pest or disease. General forest inventories of the past have not adequately addressed these needs and some additional information specific to each category of pest or disease will have to be collected and put into the inventory.

CONCLUSION

While I do not expect every organization will have all of the above information requirements, it goes without saying that the information requirements of future managers will be significantly greater than today’s. One of the major capabilities provided by a GIS-based information system is the ability to generate forest land management scenarios which include the spatial and geographic relationships of the resource base for all resources concurrently. However, before such potentials can be realized, all the pieces of the complete management puzzle must be in place. Recognition of this requirement for integration is the key to realizing the full potential of your GIS system.
GIS-BASED DECISION SUPPORT SYSTEMS:
A FOREST INDUSTRY PERSPECTIVE

Thomas W. Reisinger
Assistant Professor
School of Forestry & Wildlife Resources
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
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ABSTRACT

The real value of GIS to forest industry lies in providing accurate, up-to-date information for making a variety of forest management decisions as well as generating current maps of landholdings for implementing these decisions. Relatively few companies, however, are using GIS as a tool for making operational and long-range planning decisions. This paper presents the results of a survey of GIS use by U.S. forest industry and describes a prototype Harvest Planning Decision Support System (HPDSS). HPDSS is one example of how a large-scale industrial GIS can be integrated with several operations research/decision models to create a DSS for planning timber harvests.
INTRODUCTION

Successful applications of geographic information system (GIS) technology are, in essence, decision support systems (DSS). This important difference is underscored by Cowen (1988), who states, "GIS can best defined as a decision support system involving the integration of spatially referenced data in a problem solving environment." Others suggest that GIS must evolve from an inventory tool to an analysis tool, and then ultimately to a management tool (Crain and MacDonald 1983). The realization that GIS is much more than "automated cartography" has caused many diverse groups to take notice, particularly in the field of natural resource management.

For many forest-based industries, GIS is a vital tool for handling the large volume of detailed inventory data and other stand-related information needed for more intensive forest management. In many cases, the justification for investment in and the initial use of GIS was based solely on map production. Shortly after the land base is digitized and the database constructed, development of more sophisticated GIS applications begins. The development process will continue to grow as GIS becomes an integral part of the firm's decision support process. Sieg and McCollum (1988) argue that integration of GIS with other decision support software makes justification of these systems easier and improves their overall usefulness.

Unfortunately, complete integration of GIS and DSS is an ongoing process that can and usually does take many years to complete. For Weyerhaeuser, integration over the past 15-20 years has become so complete that GIS and Forest Inventory are "inextricably linked... for the simple reason that it provides the most efficient and effective means of collecting, storing and distributing the timberlands management information demanded by the total organization" (Wakely 1987).

This paper presents the preliminary results of a recent survey of GIS use by forest industry and describes a cooperative research study with a major forest products firm to develop a prototype decision support system for planning timber harvesting operations.

FOREST INDUSTRY SURVEY OF GIS USE

A survey of major U.S. forest industries was conducted to determine how GIS is being used in their organization. The survey focused on large forest-based companies owning 100,000 acres or more that were known to have existing or recently acquired GIS systems. In a survey assessing future needs for remote sensing data, the American Forest Council (AFC) identified 81 different companies owning 100,000 or more acres; collectively, these companies own approximately 69 million acres of industrial forest land in the United States (American Forest Council 1988). When asked if they use GIS, 56 percent of the 36 companies responding to the AFC survey answered positively; collectively, these companies own 30 million acres.

SURVEY OBJECTIVES

A total of 18 different companies known to have a GIS system were contacted and interviewed by telephone during the course of this survey. (No attempt was made to contact all 81 companies identified in the AFC survey). Although the main purpose of the survey was to determine the kinds of GIS applications used by these companies, general background information about their GIS system was also obtained. This included:

1. Experience with GIS and date the system was first acquired;
2. Personnel (full-time) involved with GIS/inventory system;
3. Hardware specifications;
4. Software specifications; and
5. Current use of the GIS system.

The combined forest land base for the 18 companies surveyed amounts to 37.9 million acres, or approximately 55 percent of the total industrial ownership estimated in the previously mentioned AFC survey. Several companies, however, do not have all their land base digitized. Roughly 21.3 million acres, or 56 percent, of their ownership is currently included in a GIS database. Recent mergers/land acquisitions, new installations of GIS systems, conversion to new software, and hardware upgrades are the major reasons why not all company lands are included in the GIS.
SURVEY RESULTS

The survey results, summarized in Table 1, indicate a wide range of GIS involvement. The following discussion should be considered preliminary because the results were obtained from only 18 companies with known GIS technology; contacts with other companies are planned. Although grouping was difficult and less than perfect, four separate classifications became apparent when the 18 companies were compared in terms of how completely GIS is integrated with other decision support software. As shown in Table 1, the four classifications are fully integrated, partially integrated, almost no integration, and none.

**Fully Integrated.** Five of the companies surveyed indicated that their GIS system was fully integrated into the management information/decision support environment of the company’s operations. Typically, the companies in this category had more years of GIS experience (9.6 years); more personnel working with the GIS system (13 full-time individuals); one or more minicomputers (DEC VAX, Data General or Prime) and several microcomputers with graphics capabilities; and more sophisticated GIS software (Arc/Info, Intergraph, or software developed in-house).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Integration of GIS/DSS for 18 forest-based industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of Integration</td>
<td></td>
</tr>
<tr>
<td>Full</td>
<td>Partial</td>
</tr>
<tr>
<td>Number of Companies</td>
<td>5</td>
</tr>
<tr>
<td>GIS Experience Average (yrs.)</td>
<td>9.6</td>
</tr>
<tr>
<td>GIS Personnel Average Range (yrs.)</td>
<td>(4 - 15)</td>
</tr>
<tr>
<td>GIS Hardware Average Range</td>
<td>13</td>
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<tr>
<td>GIS Software*</td>
<td>Arc/Info</td>
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<tr>
<td>In-House</td>
<td>Comarc+I/A</td>
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<td>Micro</td>
<td>Micro</td>
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*Mention of trade names is for information only and does not imply endorsement by Virginia Polytechnic Institute and State University.*

Well-developed applications, sophisticated analyses, and full integration into the management information/decision support process really distinguished these five companies from the others surveyed. These companies also appeared to be continually developing new macros/applications for a variety of in-house clients ranging from field foresters to upper management. In addition to the routine GIS functions of map production and inventory maintenance/update, many of these companies have developed specific macros in the following areas:

* Harvest Planning/Scheduling/Budgeting
* Forest Management Planning/Scheduling
* Long-Range Inventory Growth and Yield Projections
* Transportation Planning/Road Maintenance and Design
* Wildlife Habitat/Environmental Risk Assessment
* Strategic Planning for Land Acquisitions, New Mill Locations, and International Supply/Demand Analyses
* Corporate Accounting/Tax Record Maintenance
* Logging/Forest Management History on Fee Lands
Partially Integrated. Five other companies indicated that their GIS system was partially integrated with their company's decision-making software. This group was more difficult to distinguish than the previous fully integrated group because many were preoccupied with digitizing the balance of company ownership, converting to a new software system, redesigning their tabular databases, or upgrading their GIS hardware. As Table 1 indicates, these companies typically have slightly less experience with GIS (7 years); fewer full-time personnel (5.6); similar hardware configurations using minicomputers (DEC VAX or Data General) and/or microcomputers (Compaq 386) for primary processing; and a slightly different mix of GIS software (Intergraph, Comarc & Arc/Info, and GeoBased) than the companies classified as fully integrated.

Most of the companies in the partially integrated category readily admitted that their organization did not have a well-developed decision support link with their existing GIS. In addition to map production and inventory maintenance/update functions, the GIS was used for:

* Harvest Planning/Scheduling
* Forest Management Planning/Scheduling
* Strategic Planning

Almost No Integration. The three companies in this category were slightly more advanced in the development and use of their GIS than the next group. Two companies recently acquired a GIS through recent mergers and were heavily involved in digitizing the new land base, constructing the database, and learning how to use the system. These companies have fewer years of GIS experience (5.3); fewer number of GIS personnel (4); utilize both minicomputers (DEC PDP/11 and Data General) and microcomputers (Compaq 386); and use less powerful software (Comarc and GeoBased) than the companies in the previous categories. Map production and inventory maintenance/update were the primary uses of the GIS system.

No Integration. The last group of five companies have recently acquired a GIS and are just beginning to integrate this system with previously developed databases and decision support software. As expected, these companies are concentrating on digitizing the land base, building or integrating databases, and just beginning to develop decision support macros. The main characteristics of these five companies are an average of 1.2 years experience with GIS, a small staff of 2-3 individuals, and exclusive use of microcomputer-based hardware (Compaq 386, IBM PC AT, and other 386 compatibles) and software (PC Arc/Info, GeoBased, and InterCart). At least initially, map production and database maintenance/update functions will obviously take precedence over development of decision support applications.

HARVEST PLANNING DECISION SUPPORT SYSTEM

Since harvest planning/scheduling is typically one of the first applications developed by forest products companies, the remainder of the paper will describe a cooperative research project that developed a prototype decision support system for use in planning timber harvests. The objective of the research was to combine the spatial/database information contained in the GIS with OR/MS models designed to aid and improve the harvest planning process. Through graphical displays and printed tabular output, the decision support system identifies sites where mechanized harvesting systems can operate productively and with minimal environmental disturbance.

The Harvest Planning Decision Support System (HPDSS) is designed to help the user answer three questions:

1. Which stands should be harvested in order to meet annual mill wood requirements?
2. What is the “best” method of accessing these stands?
3. What harvesting equipment is best suited for harvesting these stands?

As illustrated in Figure 1, HPDSS consists of four separate but interrelated components:

1. the GIS/Database,
2. the Model Base,
3. DSS Software/Graphical Interface, and
4. the User.
FIGURE 1
STRUCTURE OF THE DECISION SUPPORT SYSTEM FOR HARVEST PLANNING (HPDSS)

GIS/DATABASE
HPDSS utilizes an existing GIS maintained by Great Northern Paper Company (GNP) Millinocket, Maine, the cooperator in this research. GNP's database includes forest cover types, site classes, inventory data, cadastral information on company land, roads, regulatory zones, and information on past harvesting, silvicultural, and protection activities for 2.4 million acres in northern Maine. Terrain classification data on slope (i.e., digital elevation model data), ground strength, and surface roughness were added to a smaller portion of this acreage as part of this research (Reisinger and Davis 1986).

The database and graphic design files were developed on an Intergraph system consisting of a VAX 11-750 minicomputer, dual-screen color graphics workstation, digitizer, and plotter using Intergraph IGDS/DMRS software.

MODEL BASE
The model base component of HPDSS is composed of several mathematical programming models and heuristics that the planner can use to make decisions or to develop harvest plans. The data requirements for each model are determined by the DSS and then the data are retrieved from the GIS/Database. Separate models are employed for each of the three questions that HPDSS is designed to address: Stand Selection, Stand Access, and/or Equipment Selection.

A brief discussion of these three models follows. Consult Davis (1987) for a detailed discussion of the underlying model assumptions.
Stand Selection. The objective of the stand selection model is to determine which stands should be harvested in order to minimize "risk of fiber loss" (i.e., potential loss due to spruce budworm attack) (Boss 1985). User-supplied input constraints include yearly minimum harvest volume (by species). The stand selection model assumes that clearcutting is the method of harvest and that each stand is considered as integral units. Given these assumptions, stands are selected for harvest using a linear programming (LP) model, in which the objective is to minimize the sum of the risk ratings of selected stands while satisfying yearly volume requirements.

Stand Access. The objective of the stand access model is to determine the minimum cost location of "new" roads that must be constructed to access the stands scheduled for harvest. The user supplies road construction costs (per mile). The model assumes a stand is accessible if its centroid lies within 20-chains (1/4 mile) of an existing road and the only way to gain access to an inaccessible stand is through an adjacent accessible stand. Given these assumptions, stand access is determined using a weighted graph or network. The minimum cost road construction pattern is represented by the minimum spanning tree of the graph.

Equipment Selection. The objective of the equipment selection model is to determine the lowest cost "assignment" of harvesting equipment to stands scheduled for harvest. The user specifies the number of productive units (i.e. men or machines) available and terrain operating limitations for three types of harvesting systems (e.g. feller-forwarder, feller-buncher/grapple skidder, and manual-fell/cable skidder). Assuming that only one system may be assigned to a stand, the equipment selection model is formulated as an integer program, in which, the objective is to minimize total harvesting costs.

DSS SOFTWARE/GRAPHICS INTERFACE
The DSS software and graphics interface plays a major role in driving the HPDSS system. The user determines the decision module being considered and initiates the decision process through a series of tutorial screen menus and data prompts. The DSS software determines which models to utilize and then determines what data is required to execute that model. The graphics interface then displays a base map of the GIS and directs the user to delineate the area to be considered in the planning process.

The DSS software/graphics interface then acts as a linking device between the GIS and the model base. It issues database access commands to extract the relevant information about the planning area under consideration, and then initiates execution of the mathematical programming module or heuristic. After a solution has been determined, the DSS software graphics interface displays the results in map form and/or written reports.

THE USER
The final and most important component of HPDSS is the user. His/her judgment is essential to the decision-making process since many of the decisions made are complex and semi-structured. It is the user's responsibility to express the "unquantifiable" constraints that are imposed upon the problem and to incorporate them into the solution proposed by the DSS.

The typical procedure for decision-making utilizing HPDSS is an iterative process. The number of cycles through this iterative loop is controlled by the user. When the solution proposed satisfies the user's objectives, he/she can move on to the next decision module or exit HPDSS with the appropriate harvest decisions/plans. The base map of the planning area with the current solution is displayed for the user's review and acceptance. In addition to color fill graphical displays, HPDSS also provides the user with a series of printed reports/summaries that detail the economic consequences of these decisions/plans.

CONCLUSION
Even though the results of the forest industry survey are preliminary, several trends are apparent. To successfully integrate GIS with DSS requires (1) a long-term commitment of several years; (2) financial commitment for GIS/DSS development personnel and the hardware/software configuration capable of sophisticated analyses; and (3) management commitment, at all levels, to using the GIS/DSS system.

However, an integrated GIS/DSS approach offers several advantages over current methods of operating. It provides forest industry planners and managers with a more efficient means of evaluating the large volume of
diverse and site-specific data inherent in managing large forest ownerships. The DSS also provides an improved mechanism for incorporating mathematical programming models into the decision-making process.

As the HPDSS example illustrates, a well-developed DSS permits the user to incorporate his/her experience and judgment into the harvest plans developed. This planner-computer interaction allows for expression of "unquantifiable" constraints and results in a more realistic description of the planning problem. HPDSS utilizes graphics to present the results of the optimization and/or economic decision models. Since harvesting and forest management decisions are essentially spatial in nature, graphic displays of the planning area, combined with written reports, facilitate the planner's understanding and interpretation of the proposed timber harvest plans. The net effect of such an integrated GIS/DSS approach should ultimately lead to better timber harvesting and environmental planning.

REFERENCES


HIMALAYAN-SCALE PROBLEMS AND MICRO-GIS SOLUTIONS

H. Schreier*, P.B. Shah***, M. Schmidt*, and G. Kennedy**
University of British Columbia, Vancouver B.C.
V6T 2A2

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
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ABSTRACT

An integrated land resource inventory was carried out in Nepal under CIDA sponsorship and the resulting maps and data were found to be cumbersome and difficult to use for national and district level planning. A micro-computer based GIS system was introduced to process some of the resource data and a methodology was developed to assess resource issues at the district and watershed levels. Problems relating to forest degradation, fuelwood and fodder deficiencies, and maintenance of agricultural production were assessed and a model was developed to determine where fuelwood, fodder, and food deficiencies are most acute, how much land use change and forest degradation has taken place, and how GIS can assist in the afforestation program.

* Department of Soil Science, University of British Columbia, Vancouver, B.C., Canada.
** Department of Agricultural Economics, University of British Columbia, Vancouver, B.C., Canada
*** Integrated Survey Section, Topographical Survey Branch, HMG, Box 1611, Kathmandu, Nepal.
will also be incorporated into the GIS data base so as to produce a more refined analysis of land use change. In addition, changes in the soil and water resources will also be incorporated into the model. Current water input and output, soil erosion and sediment transport are being measured at seven stations within the watershed and we anticipate using this data to arrive at a mass balance (input/output) and process evaluation of the critical resources.

**FIGURE 1**

**LAND USE CHANGES 1950-1980, JHIKHU KHOLA WATERSHED**

**Land Use Change**

**Jhikhu Khola WATERSHED, NEPAL**

![Bar chart showing land use change](image)

The third method which is showing promise is related to supply and demand analysis for fuelwood, fodder, and food at the district level. So far 9 districts have been analyzed and we hope to have the remaining 65 districts analyzed shortly. The GIS analysis provides aerial summaries of all the land use subdivisions such as forest type classes with different crown densities, or triple annual crop rotation (rice followed by corn followed by millets) on land classified as capability 2. These data were incorporated into the spreadsheet and combined with the interview data file which contains the essential information on crop and forest yields, population and livestock distribution. Supply and demand calculations were carried out to determine excess and deficiencies at the district level.
Available consumption figures for food (FAO 1972), fodder and fuelwood (Brewbaker 1983) were used as guidelines for the calculations. An example of a district balance sheet is provided in Table 2.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Supply</th>
<th>Demand</th>
<th>Deficit</th>
<th>Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuelwood (ADT) *</td>
<td>116,130</td>
<td>87,960</td>
<td>32.2%</td>
<td></td>
</tr>
<tr>
<td>Fodder (Tons TDN) **</td>
<td>63,140</td>
<td>86,650</td>
<td>-27.1%</td>
<td></td>
</tr>
<tr>
<td>Food (Mio K-cal/year) ***</td>
<td>117,280</td>
<td>98,640</td>
<td>18.6%</td>
<td></td>
</tr>
</tbody>
</table>

* ADT (Air Dried Tons), minimum requirements = 0.64 ADT or 1.07 m³/person/year and 1987 population figures.
** TDN (Total Digestible Nutrients) from both agriculture and forestry, based on 1983/84 livestock data.
*** Based on 1987 population, 2700 cal/person/day requirements, 10% of food requirements from livestock, eight major staples.

It reveals that the fodder situation in the Dhankuta district is most critical, while the food self-sufficiency is adequate. A number of assumptions were made in this evaluation and the ultimate aim is to produce such a balance sheet for all 74 districts in Nepal.

We do not claim that these calculations will give us exact values since the accuracy of our population and livestock data might be questioned. However, we hope to use the information to indicate to the Nepali government which district has resource sustainability problems and whether fuelwood, fodder, or food production needs most attention.

CONCLUSIONS

Micro-computer based GIS systems are proving to play an important role in third world resource development. We developed a GIS-based model which we used in combination with spreadsheet and graphics programs to evaluate agricultural and forestry resources at the district and watershed levels in Nepal. The cost of this technology is low, the techniques are relatively simple, and the output products are dynamic and user friendly. In a very short period we were able to train Nepali professionals to:

1) Produce portfolio maps of the basic land resources at the district and watershed level,
2) Generate terrain divisions indicative of micro-climatic conditions using DTM and climatic data,
3) Create maps that combine several resources,
4) Evaluate land use change, and
5) Produce a supply and demand balance sheet for fuelwood, fodder, and food.
REFERENCES


Financial support for this work has been provided by CIDA (Canadian International Development Agency, Ottawa) and IDRC (International Development Research Centre, Ottawa). A special thank you goes to R. Wiart (B.C. Ministry of Forests) and S. Brown (UBC-Soil Science) for their help in getting the computer system and training program operational, and to all the members of the Integrated Survey Section HMG, in Kathmandu, who helped with the data compilation.
THE ULTIMATE COMPROMISE:
SITUATING GIS IN THE ORGANIZATIONAL HIERARCHY

James L. Smith, Associate Professor
Stephen P. Prisley, Research Assistant

Department of Forestry
Virginia Polytechnic Institute
Blacksburg, VA 24060
(703) 231-7811

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ABSTRACT

Natural resource organizations typically have a hierarchical management structure with widely different goals inherent at each level. GIS could reasonably be placed at any management level, with associated advantages. The placement at any level also has disadvantages, so all placement decisions are, in effect, compromises. These issues will be discussed and considered in light of changes in machine, software and organizational environments which have occurred over the past few years.
INTRODUCTION

As researchers at an educational institution, our work emphasis by default is often on what we might call “technical issues”; you know, the speed, accuracy, or functionality of GIS. However, our experience is that what we might call “management issues” are often paramount; 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. While we are not management experts, our experience and contacts with operational users of GIS have helped us gain some insight into these issues.

This article is, in effect, an update of one we presented at GIS '87 in San Francisco (Smith and Prisley 1987). Our intent here is not to repeat, but to discuss issues raised in that paper in light of the changes which have occurred in the hardware, software and organizational environments. Thus, a short summary of salient points from the original article is appropriate.

SUMMARY OF 1987 PAPER

Large forestry organizations typically have a multi-layered hierarchy, with the most common structure exhibiting three levels of management. These levels of hierarchy have differences in responsibility created by the unique characteristics of the forest management process. The basic raw material (forests and trees) is of relatively low value per unit area, is geographically dispersed over large regions, and the resource often has diverse characteristics which require that procedures change by locality.

We called the three management levels of the typical forestry organization the Area, Region and Division. At the Area, the major function is resource management. Here, day-to-day, site-specific decisions are reached and carried-out. The most current, complete and detailed information is needed at this level. The Region is a transitional level between the “corporation” and the “forester.” The major function of personnel at this level is coordination and control. This level of management is responsible for interpreting and implementing strategic decisions reached at the Division level. At the Division level, site-specific information is virtually unnecessary because the major responsibility here is policy, not land management. Currency and detail in data are typically less important because global decisions are made here, not site-specific ones.

The question then becomes which is the “best” level for GIS? Of course, the answer will vary according to the definition of “best.” Best could mean cheapest, or most often used, or most appropriately used or something else entirely. The conflicts which most often arise are between cost, data control and data accessibility. Cost would generally be cheaper with a single, corporate wide system, but in this case, the spatial nature of the data is almost unnecessary, and will likely go largely unused. Data security would also be greater for a single “corporate” data base, but again, the data would almost always be aggregated before it is used at the upper levels of management. The data would rarely be used for site-specific decisions by foresters because it is too troublesome to reach. At the other extreme, if a GIS is placed in each Area, system costs will likely be higher, and control of the database becomes difficult. However, the data as stored by the system is at the proper level of resolution, and the true power of a GIS is most useful at this level of management. Thus, data control and data access cannot both be maximized. A decision to place a GIS at any hierarchical level is a compromise. The easy and safe decision is thus to put the GIS in limbo, middle-of-the-road, in-between, e.g. the Region. This seems to have been the most popular choice among the early users of GIS technology.

UPDATE

The issues discussed in the 1987 San Francisco paper are basically still pertinent in 1989. Changes in the GIS environment have not eliminated the conflicts which typically arise in a multi-layered organizational hierarchy. However, the way in which the conflicts are resolved has undergone a subtle evolution. We will describe three broad categories of change, the machine environment, the GIS software environment and the organizational environment.
MACHINE ENVIRONMENT

As a whole, the "machine" environment has seen the most change in the past two years. By machine, we mean any hardware or background software required by a GIS, for instance, CPU, graphics device, plotter, operating system and networking software. In almost every case, power or capability per unit cost has increased, often dramatically in great leaps of development. Everyone knows that personal computers and workstations are proliferating as the demand for individual computer power grows. In addition, examine the case of color graphics devices. In 1982, a Jupiter terminal cost approximately $10,000. Today, sufficient graphics capability for most GIS-type analyses can be purchased for less than $1000. Plotters have increased in speed and function, and less expensive versions are available for tasks which require less precision or smaller map format. In short, a wide range of devices is now available; some are big, some are small, some are expensive, some are cheap. The result is flexibility.

Of particular importance to the problem of providing flexibility in the placement of GIS in the management hierarchy is the fast pace of development in the networking industry. Rapid telecommunication of data is very important to forestry organizations because of the size and geographic extent of their basic data. Fortunately, communications between machines is perhaps the hottest topic in the computer industry today. A casual glance at Byte, Personal Computing or Digital Review will confirm this assertion. Virtually any computer can send and receive data to and from any other, regardless of brand or distance. The development of networking protocols such as OSI and TCP/IP have helped spur the interest of GIS hardware and software vendors. Again, the result is flexibility. It is now possible to widely distribute or disperse data and processing power, and yet maintain some contact and control. The gap between data control and data accessibility has thus been at least partially bridged.

GIS SOFTWARE ENVIRONMENT

The vendors of GIS and related database software have responded in kind to developments in the hardware environment. As the power of personal computers and super-micros increased, they became the machine-of-choice for developers of software. Witness the number of GIS packages for Apple, IBM and IBM-compatible machines introduced or converted in the past two or three years.

This development at the lower end of the spectrum has created a market for networking capabilities as well. In the early years, the decision to place GIS at the mid-level of the management hierarchy was in large part due to the cost of the computing and peripheral equipment needed to operate a GIS. It was not feasible to spend $100,000 for hardware at each of the lower nodes of the hierarchy. Now that the hardware costs are feasible, the data control issues typically stressed by those at higher levels of management become paramount. At least two of the major GIS/LIS software vendors have responded by developing subsystems which can run on personal computers or workstations that are upwardly compatible with the mini-computer system: Distributed VAX Center (DVC) by Synercom Technology, Inc. and pARC/INFO by ESRI. With these systems, it is technically feasible to maintain a centralized database linked to satellite work sites which have the ability to store, manipulate and update portions of the overall database. Thus, database control and security could be maintained at a higher organizational level through well defined and strictly implemented procedures, while those at the lower management levels who need the data most have direct access to the required information. Again, neither data control nor access is maximized, but the problems resulting from these fundamentally conflicting objectives have been mitigated to some extent.

It is appropriate here to discuss the issue of dispersed versus distributed data bases in reference to forestry organizations. As defined by Seaborn (1988), a dispersed database is one in which individual pieces of the database are resident at different locations, and, each piece is unique and complete for that location. In contrast, a distributed database is also segmented by location, but in this case, other locations may need to access data housed elsewhere. An example of a distributed situation is a municipal database. The roads department may control the roads database, but the sewer department may need access to the roads information for their work. The distributed situation is much more complex than the dispersed, mainly because of the need to strictly define and enforce data access. Who owns the data, and who rents it? Fortunately, it seems that the situation in forestry can be considered to be dispersed data, not distributed. Each level of the management hierarchy is defined by a
unique geographic location, and the function is the same at each location. Thus, the only need for “outside” access to the data for each location is up the hierarchy, not across to other locations. The access problems are limited by this structure, but not eliminated. The result of this is that it may be easier to put the basic data in the hands of the user in forestry organizations than it will be for those organizations exhibiting a true distributed data structure.

ORGANIZATIONAL ENVIRONMENT

There have been many changes in the organizational environment which affect GIS implementation and utilization. Of most importance are evolving objectives and needs, and the changing awareness and knowledge of employees.

Initially, GIS were typically viewed as map-making systems which could overlay maps and compute proximity zones. However, more organizations are recognizing the potential of true spatial analysis, and the effect spatial analysis can have upon the actual management of their resource. This is not entirely voluntary, however, as environmental constraints tighten and the public becomes more aware of and involved in environmental issues. Ready examples of this are many, such as the proposed Best Management Practices (BMP’s) for lands in the Chesapeake Bay watershed, and the continual litigation over the long-range management plans of U.S. national forests. These large-scale issues will impact site-specific land management decisions, creating the need for more detailed and complete data at that level of the hierarchy. This need is beginning to outweigh the data control and cost issues. Originally, despite intentions otherwise, the placement of GIS often made it more of a strategic planning tool than a land management tool. Now, information requirements for land management are subtly changing the way GIS are used.

A change in the nature of the personnel at the lower levels of the hierarchy has also impacted GIS plans for many forestry organizations. Graduates of the 1980’s are cognizant of the power of computers, and even forestry graduates can write programs and use “canned” packages. Pressure for access from below is being heard by upper level managers. This new excitement and awareness has advantages and disadvantages, however. While foresters may now be more ready to use the new technology, their knowledge may encourage them to “tinker” with the system if given too much access. Controls on the data and the software may be more important now than ever. Also, foresters may have become spoiled to some extent by computer technology. They may want to use GIS as a substitute for field work, or for their own brain. Another danger is that the users may fail to examine or question the quality of the data they utilize because it came from the computer. Finally, GIS may have unreasonably raised the expectations of personnel at all levels of management. For instance, a few years ago a standard data base query over a large acreage would have taken days to perform by hand—tedious hours of examining paper reports and collecting information. Today, someone complains if the computer takes 10 minutes to perform the same operation. Speed should not be the driving issue in any GIS operation. Only rarely is immediate information needed in an organization where the resource, planning and manufacturing cycles are measured in decades.

SUMMARY AND CONCLUSIONS

How has the environment for GIS changed? In actuality, the issues which drive the placement decision have not changed much at all. However, the solutions to the conflicts have changed, and the conflicts themselves have evolved into a new form.

We believe that the key word today is flexibility, and that the flexibility of the GIS environment has increased dramatically in recent years. Decreases in hardware cost, and increases in machine power and networking capabilities will greatly impact the decision on where to place a GIS in the management hierarchy. However, these technical advances do not completely eliminate the management problems, they only give us choices where no choices existed before. It is now possible to put information at the lower levels of the hierarchy, while maintaining contact and control with it. Further, there is increasing awareness that the true power of a GIS increases as you proceed downward through the management hierarchy, and that the personnel exist at that level to put it to good use.
Thus, all signs, both technical and managerial, point to the migration of GIS downward from the middle to the lower hierarchical levels of management. This is certainly a change from the early years of this decade. While we believe that this is entirely appropriate, caution is advised. Caution is advised because the problems of management are not abated by this strategy, and in fact, may be exacerbated. For instance, how do you insure that proper backup procedures are followed? How do you insure data consistency and compatibility across the various localities? How do you encourage use of the systems, but discourage unapproved modifications? Lastly, how do you instill a sense of "stewardship" of the data in users, without creating a feeling of ownership and possessiveness?

We conclude with two suggestions:

We request that GIS and related software vendors pay more attention to data management issues. A suggestion is to provide a facility similar to "transaction posting" which has been in use in accounting systems for years. This would allow a central data base manager to better control the updating process.

We also request that more attention be paid to management issues in research agendas, publications and professional meetings. Where do practitioners go in general to learn from others mistakes and successes?

Positive responses to these two suggestions will help to remove the last major barriers to the placement of GIS at the lower levels of management, where it actually belongs.

REFERENCES


INFORMATION SYSTEMS: A FOREST PRODUCTS PERSPECTIVE

William D. Thomas

Director,
Millwide System Studies,
H.A. Simons Ltd.,
425 Carrall Street,
Vancouver, B.C. V6B 2J6

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ABSTRACT

There are significant differences between conventional large-scale, well-ordered Management Information Systems/Data Processing systems and the new innovative world of "end-user" computing. This new user-intensive computing which is often microcomputer based can be broadly classed as applied technology. The two worlds of applied technology and MIS are planned for separately. This results in managers having two sources of system support which are usually incompatible. The experience of HA Simons in marrying applied technology in sawmills and pulp mills to traditional MIS systems may have parallels in designing GIS for forestry.
1. INTRODUCTORY REMARKS

At just about every major forestry conference there is a token computer system session, and some speaker retelling the tale of the digital promised land. Perhaps the “techies” have talked about the subject too much without adding greatly to a consensus view of what computer systems really are in management terms. Perhaps too many vendors -- and consultants -- have volunteered their subjective views, and opportunistically use the latest fashion as a strategy to “move the iron”, or move the man-hours.

Certainly computer people have a good technical grasp of systems and their integration, and our vendors are providing an ever more impressive array of innovative products: A veritable “minestrone” of computers which are usually difficult, -- if not impossible to interface with each other -- decorate most of our operations.

In pulp and paper industry production managers have generally been slow; however, to take the appropriate leadership role in defining, justifying, and introducing systems planning in their companies -- and perhaps GIS 89 is the most appropriate forum to address this problem.

For the problem is a management one, more than a technical or computer problem.

In both discrete and process manufacturing industries, we seem slow to grasp the real purpose and urgency of automation. And despite North America’s expenditure in 1988 of $17 billion on computers, systems, and process control equipment, North America still lags behind Japan, Britain, and France in productivity growth -- the lever of economic growth.

A recent issue of Business Week carried a cover story on The Productivity Paradox -- an article which every manager might do well to read -- and absorb -- and it seems that increasingly the impediments to effective investment and implementation of “Applied Technology” are seen to be in the prosaic areas of cost accounting, management planning, and other low-tech but vital management roles. The realization of this in Japan and other countries is, perhaps, the reason why the Japanese industrial miracle took place, and even more worrying, why the Europeans are now integrating new factory technology at four times the pace of U.S. industry -- even faster than the Japanese.

So it is time for management -- get seriously involved with the implications of computer systems.

Too often management seems to duck its responsibility to provide the leadership necessary to bring about the difficult changes required to take advantage of the information age.

Our concern for the pulp and paper industry derives from the experience in the American automotive industry where, for too long, Deming was ignored and the implementation of robots integrated with information systems was deferred as being too “Buck Rogers” for our factories. If a difficult lesson was learned in the late 70’s and early 80’s in “Smokestack Industries”, or perhaps “Exhaust Pipe Industries” -- I would hope we could apply this lesson to “Treestump Industries”. There is no place for hesitance in the planning for an implementation of well proven and newer technologies if we wish to remain competitive in world markets.

We, at Simons, design and build pulp and paper mills all over the world. The majority of our work is in Canada and the United States, of course, but we also work in this industry in places ranging from Australia to Chile, to Czechoslovakia, and, I can assure you that the direct involvement and leadership of mill management in Millwide Systems is a major concern with the most successful companies.

Systems and applied technologies have been extensively used within my own company and they have profoundly changed the way we work. But it was a tough sell to some conventional consulting engineering managers who would prefer to leave the hard work of change to the “techies” or to the next generation of management.

Increasingly when discussing computers, great emphasis is put on the area of “communications” -- which usually refers to “data communications” in complex networks of mixed-vendor control and information systems.

Another kind of communications is also necessary if we are to enlist the required support of management from all sectors of our industry, and at Simons we have developed a fairly trivial model to facilitate this “human communication” of the concept of integrating different fields of endeavor and, indeed, different cultures found within our companies. I will now deal with a series of slides to illustrate this simple conceptual model and perhaps
clarify some of the issues in our role in millwide automation and some of the impediments and organizational polarities which interfere with its implementation, and how this can be applied to Geographic Information Systems.

2. MILLWIDE SYSTEMS - A DEFINITION
The series of illustrations which follows is useful in setting the context in which we use the term - Millwide Systems (MWS). Equivalent terms like Computer Integrated Manufacturing (CIM) and Integrated Plant Systems (IPS) are sometimes used interchangeably, but all refer to the combination of integrated process control and management information systems.

These expressions are so general in nature that a specific mill must define them in meaningful terms for its own situation. In some mills, emphasis is on process data acquisition through interconnection or networking of current and proposed process, control systems so that process information is available to all areas in the mill. In other cases, early emphasis is on integrating management systems with process control systems in one area of a mill. An example of this is the integration of production scheduling and shipping/invoicing systems with roll handling and paper machine control systems.

Full MWS consists of both of these steps -- and involves the technical challenge of networking all process control systems, and the management challenge of making effective use of the resulting wealth of shareable data. Interfacing the “systems engineer’s” world of process control, applied technology (AT), with the “systems analyst’s” world of management information and data processing (Management Information Systems (MIS)), is the goal of a millwide system. Before this can occur, a rational and coherent networking of all equipment must be planned and implemented.

Skills in process control and systems engineering must be interfaced with skills in MIS and data processing, and the MWS evolution must be guided by a clear plan and management direction.

The following illustrations expand on these points:

FIGURE 1

THE TWO WORLDS ARE TRADITIONALLY SEPARATE AND PLANNING IS DONE INDEPENDENTLY

- SYSTEMS ANALYSTS’ WORLD
  "D.P." - "M.I.S."

- M.I.S. PLANNING
  Corporate Systems
  Central Mill Sysytems
  Distributed Mill Systems

- SYSTEMS ENGINEERS’ WORLD
  PROCESS CONTROL PLANNING

  Integrated Process Control
  Individual P/C Upgrades
  Unit Process Optimization
Fig. 1 illustrates the traditionally separate worlds of Management Information Systems and Process Control Engineering. The MIS function within a pulp and paper company is usually located centrally at a corporate office, performing data processing services for a number of mills at different locations.

Corporate System (e.g., finance, accounting) are run centrally for all mills in addition to certain common Mill Systems (order entry, production performance, etc.). Often, the central host computer communicates with local mill data processing computers. This has been an increasing mode of operation with lower cost processors providing effective distribution of mill systems to the mill sites.

Within the mills, an increasing use of process control computers is common, and for the most part, these devices are planned for and installed with little or no coordination with MIS (either central or local).

The two worlds are planned for separately and the mill manager has essentially two sources of systems support, usually incompatible.

A Mill Wide system addresses both worlds, and integrates the mill process control systems with all MIS systems, whether run locally (distributed processing) or centrally (on corporate host machines). Mill management systems can then be designed which make use of both process and business systems data.

Fig. 2 illustrates the required boundary of a Mill Wide System - encompassing both the world of the system engineer in the mill, and the world of the systems analyst at local and central data processing locations.

A company's system can be divided into three categories:
- Data Processing systems which support the basic business functions of finance and accounting (accounts payable, receivables, general ledger, etc.).
- More complex MIS systems which support the company's root business. These are industry specific and typically run on large mainframe computers or distributed mill data processing modes.
- Increasingly the growing field of Applied Technology and the advent of the "computer literate user" is leading to more systems which are outside the control of the MIS function. Examples of this would include work processing in offices, robots and CADD in discrete manufacturing, and process control computers in process industries.
The first two categories, DP and MIS, are characterized by a well-ordered operating environment usually supported by a single vendor (IBM in most cases) and are managed by the company's MIS function. The third category (AT) is characterized by many small limited function machines, from many vendors. They are usually innovative, user-controlled systems, and the personal computer or "Micro" explosion is rapidly causing this area to expand. This is illustrated in Fig. 3.

This general model can be applied to any industry. In a consulting engineering company, the model is illustrated in Fig. 4.

<table>
<thead>
<tr>
<th>SYSTEMS CATEGORIES - A General Model of the Use of Computers in Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DP</strong></td>
</tr>
<tr>
<td>* Data Processing - Common to all Businesses*</td>
</tr>
<tr>
<td>- Financial/Accounting Systems</td>
</tr>
<tr>
<td>- AP/AR/GL - Payroll, Invoicing, etc.</td>
</tr>
<tr>
<td>(Typically on Mainframes, Super Minis)</td>
</tr>
<tr>
<td><strong>MIS</strong></td>
</tr>
<tr>
<td>* Management Information Systems*</td>
</tr>
<tr>
<td>- Pivotal Information systems</td>
</tr>
<tr>
<td>- Industry specific</td>
</tr>
<tr>
<td>- Business oriented (Cobol)</td>
</tr>
<tr>
<td>- Large data bases, DBMS</td>
</tr>
<tr>
<td>- Batch/On-line/Transaction processing</td>
</tr>
<tr>
<td>- Well ordered, controlled</td>
</tr>
<tr>
<td>MIS Dept. responsibility</td>
</tr>
<tr>
<td><strong>AT</strong></td>
</tr>
<tr>
<td>* Applied Technology*</td>
</tr>
<tr>
<td>Industry Specific</td>
</tr>
<tr>
<td>(Typically on Dedicated Minis, Micros)</td>
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<table>
<thead>
<tr>
<th>FIGURE 3</th>
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<table>
<thead>
<tr>
<th>ENGINEER/PROCURE/CONSTRUCT - EPC COMPANIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DP</strong></td>
</tr>
<tr>
<td>* Finance/Accounting</td>
</tr>
<tr>
<td><strong>MIS</strong></td>
</tr>
<tr>
<td>* Pivotal Information Systems</td>
</tr>
<tr>
<td>* Project Management Systems</td>
</tr>
<tr>
<td>- Planning, Scheduling</td>
</tr>
<tr>
<td>- Capital Cost Control</td>
</tr>
<tr>
<td>- Procurement</td>
</tr>
<tr>
<td>Construction Monitoring</td>
</tr>
<tr>
<td>* Engineering Management Systems</td>
</tr>
<tr>
<td>- Engineering Monitoring</td>
</tr>
<tr>
<td>- Document Control</td>
</tr>
<tr>
<td>- B/M Processing - Data Base Retrieval</td>
</tr>
<tr>
<td><strong>AT</strong></td>
</tr>
<tr>
<td>* Engineering Analysis &amp; Computation (CAE)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIGURE 4</th>
</tr>
</thead>
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- 195 -
Like all businesses, an engineering company must support its payroll, labour distribution and other accounting applications with data processing.

The MIS functions in our engineering company tend to deal with client project management applications and internal pivotal control systems specific to this particular industry.

The newer, end user systems, outside the control of MIS, address engineering computation, simulation and, perhaps, computer aided design and drafting. Integrated systems require that the AT world of end user systems communicate with the more structured world of MIS and data processing. Computer Integrated Engineering (CIE) would imply that graphics systems, mathematical systems and management systems all communicate with each other.

In process industries, the general model can illustrate the relationship between process control functions and mill information systems (Fig. 5).

**FIGURE 5**

**PROCESS INDUSTRIES - PULP & PAPER**

<table>
<thead>
<tr>
<th>DP/MIS Central (Batch/On-line, Central Mainframes)</th>
<th>DP/MIS Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Finance/Accounting</td>
<td>IBM Host Computers</td>
</tr>
<tr>
<td>- Corporate Applications</td>
<td>370/303X/4381</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AT (Real Time-Minis, Micros)</th>
<th>MIS Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Process Control</td>
<td>- Order Entry</td>
</tr>
<tr>
<td>- Process Schedules</td>
<td>- Production Scheduling</td>
</tr>
<tr>
<td>- Supervisory and</td>
<td>- Production Control</td>
</tr>
<tr>
<td>Optimization Control</td>
<td>- Inventory Control</td>
</tr>
<tr>
<td>- Distributed Digital</td>
<td>- Warehousing</td>
</tr>
<tr>
<td>Control DIDC</td>
<td>- Shipping</td>
</tr>
<tr>
<td>- SDC/DDC</td>
<td>- Mill Simulation</td>
</tr>
<tr>
<td>- Sensor Based Systems</td>
<td>- HP-3000</td>
</tr>
<tr>
<td>- Personal Computer</td>
<td>- VAX</td>
</tr>
<tr>
<td>Interfaced with</td>
<td>- IBM S/36</td>
</tr>
<tr>
<td>Distributed Control and</td>
<td></td>
</tr>
<tr>
<td>Process Automation</td>
<td></td>
</tr>
</tbody>
</table>

For instance, pulp and paper companies usually run both data processing and some common mill MIS applications on large central host mainframes at the Corporate offices. Individual mill MIS systems are usually run on local business processing computers at each mill; with telecommunication links back to the central host.

Central and local MIS systems are well controlled and run on one vendor's equipment as a rule (2 of 3 vendors are sometimes used).

In the area of Applied Technology, however, it is not unusual to find 5 or 6 independent (and often incompatible) systems supporting the complex requirements of sensor based systems. Well established process automation is very common in the pulp and paper industry, but integrated process control is relatively rare. The further integration of process control functions with MIS is even rarer.

The integration of the MIS systems with process control systems is required if the mill manager is to have access to complete data on his mill operations and performance.
A Mill Wide System (MWS) is then defined as one which provides for the integration of process data with business data. Mill management applications which require input from process control computers and MIS computers can be developed to better manage the mill. (Fig. 6)

FIGURE 6

PROCESS INDUSTRIES - PULP & PAPER

<table>
<thead>
<tr>
<th>DP/MIS Central (Batch/On-line, Central Mainframes)</th>
<th>DP/MIS Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Finance/Accounting</td>
<td>IBM Host Computers</td>
</tr>
<tr>
<td>• Corporate Applications</td>
<td>370/303X/4381</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AT (Real Time-Minis, Micros)</th>
<th>MIS Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process Control</td>
<td>• Order Entry</td>
</tr>
<tr>
<td>• Process Schedules</td>
<td>• Production Scheduling</td>
</tr>
<tr>
<td>• Supervisory and Optimization</td>
<td>• Production Control</td>
</tr>
<tr>
<td>• Distributed Digital Control DIOC</td>
<td>• Inventory Control</td>
</tr>
<tr>
<td>• SDC/DDC</td>
<td>• Warehousing</td>
</tr>
<tr>
<td>• Sensor Based Sensing System</td>
<td>• Shipping</td>
</tr>
</tbody>
</table>

**MWS**

The integration of MIS and AT

Personal Computers Interfaced with
Distributed Control and Process Automation

- IBM-1800/1132/Ser.1
- PDP-8/11-VAX
- HP-1000
- Package Supplier
- Control Systems Suppliers

Foxboro, Honeywell, Moore, Bailey -- Accuray, Measurex, Sentinel, Lavelle

Interface between different process control functions, and between these and MIS functions, must be developed and a coherent network plan must be initiated to provide for future additional systems.

The model can be applied to woodland management in a similar manner. Woodland management require the usual accounting functions of any business concern with appropriate data processing.

Their MIS systems typically address woodlands support functions including inventories, stock and stand tables, regeneration, and cutting compliance monitoring.

In forestry operations, there are often a number of functionally separate systems sometimes referred to as "islands of automation". Typically, surveying and CAD applications are purchased from different vendors, and the AT world has difficulty communicating with the upstream management systems. (Fig. 7)

Clearly, links must be established between MIS and the functionally isolated AT systems, as in the example illustrated. If the cut block is to indicate the volume of timber, it must be linked to timber inventory. Similar links must be established in many areas.

A definition of GIS emerges from our model as illustrated in Fig. 8. The first step to integrating the MIS and AT areas is to work on integrating the various elements within AT; such that functions in the woodland can communicate with one another. "Causeways" between these "islands of automation" must be built, and the somewhat disorderly world of end user (AT) systems must introduce some of the discipline and compatibility found in the MIS and DP areas of the company.

When this is accomplished, the full integration of end-user applied technology with management information systems is possible, and the goal of GIS is achieved.

GIS is the result of marrying the "forestry support" systems with the upstream management information systems.
FIGURE 7

WOODLANDS MANAGEMENT

- Finance/Accounting

MIS
- Timber Inventories
- Stock and Stand Table
- Regeneration
- Cutting Compliance Monitor

AT
- PC's
- Surveying & Calculations
- Analytical Plotter
- CAD
- Digitizing
- Road Design

FIGURE 8

WOODLANDS MANAGEMENT

- Finance/Accounting

MIS
- Timber Inventories
- Stock and Stand Table
- Regeneration
- Cutting Compliance Monitor

GIS
The Integration of MIS and AT

AT
GIS and MWS are really the same thing - with the former applying to woodland automation and the latter to mill automation.

The final step is to link GIS and MWS systems together to achieve full corporate integration from the forest resource to the delivered product (Fig. 9). This allows the tracking of the tree’s dis-assembly and re-assembly according to the requirements of the market place.

**FIGURE 9**

MRP II
AN APPROACH TO
FULLY INTEGRATED PULP AND PAPER
OPERATIONS

3. CLOSING REMARKS

Woodland management’s role in Geographic Information Systems is, to recognize that it is your responsibility to plan it, to sell it to your funding sources, to implement it, and to facilitate change as necessary after implementation.

You need to understand what it is.
You need to know why you need it.
You need to know what the roadblocks are and understand the organizational polarities which cause these roadblocks.
And you need to seize the upper hand and assume the responsibility for leadership.

Rather than have vendors, consultants, and even your own “techies” lecture you on what Geographic Information Systems are, you need to be telling them:

What it is
Why you need it
How you are going to control it

and set about solving the management and cultural problems which are the real impediments to its adoption.

In terms of the emerging international economic realities, it is your corporate responsibility to become intensely involved.
GIS IN THE NORDIC COUNTRIES
Market and Technology
Strategy for Implementation - A Nordic Approach
Applications of GIS to Forestry and Natural Resources - Norway

Svein Tveitdal
VIAK A/S Bendixklev 2
4800 Arendal, Norway
Tel: 47-41 25014

Olav Hesjedal
Institute for Environmental Analyses
3800 Bo, Norway
Tel: 47-3-950499

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

This paper covers GIS in planning and administration in Norway, Sweden, Denmark and Finland; application of GIS to forestry and natural resources; GIS systems developed in the Nordic countries vs. technology purchased from U.S. and Canada; export of GIS technology and expertise; strategies for implementation of GIS with focus on costs and benefits based on experience from the Nordic countries.
1 GIS IN THE NORDIC COUNTRIES - MARKET AND TECHNOLOGY

1.1 Background

The Nordic Countries - Denmark, Finland, Iceland, Norway and Sweden - have, due to their large areas of land and high emphasis on rural and urban planning, built up a high capacity in traditional map production. The tradition of keeping registers of land records dates back to the end of the 15th century. This tradition continues with the advent of computerized geographic information data bases. In 1986 at least 20 000 people from national institutions, municipalities and private industry in the Nordic countries were working with production of maps and spatial data. The value of this production was estimated at $ 500 million yearly.

The work with digital map information started in the end of the 1960s, and today there is a fast-growing market for the use of GIS in the private and public sectors. At the start, most applications were connected to facility management and administration of properties. But for the last few years we have seen a fast-growing use of GIS in physical planning, management of forestry and natural resources as well as environmental data.

Each of the countries has, through the national survey departments under establishment, national geographical data bases containing a growing number of map themes. In the next decade a majority of the 1 467 municipalities in Norway, Sweden, Denmark and Finland will have introduced GIS technology as a necessary tool to obtain increased efficiency mainly in the technical sector. On this background a number of Nordic private companies have developed systems and built up expertise to serve the domestic and international market with equipment and services in the GIS sector. The value of Nordic GIS exports is today in the range of $40 million yearly including systems and services. The development is supported from national research funds.

In Norway, digital geographical information is one of four areas with highest priority under the national research programme for information technology with a yearly budget on $ 120 million. In Sweden, an R & D Council for Land Information Technology (ULI) was established in 1986.

Below we present some figures on the market for GIS systems in the Nordic countries in 1988, as well as estimated market share between Nordic and USA/Canadian systems which together dominate the market. Please note that the figures given are for systems deliveries only (hardware/software). The growing market for technical, organizational and financial services as well as training and education connected to GIS implementation is not calculated. For some of the countries the figures are based on very limited market research and might therefore have limited accuracy. The total marked for GIS systems in the Nordic countries in 1988 is estimated at $ 37 400 000 of which approximately 50 % was delivered from Nordic manufacturers and 40 % from USA/Canada (mainly USA).

**TABLE 1**

THE GIS MARKET IN DENMARK, FINLAND, NORWAY AND SWEDEN IN 1988. FIGURES IN 1000 $.

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>DENMARK</th>
<th>FINLAND</th>
<th>NORWAY</th>
<th>SWEDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORDIC</td>
<td>2 600</td>
<td>3 300</td>
<td>9 000</td>
<td>4 600</td>
</tr>
<tr>
<td>USA/CANADA</td>
<td>2 600</td>
<td>3 300</td>
<td>1 500</td>
<td>7 500</td>
</tr>
<tr>
<td>OTHERS</td>
<td></td>
<td></td>
<td>3 000</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>37 400</strong></td>
<td><strong>5 200</strong></td>
<td><strong>6 600</strong></td>
<td><strong>15 100</strong></td>
</tr>
</tbody>
</table>

1.2 Denmark

The GIS investments in 1988 were $ 5 200 000 of which 50 % were Danish systems. The main Danish system is Dangraf which is developed in a joint venture of Kommunedata, Jysk Telefon and Kampsax Data. The system is today running on PRIME computers but is now converted to IBM 6150. Main installations are by private
companies in photogrammetric map production, municipalities and utility agencies. Dangraf have also some installations in Sweden. Other Danish systems are O-Craf developed by O-C Engineering based on Auto-Cad and running on IBM 386 and GeoCAD (PC-based).

The main foreign system in Denmark is Intergraph. CV has some installations.

1.3 Finland
GIS investments in 1988 were $6 600 000 of which 50 % were Finnish systems. The dominating Finnish system is FINGIS which is developed in the Finnish National Board of Survey. The FINGIS GIS system is used for land use planning, map data inventory and production of conventional maps, and has applications for cadastral, utilities, road networks etc. FINGIS is running on VAX, and will be available on UNIX during 1989.

FINGIS has been exported to Sweden, Holland and a pilot project has been started in Canton, China.

The main foreign system in Finland is Intergraph. SysScan is also represented.

1.4 Norway
GIS investments in 1988 were $10 500 000 of which 86 % were Norwegian systems. The main Norwegian system is SysScan running on VAX, now also under conversion to IBM. SysScan is the most successful Nordic GIS system with a world-wide sales organization. Exports in 1988 were valued at $18 million which is approximately half of the estimated total Nordic export figures for GIS systems and services. Another Norwegian system is PUMATEC running on the leading Norwegian computer company Norsk Data. The system is exported to some countries.

The main foreign systems in Norway are ArcInfo (PC- and mini- versions) and Intergraph. Terrasoft has some installations mainly for applications in forestry.

1.5 Sweden
GIS investments in 1988 were $15 100 000 of which only 15 % were Swedish systems. In those figures we have not included the Teragon/Context image processing system which is the main Nordic manufacturer of image processing equipment for satellite data. Teragon/Context is dominating this market in the Nordic countries. The Main Swedish GIS system is AutoKa owned by the National Survey Department and Kordab from Kordab AB, both running on micro computers.

The main foreign systems in Sweden are Intergraph, Siemens and SysScan. ArcInfo and Terrasoft have a number of installations.

2 STRATEGY FOR IMPLEMENTATION OF GIS - A NORDIC APPROACH
The costs of operating and maintaining municipal engineering facilities in the Nordic countries is estimated at more than $15 000 000 000 annually. Geographical information is needed not only for operation and maintenance but also for planning, design and decision-making. These activities are being increasingly computerized.

Even small improvements to information processing can have far-reaching economic consequences, in view of the large sums of money already mentioned. A joint Nordic project - "NORDISK KVANTIF" - with the purpose of quantifying the community benefit of digital spatial information, was carried out in the period 1985-87. In this chapter some of the conclusions from the final report regarding costs and benefits as well as recommended strategy for implementation are summarized.

2.2 Costs and Benefits
Studies during the project showed that benefit-cost ratios achieved through GIS investments can easily bear comparison with the profitability requirements of private industry. At the same time, it was apparent that questions concerning the organization of the activities involved often present a greater task than purely technical issues. In order, therefore, to achieve the possible and demonstrated beneficial effects direction and control have to be exercised from the right level. If, for example, the aim is to obtain digital support for the supply and handling of positional information common to everybody who is actively involved in a particular field, this calls for a high
level of control. If, on the other hand, the aim is to obtain digital support for the production of maps within an administration or for a particular product, this will not call for such a high level of control. The diagram below shows that the benefit/cost ratio obtainable through GIS introduction is dependent on level of ambition.

**FIGURE 1**

If GIS is introduced as a production tool only, we found that in most cases benefit/cost ratios of about 1:1 were achieved. It will be possible to reduce the drafting staff to about the half, of operators. Even if the need for drafting staff was reduced we found in nearly all cases that the idle personnel was allocated to more useful and interesting tasks in the organization instead of being unemployed.

Higher beneficial effects have been achieved if GIS also has been used for internal planning and administration (the users of the information) in the actual organization. At the same time costs were somewhat higher as more equipment and training of more personnel is needed. Benefit/cost ratios of at least 2:1 should be achieved. If, moreover, the basic information can be used for new problem-solving in capital-intensive activities, the benefit/cost ratio can at best rise to 5:7:1.

The highest beneficial effect for the community is established in cases where full co-ordination has been achieved between different organizations using the same geographical information for planning, design and administration of for example public utilities. At least 4:1 should be possible to attend.

In Norway, the above statements are referred to as "the 1:2:4 rule" for benefits from GIS introduction. The Nordic countries have, through the political systems, a favorable background for achieving a high level of co-ordination, and subsequently high benefit, from GIS. Normally public utilities such as water, sewerage, electricity and telecommunication are administrated by the municipality or the government. In the USA for example, where most of the utilities are operated by private companies we found low levels of co-operation to be the normal case. Benefit/cost ratios here were normally around 2:1 in efficient cases. This is, however, sufficient to make GIS investments competitive to alternative investments in the utility companies.
The chart below illustrates a healthy, positive development of cost/benefit relations. A picture of this kind is only obtainable with a properly thought-out strategy. The project has shown that the likelihood of finding a proper strategy is distinctly increased when the introduction of GIS begins with cost/benefit analyses based on user studies.

**Figure 2**

![Figure 2. Development of Cost/Benefit Relations](image)

### 2.3 Recommended strategy for implementation of GIS

We found no indications in the project to show that certain systems or software yield better profitability than others and could therefore be recommended. The level of success was varying from no benefit at all to benefit/cost ratios higher than 5:1. This was dependent on organization, co-operation and technical skill, and selection of the right strategy for implementation. Below are some key questions to be considered to achieve a best possible economic yield out of GIS investments:

1. Begin now or later?
2. Invest aggressively or within the normal budget?
3. Tailor-made or general systems?
4. Limited or comprehensive geographical coverage?
5. Build-up and maintenance of the database?
6. Changes of organization and routines?

The following recommendations are made in reply to these questions, with regard to the current developmental state of digital technology and in the light of our studies.
2.3.1 Starting Up

* Waiting means later results.
* Technology is no longer an expensive bottleneck.
* Don’t obstruct the disseminating of information in the community!

Technical progress has now reached a stage where it no longer constitutes a bottleneck for traditional products and applications. Deferment of introduction means an additional time lag and augments the cost of future conversion. Remember too that technical progress is a continuous process whereby you will still be facing the same problems in the future.

In cases where work is devoted to selecting a suitable strategy, it has not been possible to establish in this project that greater benefits would have been achieved by postponing the start. Organizations thus awaiting events are also found to have a negative impact on the flow of information in society, the reason being that information in digital form cannot then be transmitted to other users in the community by whom it is needed, or to those who subsequently introduce digital processing.

Normally, an organization only takes this kind of technological step once in its lifetime. Dealing with such a situation can in itself be expensive, frustrating and time-consuming, and so it is normal to engage outside assistance in the selection of strategy.

2.3.2 Investment Intensity

* All experience shows that, once the objective has been decided on, a high rate of investment is needed in order to obtain a high level of benefit within a short time. (Equipment, personnel, data, organization.)
* Conversion of data should be done rapidly.
* The effect will not come until a complete database has been established for at least one theme/application.
* Several themes in one and the same field have a synergistic effect.

Practical experience from users interviewed in the project has shown that relatively intensive investments are needed. Above all, information should be converted with great care and within the shortest possible period, provided of course, that the needs and fields of activity to be concentrated on were specified before the decision was made. The reason for preferring a short conversion period is that no benefit will be obtained until a complete database exists for at least one theme. Additional themes of a single kind will enhance the benefit to reach individual users, due to synergistic effects. Tests of smaller systems are to be recommended during pilot study and pilot project, as a means of obtaining practical experience with the technology and its possibilities.

2.3.3 General or Tailor-made System - Cooperation

* Choose a general system from the beginning.
* A tailor-made system limits the possibility of development and reduces the beneficial effects of the database.
* Co-operation among agencies and organizations is low in the USA. This limits the benefit/cost ratio when adopting digital technique to 2:1.
* Canada and the Nordic area present a better climate for information interchange and co-ordination across organizational and administrative boundaries. This facilitates a benefit/cost ratio of 4:1.

The best idea is to bank on a distributive system from the very outset. Experience has shown that in the great majority of cases a general system confers most benefit on users. In the USA it is normal to introduce tailor-made systems for every organization. This limits the opportunities for information interchange between different organizations. The climate for co-operation between different organizations and companies is more favorable in the Nordic area and Canada. This means more opportunity for the joint build-up of information systems.
2.3.4 Field Coverage

* Introduce at least one theme in a complete administrative field.
* A mixture of analogue and digital information for the same theme, with parallel routines, should be avoided.

Field coverage will of course depend on the activities which are to benefit from the information. Activities are often divided into different administrative or functional fields. It is always an advantage if a complete field of this kind can work with the aid of a new technique introduced. The use of parallel routines within such a field leads to unnecessary duplication, problems of interpretation, etc. Individual projects within a field of activity can benefit from digital support. The benefit in other fields or to subsequent activities, however, is difficult to achieve with the surrounding information being processed by traditional methods.

2.3.5 Build-up and Maintenance of the Database

* The content of the database is selected, right from the start, with reference to the needs of identified users.
* Distinguish between common and user-specific information
* The base(s) must be structured in such a way as to facilitate flexible use of data and the updating and expansion of content.
* Once the base has been installed, the users will find a host of new applications.
* User-specific information should be stored and maintained by the individual user.
* Try to make provision for future technical developments.

Without any information users, it is hard to arrive at a practical scheme of maintenance. Make a policy, therefore, of entering a content selected with reference to identified user needs. Information entered in case somebody should happen to need it often causes problems. Choose a flexible, expandable database structure instead. This will facilitate additions when needs are identified. Segregate common and user-specific information. For municipal engineering activities, for example, the geographical localization of facilities and a "base map" constitute important common information. Particulars about facilities and statistics relating to them, on the other hand, are for the most part valueless except to the administration or enterprise concerned.

2.3.6 Organization Conditions

* Organization problems present more of a challenge than technical ones
* The introduction of GIS leads to changes in existing routines for information exchanges between and within administrative authorities (e.g. the establishment of networks).
* Organization changes within the individual administration are also necessary in consequence of revised working routines.
* Normally speaking, every organizational change is opposed by at least 25% of the personnel.
* Project-orientate the introductory phases when introducing GIS.
* Permanent organizational changes can only be introduced after introductory experimental operation.

All organizations switching to GIS must devote a great deal of attention to organizational questions of different kinds. These questions are often more complicated than technical questions and at the same time crucial to the degree of success achieved. It is essential for permanent working units in the organization to feel genuinely responsible for creating and maintaining the entire organization/function with a complete overview and overriding responsibility. It is normal for the introduction of GIS to lead to changes of organization and routines, both within and between different organizations and administrative units.
The figure below shows what optimum introduction can look like, given the right choice of strategy. This figure also illustrates the benefits and costs figures. Benefit will be higher than costs first when the database for the actual area is converted. More themes in a common data base creates synergy effect and increases the benefit.

**FIGURE 3**

![Figure 3: Optimum Introduction of GIS](image)

3 APPLICATION TO GIS TO FORESTRY AND NATURAL RESOURCES IN NORWAY

A growing number of firms and organizations in the Nordic countries have during the last years taken into use GIS in mapping and management of forestry and natural resources. Below is a description of the most well-known installations in Norway. It is seen that Terrasoft and ArcInfo so far dominate the market for GIS applications to forestry and natural resources in Norway.

3.1 Terrasoft Installations

*Fotokart A/S, Kongsberg, Norway.*
Tel: 47-3-732350 (Bakken)

Fotokart delivers stand maps from photo surveys to forest owners associations. Up to now the products have mainly been hand-drawn overlays of stands, copied onto economic maps, with maturity class and site class added for the individual stands. In addition they deliver lists of areas, summed for each property or part of property, plus other stand information from the photo-survey. This information is stored on dBase-files that can be directly connected to the digital map in the GIS-part of Terrasoft.

The use of GIS has been mainly experimental up to now. The most likely products are thematic maps for various combinations of maturity class and site class, plus reports/statistics about area composition of properties according to various characteristics from the stand survey. GIS is also used to extract, for example, information about stands in a 100-metre belt along forest roads. Use of raster plotter for map presentation is presently being evaluated.
Norwegian Institute of Land Inventory (NIJOS), As, Norway.
Tel: 47-9-948850 (Hjeltnes/Angeloff)

NIJOS uses both the digitizing, plotting and analyses parts of Terrasoft. One of the digitizing systems operates a PC-based analytical stereoscope instrument, AP 190 (Carto Instruments).

Area data
Terrasoft is used both for vegetation mapping and soils mapping. After a digital manuscript for a mapping theme (cover) is established, various subthemes are derived from the polygon label point signatures using the data bases programming system DBXL (for example, map of grazing value or productivity derived from vegetation maps). This theme can then be drawn on a topographic base map in an appropriate scale with a plotter that gives visually contiguous colours.

NIJOS has its own area summation program that gives area data for desired area classes.

Point data
A data base of characteristics is coupled to the point net. This is expanded upon using the DBXL-program to include for example climatic parameters and information on plant or tree species. Mapping themes that are combinations of the information contained for each point are defined in a separate program. These themes are presented as various symbols from the symbol register in Terrasoft.

Line data
Plans are being made for "traffic load maps" for natural and other areas. Data on the type and intensity of traffic will be combined with production data and vulnerability to damage, and the new map themes emerging from this combination will be plotted out.

(This type of analysis result, based on GIS-technique, is considered an important information product in our society, where all political parties have a common goal that the general public should have insight into and contribute to planning and management of natural resources and the environment).

The State Forests and Lands Administration, Oslo, Norway
Tel : 47-2-417320 (Berg)

The State Forests and Lands Administration is responsible for mapping and survey of state-owned forest lands. Boundaries for forest stands are digitized manually, with subsequent calculation of areas and plotting of transparencies. Maps containing stand boundaries are used together with register data as a basis for planning. 27 000 hectares have been mapped by Terrasoft. 69 300 hectares have been mapped by the Norwegian system MAPDAT-Skog. All the material is now being converted to Terrasoft.

Application of GIS has until now been limited to map production. Map production and area calculation using GIS is at present not less expensive than manual methods. It is expected that GIS will be more advantageous with repeated surveying, and that GIS techniques will gradually find a place as a tool for rolling local planning. The State Forests and Lands Administration is expected to become a significant user of GIS.

Plans also exist for the use of GIS in connection with cultivation plans, development of tourism, and other activities within areas managed by the State Forests and Lands Administration.

Norwegian Mapping Authority, Resource Division, Honefoss, Norway
Tel: 47-67-24100 (Gilhus)

The Norwegian Mapping Authority has Terrasoft in their training lab, but it is not used in the normal production.
Mineralogy, quaternary geology, hydro geology, geochemical and other geological mapping. They have used Terrasoft until now for terrain modeling, geochemical mapping and for construction of data bases for characteristics. ArcInfo and other programs are under evaluation. No decision has been made as to which system will be used most.

3.2 ArcInfo Installations

ArcInfo, especially the PC version, spread rapidly in Norway last year, and Norway has, as far as we know, the most users of this program in the Nordic Countries. The minicomputer version is also installed in several places.

Centre for GIS and Remote Sensing, Arendal, Norway
Tel: 47-41-38870 (Bernhardsen)

One of the most interesting installations is perhaps at the Centre for GIS and Remote Sensing, where preparations are being made to couple ArcInfo (on VAX) to the swedish image-processing system Teragon. The Centre is working as consultants in GIS and remote sensing in Norway and abroad, and carries out image processing, satellite mapping, satellite/GIS applications and establishment of geographic and environmental databases. Vegetation mapping from satellite data is a specialty. The Centre also undertakes training and education and institutional building in less developed countries.

In the fields of forestry and natural resources the Centre is at present testing SPOT HRV and Landsat-5 TM-data in forest resource mapping in two townships in Aust-Agder County. Ground truth consists of forest inventory in forest productive areas, and plant sociological mapping above the tree line. The study aims at clarifying the possibilities for use of satellite data for overview mapping and stratification, for example as a basis for structuring mapping at more detailed levels. Whether existing, traditional methods for detailed mapping can be adapted to make cost-effective use of satellite data, is also considered.

Satellite data and digitalized, infrared-sensitive colour photographs are also tested for practical application in identification of forest decline. Special emphasis is given to tree vitality in parks and adjacent areas of the industrial town Porgrunn, Telemark County. All satellite images are precision corrected, and can be combined with topographic or thematic maps at given scales, for analyses and for the documentation of findings.

Mapping of environmental data has started extensively as a part of a national project with 80 Norwegian municipalities involved in pilot projects for environmental management.

This year mapping of national parks will be started up.

The Centre is at present working with vegetation mapping fro a major fuel wood project in Malawi funded by NORAD (Norwegian Agency for Development Aid).

The Centre might become a Norwegian national node to UNEPs Global Resource Information Database (GRID), headquartered in Nairobi, Kenya. Establishment of a GRID node in Norway is expected to be one of the recommendations in a parliamentary report on Norwegian follow up to the World Commission on Environment and Development, headed by the Norwegian Prime Minister Gro Harlem Brundland.

Institute for Environmental Analyses, Bo, Norway
Tel: 47-3-950499 (Hjesjedal)

The Institute is installing ArcInfo and ERDAS for research and development, teaching and small projects in Norway and less developed countries. Applications include all kinds of environmental data. The Institute is co-owner of the Centre for GIS and Remote Sensing in Arendal, and the installation can be related to internationalization of activities there and projects for the Ministry of Development Cooperation, Norway.
Norwegian Institute of Land Inventory (NIJOS)

NIJOS is starting up several work stations with ArcInfo for projects as discussed under TerraSoft.

There is good reason to suppose that ArcInfo and ArcInfo/digital image processing will come into relatively wide use in Norway in the coming years, not least in connection with the analysis of natural resources and environmental data. In addition to the installation at the Institute for Environmental Analysis, ERDAS/ArcInfo is under planning or trial at several other institutes that work with environmental data, including the Norwegian Mapping Authority, Resource Division and the Directorate for Nature Management in Trondheim. A combination of ArcInfo and I2S is reportedly under way at Tromso University. Increasing interest in these GIS-systems has also been shown in the institutions working with projects in Development Cooperation.

One further condition for a true "breakthrough" in user environments is menu-steering. ArcInfo is still considered complex for new users, with a multitude of commands and possibilities in various "boxes". It will take some time to structure production methods that can easily be adopted by personnel without special training.

3.3 SYSSCAN, PUMATEC, MAPDAT-skog and Other Installations

These are Norwegian systems, the first two are relatively expensive as complete systems. There are few users in forest and resource mapping. MAPDAT-skog has (and has had) users in the forestry sector. The State Forests and Lands Administration has mapped 69 300 hectares using MAPDAT-skog. The program seems to have problems with getting upgraded at the same rate as ArcInfo and Terrasoft, for example.

4 REFERENCES


GIS - A TOOL IN FOREST PEST MANAGEMENT

G.A. Van Sickle

Head, Forest Insect and Disease Survey
Forestry Canada
Pacific Forestry Centre
506 W. Burnside Rd.
Victoria, B.C. V8Z 1M5

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

ABSTRACT

The Forest Insect and Disease Survey of Forestry Canada annually monitors forest pest conditions across Canada. About 1/2 million insect and disease records on a wide range of forest plants exist for British Columbia, and major infestations continue to be mapped annually. Through GIS capabilities developed at the Pacific Forestry Centre, regional and provincial pest summaries are prepared, multi-year infestations analyzed, and comparisons of pest distributions made with biogeoclimatic zones, inventory, or climatic and moisture data. Results help in risk rating stands for potential pest problems, display infestations for control planning, and allow analysis of possible relationship among pests, and between pests and other factors.
INTRODUCTION

Tree mortality and growth loss caused by forest pests in the Pacific Region each year exceed 25 million m³, which is a volume equivalent to about one-third of that harvested annually. To the extent that major losses to bark beetles, defoliators, dwarf mistletoes and root rots can be salvaged or reduced, the impact of projected wood supply shortages can be alleviated. Additionally, there are losses not easily measured by volume such as constraints on the use of desirable species; constraints on seedling movement or trade exports because of international and provincial quarantines; losses in young stands, in aesthetics, in recreational values or increased fire hazards. Also, significant and increasing investments in silviculture can be eroded if pests necessitate replanting or cause understocking of thinned stands before they reach merchantability.

The Forest Insect and Disease Survey (FIDS) of Forestry Canada each year conducts an overview of pest conditions in the forests of Canada which is useful in support of: forest management decisions; regional, national and international plant quarantines and regulations; and in forest research and development programs. The surveys are accomplished in part by random and permanent sampling station collections and observations, pheromone trapping, stand cruises, evaluation of parasitism, egg counts to forecast future populations and damage, aerial detection and delineation mapping, photography, and extensive liaison with industrial and provincial forests or parks staff. The great diversity of topography, climate, vegetation and pests over the 51 million ha of productive forest in B.C. and 8 million ha in the Yukon Territory creates a complex mosaic of information difficult to interpret and manage.

The Forest Insect and Disease Survey has annually monitored forest pest conditions and maintained records of identifications and collections of forest insects and diseases since 1936. In the Pacific Region, additional observations and collections were made even pre-1900. Almost 40% of the national database of 1.3 million pest specific records are from the Pacific Region. Included in this regional database maintained at Pacific Forestry Centre (PFC) are 171,000 disease and 295,000 insect and parasite records with associated host and location information. About 6,000 new records are added annually. This paper describes developments with a geographic information system (GIS) since 1984 to more accurately, quickly and thoroughly present, analyze and interpret annual and historical records.

INPUTS AND EQUIPMENT

Aerial surveys for detection and mapping of forest pests have been quite regular since 1960 and were conducted for selective problems since the late 40's. Earlier cartographic records of infestations were largely limited to mapping from vantage points and date back to the 20's. For provincial and national overviews, aerial sketchmapping is still the most time and cost-effective procedure for conducting a detection and initial survey over vast areas on a yearly basis. Currently, sketchmapping for a first stage overview is mostly on 1:100,000 scale maps, occasionally at larger scales and, if necessary because of map availability throughout the region, at smaller scales up to 1:250,000. Consistency is increased by using the same few experienced observers. Sketchmapping can often be completed under less rigorous weather conditions than photography, reports and summaries are more readily available, and costs are only about 10 cents/km². Areas justifying more detailed helicopter reconnaissance or photography can then be identified and efforts better focused. Attributes for each sketched polygon normally include tree species damaged, severity, year, and pest. Those pests most commonly distinguishable from fixed-wing aircraft include the major bark beetles; defoliators such as budworm, Douglas-fir tussock moth, and tent caterpillars; and porcupine, blowdown and storm damage.

Ground-based observations and collections have included additional information on geographic location based on a 10 km UTM grid, elevation, stand attributes, host tree, sampling method, pest species identification, collector, date, etc. Since 1967 this has been a standardized 80 column entry and earlier records were converted from punch cards. Both the ground and aerial records can be usefully presented, analyzed and summarized with a GIS.
The large volume of the national database can be accessed and manipulated through FIDS INFOBASE, a relational database management system using INGRES developed by the FIDS technology development project (Power 1986). It is currently operating on a Digital Equipment Corporation VAX 11/750 at the Petawawa National Forestry Institute in Ontario with decentralized on-line capability to input, update and retrieve regional data. The required data can be selected and summarized within INFOBASE or by standard SAS routines, then if geographic presentation is necessary, transferred to a GIS.

Development of GIS capabilities has been underway at Pacific Forestry Centre (PFC) since 1984. Through a development agreement with Northwest Digital Research Ltd. of Vancouver, hardware was supplied and the necessary software links developed to make their program series “OVERLAY” suitable for regional FIDS mapping and analysis. The system was purchased in 1986 with cooperation and development continuing. OVERLAY is a spatial analysis and spatial database module which inputs in vector, raster, text and polygon form. Spatial data is managed using an unique proprietary data structure called associative maps. Attributes, resolution and number of layers are limited only by hardware capacity. It is currently running on a Hewlett-Packard workstation linked to a large E-size plotter and digitizer, a 9-track tape drive, high resolution monitor, printer and a 400 M byte disc drive. Easy selections can be made using the mouse or keyboard of 7 levels of display or plot resolution, normal or polyconic projections, 15 colors, 8 fill patterns, variable paper or map size, variable or customized map windows, and overlay functions of union, subtraction, etc.

Presently the system contains data for more than 700 insect or disease maps (with additional historical maps being digitized as time permits); biogeoclimatic (ecological) zone maps for B.C. at 1:2 million; selected geographic data to create outline maps of boundaries, lakes, rivers, major towns and B.C. Forest Service forest regions; a partial national level forest inventory; and some detailed forest cover information, growing degree days and climatic moisture deficits.

OUTPUTS

**Annual infestation maps and summaries**

Upon completion of the aerial surveys each year in August or September, the field technicians return to PFC and enter into the GIS the current infestations by digitizing the polygons and assigning attributes of pest, severity, year, forest region and map reference. From these data, searches or compilations, of any combination of desired attributes can be made. A map of the previous year's infestations is generally used during flights to improve the accuracy of locating continuing infestations, to more clearly identify changes and to ensure that major infestations are reflowed. Also, during digitizing the current and previous year's infestations can be viewed on the screen and any differences are corrected or accepted by the technician before entry into the database. With the field technicians responsible for input of their own data, errors of missing labels, placement, etc. can be detected and corrected.

Maps are then computer-produced at various scales and distributed to cooperating provincial forest service and forest industry staff, and are available to parks and others. By combining 20 to more than 100 such maps, regional and provincial maps are available for review and planning meetings and reports (Figure 1). Rapid edge matching of data from virtually any number of maps or scale, and relative ease of the digitizing procedure are advantages of the developed software. Using report generators, area and polygon tallies can be derived for selected areas, map sheets, regions or the Province (Tables 1 and 2).
### TABLE 1

**AREA (HA) OF SELECTED INSECT INFESTATIONS IN BRITISH COLUMBIA IN 1988 BY FOREST REGION.**

<table>
<thead>
<tr>
<th>Pest</th>
<th>Cariboo</th>
<th>Kamloops</th>
<th>Nelson</th>
<th>Prince George</th>
<th>Prince Rupert</th>
<th>Vancouver</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain pine beetle</td>
<td>1290</td>
<td>17 642</td>
<td>26 180</td>
<td>3972</td>
<td>12 974</td>
<td>841</td>
<td>62 898</td>
</tr>
<tr>
<td>Western budworm</td>
<td>8047</td>
<td>344 710</td>
<td>3275</td>
<td>0</td>
<td>0</td>
<td>3640</td>
<td>359 671</td>
</tr>
<tr>
<td>2-year cycle budworm</td>
<td>40 215</td>
<td>44 452</td>
<td>0</td>
<td>17 519</td>
<td>0</td>
<td>0</td>
<td>102 185</td>
</tr>
<tr>
<td>Eastern budworm</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>35 889</td>
<td>0</td>
<td>0</td>
<td>35 889</td>
</tr>
<tr>
<td>Blackheaded budworm</td>
<td>0</td>
<td>877</td>
<td>0</td>
<td>0</td>
<td>58 669</td>
<td>4829</td>
<td>64 375</td>
</tr>
<tr>
<td>Forest tent caterpillar</td>
<td>462</td>
<td>0</td>
<td>1536</td>
<td>48 317</td>
<td>1557</td>
<td>0</td>
<td>51 872</td>
</tr>
</tbody>
</table>

### TABLE 2

**AREA (HA), SEVERITY AND NUMBER OF AERIALLY MAPPED POLYGONS OF FOREST PESTS FOR A SELECTED (1:100 000) MAP SHEET IN 1988.**

<table>
<thead>
<tr>
<th>Mapsheet</th>
<th>Pest</th>
<th>Severity</th>
<th>Area (ha)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elko - 1988</td>
<td>Douglas-fir beetle</td>
<td>severe</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Forest tent caterpillar</td>
<td>severe</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Larch sawfly</td>
<td>moderate</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Mountain pine beetle</td>
<td>light</td>
<td>4129</td>
<td>306</td>
</tr>
<tr>
<td></td>
<td></td>
<td>moderate</td>
<td>294</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>severe</td>
<td>192</td>
<td>635</td>
</tr>
</tbody>
</table>

**Multi-year overlays**

The ability to create and analyze multiple overlays is a most useful function. In 1987, Douglas-fir over more than 834 000 ha were defoliated by the western spruce budworm which was the largest infestation by this insect recorded in British Columbia. This insect feeds preferentially on current year foliage, hence damage is greatest after several consecutive years of feeding. In order to identify areas of greatest damage and better determine the magnitude of the problem, overlays of the yearly defoliation maps for 1983 to 1988 were created and analyzed. Almost half of the total area had been defoliated for one of the six years, 36% for two consecutive years, and 15% for three or four years. Only 1% had been defoliated five or more years. Areas could be identified for salvage, treatment consideration, or deferred action.
In a similar manner, long-term records of occurrence and severity for pests of concern can be summarized and visually displayed for use in planning. To the extent that history is a good teacher, the forest manager could consider planting non-host trees in areas of highest infestation frequencies, or at least be forewarned to expect 0, 1, or more infestations during the next rotation. Mapping the spread of introduced forest insects such as larch casebearer over time is similarly possible and useful.

**Analysis of relationships**

GIS’s can also be wonderful integrators of efforts in many areas. Specialists in many fields (entomology, pathology, soils, hydrology, fire, climate, mensuration, recreation, wildlife, remote sensing, modelling, etc.) can enter and use data of unique interest and the opportunities and benefits of interaction greatly exceed the sum of the parts. In the past, possible relationships between or among insect and disease distribution patterns, biogeoclimatic zones, climatic variables, forest types, slope or aspect, etc., were difficult to evaluate or quantify. GIS capabilities greatly reduce the drudgery and make possible “let’s look at...” scenarios.

**FIGURE 1**

REGIONAL SUMMARY MAP OF MOUNTAIN PINE BEETLE IN 1988
A COMPUTER AMALGAMATION OF 72 MAP SHEETS, MOSTLY 1:100,000 SCALE
INVOLVING 8,558 POLYGONS WITH A CUMULATIVE AREA OF 62,898 HA
Douglas-fir tussock moth periodically causes severe defoliation, growth loss and mortality of young and mature Douglas-fir. Defoliation has been mapped by the Forest Insect and Disease Survey during eight outbreak periods since 1916. Each period of defoliation by Douglas-fir tussock moth usually lasts one to four years before natural factors, usually a virus, reduce the larval populations. These were overlaid to determine correspondence of the insect with forest habitat and climatic maps in order to identify the most susceptible ecozones and key climatic conditions. More than 600 overlays, intersections, unions or subtractions of map polygons were completed which would have been impossible without a GIS.

Of the 12 ecological zones considered, the majority of the infestations occurred within PPB Gd and IDFc and a, and within these where temperatures were moderate (1,500 to 1,900 cumulative degree days/growing season), and where moisture deficits were extreme (~300 to ~500 mm/growing season) (Shepherd, Van Sickle and Clarke, In press). Identification of the most susceptible areas and stand types focuses and improves monitoring techniques, provides a basis for risk assessment and identifies the probable need and frequency for direct control of infestations in future rotations. Information on the environmental requirements and limitations for outbreaks can improve predictions of where and when future outbreaks will occur, and is basic to estimating damage which may be expected with climatic shifts because of atmospheric pollution or global warming effects. An additional useful observation was revealed during the GIS analysis. Even though multiple outbreaks had been recorded and referenced to the same place names, exact geographic overlaps were not common. Of the total area defoliated in the 8 outbreaks, 90% had been defoliated once, 8% defoliated twice, and only 2% defoliated three times.

The GIS is also being used in cooperation with a contractor to compare the historical areas of western budworm defoliation and various stand harvesting or management procedures. From aerial sketch mapped records of widely scattered, previously defoliated stands totalling more than 800 000 ha and almost 500 stand harvesting records, 95 locations were selected for further analysis and of these, only 15 of these had sufficient historical data. In this case, GIS analysis quickly identified the few stands which satisfied the sampling requirements and focused the subsequent fieldwork.

Pest distribution maps developed from a computer search of many years records and plotted using the GIS have also been useful in plant quarantines (e.g. the introduced balsam woolly adelgid), or in managing the large insect and disease collection to quickly determine which new collections represent significant extensions of known distributions. Some pest outbreaks, such as black army cutworm are in part initiated by wild or prescribed fires, and distribution maps assist forest managers in identifying areas most frequently affected, and conversely those not affected, in order to modify silvicultural practices when appropriate.

By overlaying and combining pest distributions, severity and duration records with national level forest inventories (volume summaries by species for map sheet sized cells) and applying mortality and growth loss factors, pest-caused volume losses can be estimated. This is in progress with preparation of a regional contribution to a national reporting of losses to major forest insects and diseases during the last six years. The previous, rather laborious, estimate with many assumptions found more than 107 million m³ were lost each year to pests from 1977 to 1981 (Stern and Davidson 1982). With input, expectedly on machine-readable tape, of the geographic boundaries of parks, forest regions and districts, timber supply areas, electoral districts, etc., it should also be possible to partition the losses and pest distributions according to major land ownership types. Cooperation with the B.C. Forest Service for data sharing has been excellent with only the development of the software linkages between the different mapping system taking some time and effort.

CONCLUSIONS
A large national and regional historical database on the identification, hosts, distributions, frequency and cycles of many forest insects and diseases, has been created over several decades, but only recently has the computer capability of relational database management and geographic information systems enabled fuller analysis. To guide and assist forest protection research and management, the database can be interrogated interactively or in batch mode, a wide range of maps can be stored and produced, and maps can be overlaid, analyzed and summarized in association with pest distribution and history, forest inventory, biogeoclimatic vegetation zones, administrative boundaries or climatic and other records. Results help in risk-rating for potential pest problems,
support quarantine decisions and regulations, display infestations for control planning, and allow analysis of comparisons and relationships among pests and between pests and other factors -- and we've really just started to tap the power and integrating capabilities of the GIS!

REFERENCES


DEVELOPING A NEW GIS - EVOLUTION OR REVOLUTION?

Richard R. Wakeley
Manager, Inventory and Systems
Weyerhaeuser Company
Tacoma, Washington

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ABSTRACT

Survival of any information system in changing management culture demands flexibility of both people and programs, particularly in the private sector. Response time to changing objectives is the key to success of any system including a GIS. Weyerhaeuser is in the process of building a new system, as we have been for the past 22 years, by evolution - not revolution.
JUSTIFICATION FOR GIS/MIS

David Wills
Director
Sierra Systems Consultants Inc.
Vancouver, British Columbia

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ABSTRACT

Completing some sort of strategic plan and cost benefit analysis have historically preceded most GIS projects. For some the justification emphasis is on financial payback. For others the justification may be in improving information handling, complying with government regulatory requirements or providing better planning. This paper takes a look at the technical issues and costs involved in developing a strategic plan and cost-benefit analysis. It discusses key steps required for a successful GIS cost-benefit analysis.
“PHOTOGRAMMETRY AS A DATA SOURCE FOR GIS”

S.E. (Al) Daykin

General Manager
Digital Mapping Group Ltd.
Burnaby,
British Columbia

GIS'89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
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ABSTRACT

Creating and updating digital maps using photogrammetric techniques is a cost effective method of acquiring digital spatial data for use in geographic information systems. This paper deals with some of the technical and managerial considerations in the acquisition, training and implementation of a digital photogrammetric data capture system, some of the problems associated with acquiring and supplying spatial data to GIS users, and the related benefits of photogrammetric techniques.
In this age of satellite imagery, video cameras, and global positioning satellites it is often easy to overlook the many advantages and uses of aerial photography and the science of photogrammetry as sources of spatial information. Let me suggest some of the many reasons why aerial photos will continue to be an important primary source of spatial data for a long time to come.

From a historical perspective there is no substitute for aerial photography, and any project which monitors or reviews changes over time must rely on this medium. An example of this would be a cumulative environmental impact study to assess the incremental effect of an action when added to past, present and foreseeable future actions. Obviously satellite imagery and other remote sensing data are still relatively new to be of much historical significance, at least at this point in time.

In addition, despite the perceived capabilities of newer satellites, some not yet launched, aerial photography is still the standard for almost all topographic mapping in the world today. Satellite imagery may enable preliminary maps to be generated for areas of the world where no topographic data previously existed, but this imagery cannot provide the wealth of information available from aerial photography, nor the accuracy achievable by photogrammetric methods.

It is well to keep in mind that, although remote sensing data can be an important data source for a GIS, it cannot yet be considered a primary source. The accuracy, precision, and degree of detail required for most mapping projects, as well as for many GIS applications, dictates the use of aerial photos.

Having said that however, satellite imagery is being extensively used to record significant changes in the terrain -- recording cut-over blocks for forestry for example -- as well as for updating 1:250,000 scale national topographic series map sheets. Digital image processing systems now include most, if not all, of the functions of a GIS. These remote sensing analysis systems which include spatial data handling functions provide a powerful means for increasing the utility of remote sensing data.

One final advantage of aerial photography which must be considered concerns the ease and simplicity of use compared to other remotely sensed data. The aerial photograph might in fact be considered an introduction to remote sensing as a source of spatial data.

Conventional or analogue mapping on stereoplotters has been carried out in Canada for perhaps 50 years in both the public and private sectors. Although there have been significant technological advances in aerial cameras with virtually distortion free lenses, in stable based high resolution aerial films, and in the sophistication and improved capabilities of stereoplotters, mapping operations and management procedures have remained virtually unchanged over this period.

A recent advertisement by a prominent supplier suggests that “the last few years have seen a change in photogrammetry from graphic products to digital, brought about by the ubiquitous computer”. How true. In fact the trend to digital mapping began in Canada during the late 1970’s, about the same time that GIS began to emerge a decade ago.

For several years, however, most of this new digital mapping technology was directed towards automating the cartographic drafting process without much thought to its potential use as a digital topographic data base. In 1983 the Canadian Council on Surveying and Mapping, a joint Federal and Provincial body, produced a National Standard for the Exchange of Digital Topographic Data. These two volumes include standards and codes for classification of features, and standards for data exchange formats.

During the early 1980’s hardware and software evolved rapidly and users began to demand more structured data. We are presently at the point where the shift from conventional to digital mapping is now almost complete in Canada, and the picture has changed dramatically.

- The Federal 1:50,000 scale mapping program is now almost fully digital. The existing 1:250,000 map series is also being scanned and converted to digital files.
- Almost all Provincial Governments are planning or have initiated digital base mapping programs, and most have at least one GIS-related inventory program now underway.

- Most major Canadian cities undertaking new mapping programs are opting for digital data as part of an integrated mapping system.

- Many larger engineering consultants are now ordering mapping in digital form to enable further processing and modeling on their own CAD systems.

This transition to digital technology has been a traumatic experience for aerial survey companies across Canada -- an industry long considered to be fully 'mature'. Costly hardware and software had to be purchased, new specialists hired, and an extensive period of retraining of existing staff was required.

At the same time both producers and users alike have been faced with rapidly-evolving product specifications, user requirements and system capabilities. In addition the learning process associated with this digital transition proved to take longer and was much more costly than many anticipated, causing some of the major Canadian mapping companies to restructure due to heavy financial losses, and several companies across Canada have in fact failed over the past three or four years.

The data capture process involved in digital mapping is far more complex than the production of analogue mapping. In many instances it is not an easy task for photogrammetric technicians to make the mental transition from producing a cartographic product, to one of producing topographic information as a series of points, lines and polygons or area features, all in machine readable formats. We must now specify three things to the computer:

- where each feature is in three dimensional geographic space,

- what each feature is by means of a feature code, and

- what each feature's spatial relationship is to other features in the map file.

Here in British Columbia only one or two companies had any previous digital mapping experience until the advent of the Province's TRIM program in 1986. The specifications for this project were developed to meet the current demands of users, and to deliver a digital topographic data base whose format is generic enough to meet the capabilities of most if not all GIS systems presently available.

To facilitate analysis, the data must be somewhat topologically structured which dictates certain rules during the data capture process.

- All polygonal or aerial features are captured using a right hand rule, and are explicitly closed by duplicating other features where necessary.

- A continuity rule ensures that all hydrographic features are unbroken and continuous, and these features are captured in a downstream direction.

- Connectivity and networking is assured by having all like and unlike features which intersect or close on themselves do at numerically and mathematically exact coordinate junction points or nodes -- in most cases an exact three dimensional node.

The difficult topography of this Province dictates that all features must be captured three-dimensionally. Instead of producing contours manually, a digital elevation model is generated during data capture which provides more information in terms of terrain modelling, as well as providing the capability of producing varying contour intervals using the computer. This same digital elevation data can be used to geometrically correct satellite imagery and will no doubt provide the means of updating the TRIM topographic data base as the resolution of satellite imagery improves in the future.
Although the interpretive process of recognizing and capturing features is much the same for digital mapping as for analogue, the digital procedures are much more complex and demanding, in order to ensure the integrity of the digital topographic data files.

The shift in major market emphasis from conventional to digital mapping is now almost complete in Canada, and virtually all companies are seriously involved with digital mapping, and to some degree with geographic information systems. Mapping companies are also providing data conversion services, including manual digitizing of existing graphic products, as well as the input of related statistical or attribute data. Some companies also provide consulting services, assisting users in the implementation of GIS, researching data sources, or in preparing specifications for data acquisition.

Clearly GIS technology is a tool that has the potential to assist in the performance of specified activities more effectively, efficiently and accurately by automating the heretofore manual process of gathering and analyzing data as an input to decision making. Front-end costs associated with implementing a GIS are rather high however, and one should not expect a payback early in the life of such a program. An analysis of the costs and benefits of incorporating GIS technology may be appropriate before making such a commitment.

In addition to the obvious capital costs of hardware and software, and of system maintenance, there are the not so obvious but significant costs related to data input and personnel training which are often more than a user anticipates. Benefits are more difficult to quantify and include information efficiency, analysis capability, cost avoidance due to error avoidance, and ultimately cost savings compared to manual methods. But one should not expect an early return on investment -- like digital mapping or playing poker - the learning process associated with implementing GIS can be costly.

Finally, there is a wealth of existing spatial and textual data presently available in the public sector which may answer some GIS needs. Care should be taken however to check the suitability of the data in terms of age, format, method of collection, and completeness as well as accuracy. When in doubt one can always revert to the tried and true digital photogrammetric techniques which will continue to provide the structured data required for GIS for years to come.

REFERENCES


TEXT OF AFTER-LUNCH SPEECH

Chuck Lankester
Principal Technical Advisor
United Nations Development Programme
New York

GIS'89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
MARCH, 1989

Note
The following text was transcribed from a tape of Mr Lankester's speech, and has not been subsequently edited for content correctness or style.
Ladies and Gentlemen, my short speech is as follows:

- I want to tell you that the environmental situation out there stinks;
- that we have to correct it or we will all go down the tubes together;
- and that to do so is going to require a great deal of skill, imagination and a lot of money.

And thank you.

My long speech is a bit trickier. I have to develop those three points, introduce at least two more and show a few slides. And since you have already been gracious enough to reimburse my round trip ticket for an incredible $1,119 from New York last night and back tomorrow morning I think I have to go for the longer version.

I want to direct my remarks to you today as businessmen and women, as civil servants, consultants, and perhaps above all, as private citizens of planet earth.

I am going to talk for a moment about the situation and then give you some numbers.

The forestry cover in the developed world has more or less remained stable since the turn of the century, from 2 to 2.1 billion hectares. That is not the case in the developing world. Somewhere between 40 and 50% of the cover has been lost; you may care to recall this statistic: 1 and 1/2 million hectares of annual loss. That is equivalent to 20 football fields cut down each minute with a machete, chain saw or plow.

Our database comes from 1979 from a global perspective, and is only now being updated. Will it be up or will it be down? Certainly, if recent trends in some critical countries are to be believed, the loss will have been even greater than the 1979 figures project.

We are losing 17 million hectares each year to desertification or land with zero economic yield and another 6 million hectares of crop land are being lost each year. There are 160 million hectares of watersheds that have already been destroyed and another 160 million hectares in a critical condition. These are in the zones such as the Himalaya, where 550 million people in the Indo-Gangetic plain beneath those watersheds, depend on soil and water conservation in the hills.

Last year we put 5.5 billion tons of carbon into our atmosphere from fossil fuels and another estimated 2 billion tons from deforestation. I do not have to tell you in Canada about acid rain, but you will have also heard about other atmospheric problems, such as the thinning of the ozone layer and the impact of global warming.

I think these are perhaps the greatest threats that we face today and if we do not conquer the problems - particularly the atmospheric problems - I think we are in for grave social and political conflict.

I would say to you that on all of these issues we need MORE information, BETTER information, FASTER information, and information which intergrades the disciplines of forestry, agriculture, water and soils better than they have ever been integrated before. Above all, decision makers need to know the costs of action and inaction in order to make the best decisions they can.

When I talk numbers, I always find that the hardest part is to get my audience to understand that this really is going to effect their lives.

Let me ask you to reflect on whether you are influenced by any of the following four points;

Do you know anybody recently who has had open heart surgery? who is fighting cancer or who is dependent in any way on the roughly 1/3 to 1/2 of all the drugs used on this continent that are derived from the tropical forest?

Do you know anybody in the Fraser Valley or elsewhere who is living only 1 to 1 and 1/2 meters above sea level?
Are you engaged in trade of any kind with Third World countries?

Do you drive a car or are you in any way effected by the use of fossil fuels?

I could mention many other categories, but if you fall into a category influenced by any of the four items above, then your life styles, your adjustments in life, are going to have to be very seriously reconciled with today's challenges.

And are we taking these challenges seriously enough?

My answer is a categorical "No!" - we are only just beginning.

I see hopeful signs.

Many of you will have heard of the Brundtland Commission set up in 1987. I was in Vancouver approximately 5 weeks ago to participate in one of six cross-Canada meetings that were held by the Canadian Government to gather public and private opinion on the recommendations of the Brundtland Commission to determine how its own bilateral program in the future should be adjusted to take consideration of the Commission's recommendations.

If you haven't yet read the book on the work of the Brundtland Commission entitled "Our Common Future", I urge you to read it. I urge you to ask your children and friends to read it.

I would also say that the Montreal Protocol and the recent press about the ozone layer is encouraging. I was in Toronto on the 20th of February in a taxi when I heard the Minister of the Environment announce that Canada intended to go beyond the legal provisions of the Montreal Protocol on the use of CFC's in Canada and just this week, a whole succession of political leaders at the Ozone Conference in Europe have attempted to leapfrog each other and establish higher standards for their own countries.

I would say that what we have done in trying to address the problems of tropical deforestation is an encouraging beginning. We have a document called the Tropical Forestry Action Plan which has, since 1985 brought together a coalition of all the parties involved, especially the developing countries themselves but also the multilateral, the bilaterals, the financing institutions and the NGO programs, to try to make a concerted effort to correct this problem.

I would say that the aroused political sensitivity is also an encouraging sign but we must remember that politicians respond to what the people say; if we are not informed and if we do not press our elected representatives to take environmental issues seriously then we are failing in our responsibility as citizens as well.

There are new problems that we are beginning to recognize. We're beginning to recognize the problems of the sovereignty of nations and if you read the press about what is happening in the Amazon you will realize that that is an extremely sensitive issue. We are also beginning to address the individual rights and the responsibilities that we have.

To explain the latter, I sometimes try to tell people that I've been driving a 1976 Toyota that is rusting out and that 4 years ago I was offered $200 for it when I tried to trade it in when I had a little money for a brand new Toyota Stationwagon. Secretly I covet, like a good yuppie, a nice Volvo stationwagon. I can't afford it now, but that is what I really want. The question is: "Can Society afford for Chuck Lankester to drive that Volvo?" It is going to consume a lot more fossil fuels, it is going to pump a lot more carbon dioxide into the atmosphere and so on. Those are the kinds of questions that we are going to all have to address.

I would say, in particular, that some of the actions that we note in the field are encouraging. I would cite the situation in China right on the top of the list: decreased military expenditure, increased financing for soil conservation for reforestation and for family planning and, over the last 10 years, a steadily rising agricultural productivity.
On the homefront, I think we are beginning to all ask ourselves what can we individually do? Recycle our newspapers, avoid products that are made of CFCs, foam products in the fast food industries? How can we conserve energy and how can we become more informed?

I would like to reflect a moment on today's environmental agenda. I suppose we could put 20, 30 or even 40 points on a list.

Let me mention the following:

- deforestation;
- the assurance of clean water and water for agriculture;
- acid rain;
- the thinning of the ozone layer;
- global warming;
- toxic wastes including nuclear wastes;
- declining agricultural productivity in the third world;
- the increasing population problem;
- desertification; and
- the loss of species or the loss of biodiversity.

Concerning this last one, let me just mention that our best estimate is that we lost 10 thousand forms of life in 1988. I mentioned a moment ago the question of sovereignty of nations and our individual rights and responsibilities. It profoundly concerns me - and I think it should concern you - as to whether we have the moral right and responsibility as one of God's creatures to preside over the extinction forever of an estimated 10 thousand forms of life last year.

Now if you reflect on the list above you can realize that they result either from desperate poverty or from complete loss of human dignity in a fight for survival in an over-populated world or as the result of overindulgence (from greed if you wish), combined with an irresponsible use of certain technologies.

Correcting this action is going to necessitate a massive shift of capital from the developed to the developing world. It is going to mean lowering the expectations in the lifestyles that we lead. It is going to mean developing new and benign technologies - substitutes for CFCs is a prime example in that regard.

If you think about this, you also realize that unlike the last decade where we were mostly talking about local problems, we are now indeed truly forced to look at the life support systems of our planet's biosphere - air, water, soil, forest cover and vegetative cover and the oceans.

Today's problems are bigger; we are not just talking about the release of a little methane from some horse dung from carriage drawn conveyances in the streets, we are talking about 7 and 1/2 billion tons of carbon in 1988 that went into the atmosphere. We are looking at CO2 concentrations that are going up 1/2 of 1% per year since 1958 and have increased by 25% since the Industrial Revolution in the very air you are breathing now.

Today's problems are bigger and they are nastier. We are talking about huge quantities of nasty things that we are using supposedly to make our environmental situation better and more tolerable. We are talking of a shift from natural products to highly toxic ones and I only need to mention words such as Agent Orange, dioxin, Bhopal and Chernobyl for you to understand the kinds of games that we're playing with our lives.

The problems are bigger, they are nastier and they are everywhere. The problems are no longer confined to the west, to the north, to the industrialized consumer countries. We are finding them also in the third and in the fourth world.

I have not mentioned the problems of urbanization but if you stop to reflect for a moment that at the end of the century there will be 10 cities in the world each with a population of over 30 millions, all of them in the developing
countries and that 90% of the population growth is going to occur in the developing countries where people today do not have housing, food, clean reliable water, and they do not have education, you realize the explosive situation that we are facing in the urban areas of the developing countries.

The problems are bigger, nastier, everywhere and they are trans-boundary. You should know that acid rain is a trans-boundary problem that been a dominant feature of US-Canadian discussions and negotiations for the last few years. And we have the global imperative to preserve geoplasm.

The list is long. You can think of many examples yourselves. My point is simply this: common interests require articulation and correction of these problems through international corroboration.

Let me say a few words on the agenda that I see ahead for the 90s. I have already mentioned 10 or 12 urgent problems. You could perhaps add others to that list but I see four emerging imperatives that we have to address in the 1990’s.

I would put population planning on the top of the list. I was asked to talk in the context of forestry and I suppose that foresters have contributed to the population problem in the past. But seriously, the key is information, access to services and above all, giving women a choice.

I would say the second imperative for the 90s is food security. Today we estimate that 65 countries will not be able to feed themselves at the end of the century. And it could very well be that if global warming and shifts in climate do occur as they seem indeed to be giving us cause for concern that they might, that could be even more than 65 countries. I am sure you realize the state of food stocks in the United States, the country that for the first time last year in its history consumed more grains than it was able to produce. Critical, as we look at food security, for those of you engaged in information systems, will be ecological zoning, surveying, soil surveys, soil and water conservation work, watershed management, the design of irrigation systems and water storage facilities. There is a huge role and responsibility for those of you interested in this convention in this area. And I need hardly say that there are all kinds of forestry applications.

The third imperative that I see for the 90s will be the question of energy, particularly the problem of fossil fuel consumption. We are going to have to find energy systems, that are benign and sensitive to the climate, solar, hydro and, in my judgement, nuclear will all feature heavily on that list.

And the fourth imperative will be the broad field of forestry. I think that this will be the linchpin for much of the global environmental recovery program that we must address.

The issues will not just be those of food security that I mentioned a moment ago, they will be issues of combating desertification. Foresters will have to learn to be sensitive to the income distribution needs in third world countries. And to the colossal problems of unemployment and underemployment that these countries face. As foresters, we are going to have to be concerned with the mobilization of grassroots participation in this problem in our countries and play a major leadership role in that regard.

We are going to have to be concerned about biodiversity. We are going to have to be concerned about the over 2 billion people whose energy crisis at the end of this century will be insufficient fuelwood to cook their food or to keep themselves warm at night. We are going to have to be concerned about the production of industrial wood and all the chemicals that can be produced from the forest which will be renewable, biodegradable and in many cases recyclable. And above all I think we are going to have to be concerned about the problem of what we call the carbon sink. We are going to have to address ourselves to the problem of the increasing concentration of carbon dioxide in the atmosphere.
I would like to leave you with four figures that Lester Brown of the World Watch Institute included in his State of the World Report for 1989:

With a 15-year program of reforestation in both developing and developed countries (including 130 million hectares of plantation in the developing countries 40 million hectares of plantation in developed countries such as Canada), and with a halving of the present rate of deforestation in the tropics we could reduce carbon dioxide levels by 24% of that which we presently breath.

And that might be the global imperative that we face.

That might be the challenge that the forestry community is asked to address by the political leaders of the world. Not something that a few people like myself would be saying that we think we should do but things that we will literally be instructed to do if were all going to survive together.

I think the future for foresters, for the forestry profession, is an extraordinary challenging one. I think it is extremely challenging also for information systems specialists and those of you who are engaged in engineering in design, in surveying, and those of you attending as geographers in this symposium.

To conclude my talk, I have a few slides that I would just like to briefly show to you:

My first one is a graph that shows that from 1980 onwards, we are looking at an increasing population of 1.7 million persons and a need to increase our 1980 levels of food production by 55%. This raises the question where will that food be raised - on what land? What surveys are going to be required?

What shakes me when I consider that problem is that since 1980 we now face this global problem of carbon dioxide emission and the likelihood that topical forests deforestation is contributing 20% to that carbon dioxide build up. So anybody who thought that the solution to the question was to go down to the good old land bank, the good old bank of tropical forestry and cut a little bit more down for agriculture, has got to do some serious recalculation.

My next slide is of the virgin tropical forest - benign, with a steady flow of water for agriculture, for industry, for human consumption. This is followed by a slide showing that little chap standing on the edge of this cleared, planted area. We believe that there where 8 million hectares went under this way in the Amazon last year alone. That area looks fertile to the politician, and you can see the crop that was planted - we know that there will be a good yield for the 1st and 2nd years from the ash that remains after burning and the nutrients but then there will be nothing. Instead there will result severely compacted soils and we will even begin to see sand dunes in the tropical forest areas.

Another slide shows the effects of over-grazing, leading to erosion on slopes that are not particularly dramatic, in a region that was the cereal land of Ethiopia not so very many years ago.

I earlier mentioned we have 160 million hectares of badly damaged watersheds and another 160 similarly threatened. We are losing 1 and 1/2 million hectares of prime crop land to salinization also each year. And I mentioned 23 million hectares that are lost to the process of desertification. Already 1/2 of all of the world's irrigated agricultural lands are beginning to show some signs of serious salinization.

This slide shows the people who are threatening those tough loggers who come in and chop the tropical rain forests down. 200 million indigenous populations living for hundreds of thousands of years in perfect harmony with their resources, dependent totally on the forest for their medicines, for their food, for their clothing - everything that they require in their daily life. Imagine the loss of information about all the pharmaceuticals, plants and herbs that they use; realize the desperate need now to capture this information for our own society before these people also become extinct and that knowledge is lost.
I hope none of you have to go to the clinic each day to get a shot of any of the drugs shown in the next slide, but it just might make you reflect on the dependency that you have on the tropical forests and on tropical forest products. Did any of you have anything that’s on the next slide for breakfast or lunch?; coffee, corn flakes, a variety of fruits, cocoa and so many, many other products.

The U.S. Cancer Society has identified 2000 tropical plants that have potential in the fight against that deadly disease. In 1985, the use of the little plant called the Rosy Periwinkle from Madagascar was an industry of 150 million U.S. dollars. I do not have the 1988 figures but it no doubt increased; and today, thanks to that flower, 4 out of 5 children who would of died of leukemia 15 years ago will survive.

That is just one example. Try to visualize a world without coffee.

I did mention earlier the problem of population control. Here again is the size of the crisis that we face: 2.4 billion people in the year 2000 whom we estimate will not find sufficient fuelwood for their heating and cooking needs. That is the fuelwood crisis, that is the energy crisis of the third world. And if these people cannot trade that is going to affect us. There has been an enormous acceleration of imports of forest products by the developing counties since the year 1975.

I think we in the forestry profession are perhaps at the first week of where the agricultural community has been for the past 20 years. We are just beginning to apply science and technology to our profession and the benefits could be tremendous.

In 1970 we were using in Malaysia less than 100 species from the tropical forest and in 1980 over 500 species have now found their uses and their place in commercial markets. One of these, rubberwood, in 1979 was just beginning to show offshore earnings from sawing; in 1987 it built to a trade of 37 million U.S. dollars. This change is just from one species, which until those years had been declared a weak species and a nuisance.

Another slide shows you the impact in the Mia Valley in Nigeria of wind-breaks and shelter belts. And how even though we take land out of agricultural production for the planting of those wind-breaks and shelter belts we got a 17% increase in the yields of millet plus forage for animals and fuel for the local people - an example of the integration of forestry with agriculture. An example of what our profession must work much harder to achieve. And finally just to make some of my own British Columbian colleagues a little bit jealous I have thrown a few slides in from Brazil. Again an example of the application of research and development. This is a root cutting at the age of 5 weeks after treatment with IDA root hormone. In the foreground, 4 months. In the background 10 months. This is harvesting at 7 years. You will note the extraordinary uniformity in the appearance of the trees, their crowns and stems. And you can eat your hearts out with this last slide. You may just be able to distinguish a white mark at the base of that tree. It’s a forester who’s a little over 6’ tall. And that tree is approximately 80-90 feet tall and a little over 6 going on 7 years of age.

I would like to conclude with the following words:

**There is grave cause for alarm.**

And anybody who doesn’t recognize it and doesn’t want to start doing something about is simply burying his head in the sand.

But there are also glimmerings of hope.

To correct these problems is going to require tremendous energy and tremendous sacrifice from all of us. I think there are grave responsibilities and huge problems that face the forestry profession. We’ve gone through extraordinary changes already. I graduated in the class of 1961. I do not recall hearing a single word about social responsibility, about climate change, about fuelwood needs in developing countries, about food security, or about biodiversity. In fact, if Harry Smith had asked me: “What do you think about biodiversity, Chuck”? I probably would have said: “Well, I think their lead guitarist is simply great”!
And I think that the nature of the change in front of us will be equally challenging and equally exciting. We have been borrowing environmental capital from our children, since time immemorial particularly in the last 2 and 1/2 decades. And we show very little sign of repaying that capital that we have been borrowing and our children will not be able to collect on the debt.

Ours is the first generation on this planet that has to take a conscious decision as to whether or not we want this planet to remain hospitable. Wisely handled with a lot of courage, imagination, and inventiveness, the environmental challenge which I have attempted to sketch out to you this afternoon could become the single most powerful unifying force for all nations to pull together and address for their common benefit. But without full and fair consideration of the economic and social issues, of our concern for human dignity, of our respect for the sovereignty of each nation, without recognition of our individual rights and our individual responsibilities then environmental deterioration, that we are presently presiding over could become the single most divisive issue and tear our society apart.

Thank you very much for your attention today.
"A WIDER PERSPECTIVE"

Warde Shearing
Director, Computer and Communications Systems
H.A. Simons Ltd.,
Vancouver, British Columbia

GIS '89 SYMPOSIUM
VANCOUVER, BRITISH COLUMBIA
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CONFERENCE SUMMARY SPEECH
As someone with a forest industry background and one of the people in our company keenly interested in GIS, I am pleased to be able to address you this afternoon. My task today is to provide you with a summary of the over forty wide-ranging talks and discussions we have heard over the past three days.

In preparing my comments I have kept in mind the Conference’s theme of a “Wider Perspective”. On this basis I thought it would be useful to:

- first, place GIS ’89 within a historical context,
- then discuss the events of the past several days from this vantage point, and finally,
- to provide some comment concerning the future of GIS technology and the challenges which lie ahead.

Let me begin.

As several speakers have noted, the first use of GIS in Canada, and for that matter the first true GIS in the world, was for the creation of the Canada Land Inventory. This began in the mid-60’s. Though Canada may have been first, Scandinavia and the U.S. were quick to follow. In his paper Svein Tvedtal pointed to the late 60’s as the beginning of work with digital mapping in the Nordic countries. Several of our American guests have confirmed that the development of U.S. technical capability roughly paralleled that of Canada and Scandinavia.

Returning to Canadian developments, Frank Hegyi pointed out that the B.C. Forest Service first acquired a computer assisted mapping system in 1978. Fern Gruenzka informed us that the Province of Saskatchewan began evaluating GIS technology in 1979. But it wasn’t until five years later that the acquisition of a system actually took place. Similar kinds of delays were reflected by David Brand when he commented that most provinces are only now completing the digitization of map sheets, and that B.C. is the sole jurisdiction in Canada where GIS is used for timber supply analysis.

This brings up an important point which was implied by a number of the presentations which dealt with GIS in Canada. The private sector has been slower than government to implement GIS technology. While many forest products companies were showing a growing interest in GIS in the late 1970’s the economic events of the early 1980’s caused most companies to put their GIS plans on the shelf. And in most instances that is where they remain today.

I would now like to turn to what we have heard about GIS over the past three days.

The initial literature concerning the Conference stated that it had a number of objectives. They were to:

1. Review the present state of the art,
2. Ensure the exchange of expert views, particularly of those currently using the technology in a forestry setting,
3. Provide a forum for discussion between experts and decision makers, and to
4. present the latest developments in techniques for evaluating GIS options.

I think we can all agree that to a large extent those objectives have been achieved. The experts certainly held up their end of the bargain, and the question and answer sessions demonstrated to me that there was a meaningful exchange of views and information.

To analyze what has been said during the Conference, I grouped topics into three main themes: Data, Applications and Management. Let me summarize what seemed to me were the important points and issues raised in each of these areas.

Concerning data, quality was emphasized by a number of speakers. John Antenucci pointed out that content and accuracy is critical to the success of any GIS. David Armstrong in his paper on scanning made the comment: “the generation of structured, intelligent data that is readily usable is the most important and complex task upon which
the usefulness of GIS depends." In their paper on Data Integrity, Reeler and Masry took the quality argument one step further by noting that with the present emphasis on data sharing and the networking of systems, firm adherence to a code of compatible standards is a future necessity.

Gordon Plunkett of the federal Department of Energy, Mines and Resources noted that this kind of initiative is under way in Canada. A Memorandum of Understanding has been signed by all provinces and industry associations. It calls for, among other things, the adoption of a common set of GIS standards.

I might comment here that there would appear to be a growing need for a set of international as well as national standards. As one of the pioneers in GIS technology, Canada should take the lead in facilitating this process.

A number of speakers pointed out the obvious benefits to be derived by government and industry sharing data. Fern Gruzkza described an on-going data sharing relationship between Saskatchewan's Forestry Branch and Weyerhaeuser. Here in B.C. the Ministry of Forests has been sharing its GIS data with private industry for some time.

Data cost was also mentioned in a number of presentations. Bill Johnstone estimated that data acquisition typically accounts for at least 60 per cent of the cost of a GIS. While it is important to understand this, it is also important to note that data costs are likely to fall in the future. The exploitation of remote sensing technology promises to reduce the costs of creating and maintaining forestry GIS databases.

Al Daykin in his paper on photogrammetry made an observation concerning the hidden costs of data input in stating that they, and those of personnel training, are often more than a user anticipates.

With data collection, the first priority is to do it right. This is particularly true in northern climates such as Canada where growth cycles are a minimum of 75 years. The data we collect today will have usefulness for decades to come. This fact was made reference to by John Keatly in his luncheon address. One of his remarks bears repeating here: "The people we will be sharing this information with may not yet work for Weyerhaeuser and the function that we will be supporting may not now exist."

This brings me to the Applications segment of my summary.

Many of the talks we have heard used the term revolutionary in discussing the development of GIS applications.

We have heard that typically GIS is first used for no more than automated cartography. However, shortly after maps are digitized and a database is constructed, more sophisticated applications begin. Don Couch's paper touched on this process. For his firm the major selling point of GIS was the time saving to be achieved by producing maps electronically. He stated, however, that two years later that initial reason had been surpassed by other strategic planning uses.

As Jim McDougall pointed out, when GIS becomes an integral part of an organization's larger management information system a much more powerful competitive capability can be created. Together GIS and MIS can provide the basis for faster, more informed decision-making. The papers by Bill Thomas and Tom Reisinger, also echoed this view.

If Data was the area of cost, Applications is certainly the area of benefits. Tweetal quantified the various cost benefit rations to be achieved through GIS applications, and made the following points based on his research:

- If used simply as a production tool, e.g. for mapping, the benefit to cost ratio is 1:1.

- If used for planning and administration purposes, the benefit to cost ratio improves to 2:1.

- If used for new problem solving, the benefit to cost ratio can improve to as high as 7:1.
Tveitdal's research points out that where co-operation exists between data users, benefit to cost ratios are generally in the 4:1 range. In the Nordic countries and Canada productivity gains of this size are possible due to the level of co-operation which exists between government and industry. Tveitdal observed, however, that the U.S. is less favorably positioned and as a result productivity gains are likely to be restricted to the 2:1 range.

A number of speakers addressed specific GIS applications. Allen Van Sickie described the use of GIS for pest management; Andrew Mitchell talked about GIS and harvest planning; and Patricia Benson spoke about GIS as a resource management tool for our national parks. As varied as these applications might seem, we have really only begun to scratch the surface of potential applications. As Don Couch said "Let your imagination go" and you will find yourself using GIS for "projects you never dreamed possible before."

This brings me to my third topic area - that of management and organizational change.

Allen Levinson opened his remarks with the clearest indictment of why systems fail: "Most automated information systems projects do not fail because of lack of technology. They fail because of poor project planning and management." Bill Thomas used virtually the same words: "Management and cultural problems are the real impediments to GIS adoption."

Levinson points out that one common mistake is the selection of hardware and software before an implementation strategy has been devised. When the cart gets before the horse, results are rarely favorable.

John Antenucci made the point that another reason for less-than-successful GIS implementations is the tendency to take on too much too soon. He also provided some pointers on gaining and maintaining support for GIS. He classified the methods as Technological, Political, and Educational. The technological approach emphasizes utility whereby support is earned primarily through cost/benefit analysis. The Political approach emphasizes support through executive sponsorship. The Educational approach emphasizes the addressing of concerns at various levels of the organization. If this is accomplished successfully, the initial reaction that GIS technology is a threat can be reduced or eliminated.

In his paper, Charles Goodbrand discussed the necessity for both initial and continuing education at all levels of the organization if a GIS installation is to ultimately be successful.

Concerning organizational change, John Antenucci provided this warning: "though it is possible to introduce GIS as a tool...its integration...will likely necessitate changes in organizational structure." and "to do less will limit the benefits that are latent to GIS".

To now turn to the future, let me first touch on the evolution of GIS as a technology. In his talk Charles Goodbrand drew the analogy that GIS technology today is in the same position that the automobile was at turn of the century. I agree. I would add, however, that if the automobile developed at the same pace GIS technology is likely to develop over the next decade, by 1910 cars would have been whistling along at least 1000 miles per hour. I say this because the computer technologies upon which GIS is dependent are now poised for some significant breakthroughs in those areas which are of importance to GIS capability and cost.

We heard evidence of this during the Vendors' Panel this morning. Vastly faster processing speeds and data storage capacities are to be incorporated not only in mainframe systems, but also in desktop and portable computers. This, coupled with the increasing ability to network systems will have a dramatic impact in the GIS arena. Likewise, GIS will greatly benefit from the continuing rapid evolution of Database Management, Artificial Intelligence, and Expert Systems software technologies.

And not to be ignored are the simply profound implications held by remote sensing technology, both airborne and satellite. Another satellite related capability is NASA's GPS, or Global Positioning System. Scheduled to be operational in the early 1990s, GPS is a network of satellites which will allow one to position him or herself anywhere on the globe with accuracy which can be measured to the meter. Eventually to be the size of a wristwatch, this is the device that Federal Forests Minister Frank Oberle's guy - remember him, he's the
Computer Assisted Cruiser - will use to tell him where he is and will reference the data he is collecting. At long last foresters will be able to get back to the same spot to check or update historical information. As you may or may not be aware, the current inability to do so is one of the best kept secrets of foresters.

Now let me turn to what I have interpreted from the conference proceedings to be some of the challenges which lie before us in utilizing our evolving GIS capabilities. Let me first make a distinction between those challenges confronting the developed, as opposed to the developing nations, as clearly this distinction must be made. And within the developed nations let me separately summarize those challenges confronting the public sector as opposed to the private sector, as these also are clearly different.

Certainly government in Canada, both the Federal and Provincial governments, have led the way over this past decade in embracing the concept of GIS and accepting the significant costs which have been associated with the initial development of databases. This first hurdle has now been largely overcome. The challenges now facing government would seem to be as follows:

1. The cost of database maintenance and updating.

We heard Assistant Deputy Minister of Forests Tom Lee speculate in his opening address that government is unlikely to be able to continue to shoulder this burden as it is now doing. As he termed it, we are likely to see some "parturering" arrangements develop with the private sector over the next 5 - 10 years.

2. The role of government with respect to databases.

Tom Lee envisioned government's role evolving to that of "stewardship" - setting data interchange standards, ensuring data quality, and acting as a clearing house and distributor of data.

3. The development of new GIS applications.

These new capabilities will assist in the setting of policy with respect to land use and resource management. Such policies should move us toward a balanced, sustained development future. As we have heard, while we are now completing our basic c databases, we have barely begun to utilize this data in terms of applications. And it is in this area that the true power and benefit of GIS lies.

And finally,

4. The movement of GIS usage to the field.

This will place new capability in the hands of those who require GIS information for their jobs. It will also permit the direct field updating of central databases. This in turn should reduce database costs.

Turning to the private sector, the challenge is that of accepting GIS as the powerful technology it is, and getting on the implementation band wagon. When, as Tom Reisinger pointed out, the American Forest Council conducts a survey and can only identify 20 large US forest products firms using a GIS system, there is certainly a long way to go. And we know this situation to be no better in Canada.

The primary issues concerning GIS with respect to private firms are:

1. Gaining senior management support of GIS.

It is safe to say that this does not exist at present. One of the initial objectives of this conference was to attract senior managers. And if the conference has fallen short in any respect, it has done so here.
Before progress can begin to be made, senior management support must be obtained. Be it through John Antenucci's technical, political, or educational routes, or what ever other means, corporate sponsors and champions of GIS are essential. The cost effectiveness and benefits of GIS are there; senior management understanding of them currently is not.

2. **Implementing GIS systems in a well planned, systematic fashion;**

   - Plan first, buy later.
   - Don't take on too much too soon.
   - Don't create undue levels of expectation.
   - Make sure management accepts that long time frames can be involved before benefits begin to show themselves.

While easy to say, these are vital points. In the private sector they will make or break a system. Go slow - do it right. The long-term implications are too important to do otherwise.

3. **Developing new GIS applications to meet operational requirements.**

As we are just now beginning to develop harvest planning models, we obviously have a long road before us. System Vendors can be expected to make contributions in this area.

4. **Integrating GIS with traditional Management Information and Decision Support systems.**

It is through this integration that GIS can provide a sound basis for product and conversion facility planning.

A final comment concerning the private sector can be made in terms of the extension of a point Frank Hegyi made in reference to government GIS experience. He said, "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" ...and he went on... "the impact of delays has often been to incur costs far in excess of the proposed acquisition".

Now, let's move on to our final topic area, that being the application of GIS for resource management in the developing nations. Yesterday, Chuck Lankester presented us with an unsettling look at the forestry problems faced by the developing nations. He also made the point that their problems are unavoidably our problems. Among other examples, he cited the growing global carbon dioxide deficit, which is primarily being caused by the deforestation of tropical rainforests. He suggested that the resolution of this problem will undoubtedly require co-ordinated international action.

In light of this and the growing number of other global environmental imperatives, international response does seem to be galvanizing. Many of you will be familiar with "Our Common Future", the report of the UN sponsored World Commission on Environment and Development. This commission was chaired by Prime Minister Brundtland of Norway, and as such is commonly referred to as the Brundtland Commission. The basic message of the Commission was that if our Planet is to continue as a hospitable environment for life, we must begin to move now toward the concept of "sustainable development". This means that economic development must fully incorporate the requirement for environmental integrity.

Internationally, the findings of the Brundtland Commission have been accepted almost without reservation. It is simply an idea whose time has come. The World Bank has now committed itself to the principle of sustainable development as a cornerstone of Bank lending policy. Glen Morgan made reference to this in his talk yesterday. In Canada, our own Canadian International Development Agency (CIDA) has announced a similar policy.

We in Canada can be proud of our response to the challenge laid down by the Brundtland Commission. Subsequent to it, the Federal Government formed a "National Task Force on the Environment and the
Economy.' It mirrored the Brundtland Commission in that it was comprised of representatives from government, industry, and environmental groups. Its work has led to the formation of similar provincial level task forces, such as our own recently appointed "Task Force on the Environment and B.C.'s Economy". Headed by David Strangway, the President of UBC, the stated commitment of this B.C. Task Force is to implement the recommendations of the Brundtland Commission and our National Task Force. I have related the foregoing because, here in B.C., the GIS systems and capabilities we have developed will prove essential in permitting us to move towards a sustained development future. And if we, here, now, with our:

- tremendous economic base,
- high standard of living,
- understanding and growing concern for the environment,
- well developed institutional structures,

and last but not least,

- technological capability

cannot achieve the balance of sustainable growth - what hope can there be for the developing nations.

But while it may seem a rather painful process at times, this is a future I am sure we can and will achieve in B.C. And in doing so we will, out of sheer necessity, be developing and extending our GIS skills and capabilities.

In their opening remarks both Frank Oberle and Michael Heit noted the leadership role that B.C. has traditionally played in the international forestry scene. They also noted the importance of the continued exporting of our technical expertise. Given the nature and magnitude of the world's forestry problems, one of our most important future forestry exports, and even gifts to the world, is likely to be our GIS technologies.

Thank you.