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Planning for World Heritage: Experiences & future directions for use of Geographical Information Systems

Robert Preston[†], Jerry Vanclay[†], Geoff Gibson[†] and Glen Dale[††]

[†] Department of Forestry, GPO Box 944, Brisbane, 4001.
[††] Department of Forestry, PO Box 210, Atherton, 4883.

Summary

Events leading to the World Heritage listing of north Queensland rainforests and subsequent ban on timber harvesting result from a number of factors including insufficient education of an increasingly articulate and environmentally aware public. Foresters should meet this challenge by renewing efforts to collect reliable information on the multi-resource values of forest areas. GIS has the potential to contribute to this process, particularly when applied as part of a multi-resource decision support system. Source data for multi-resource management could be collected in conjunction with timber inventory, provided additional funding is made available. Use of a GIS as a map overlaying tool can be prone to error unless its users are fully aware of limitations that can arise with this approach. Any multi-resource strategy should be phased into existing timber inventory programmes. Full scale adoption of a multi-resource decision support system in forest services is not likely to occur until the full cost of land use conflicts is included in the cost benefit equation.

Experiences from north Queensland

The cessation of timber harvesting in the rainforests of north Queensland brought about by World Heritage listing is a landmark for the Australian forestry profession. This move by the Federal Government was intended as a step toward better conservation management, but calls from international environmentalists for sustainable utilisation of the world's tropical forests have cast aspersion on the logging ban. At a recent international conference sponsored by Time Magazine to define solutions to global environmental problems, distinguished experts called for action on sustainable utilisation (Linden, 1989).

> "Development should be sustainable, meaning that it should use up resources no further than they can be regenerated by nature. Governments ... should organise projects to show that forests can be used without being obliterated. If trees are cut selectively, forests can yield profits and survive..."

Rather than have their management condemned, foresters and forest officers of the north should take credit for the development and implementation of sound silvicultural practices that have left the rainforest in a state of such high integrity that it remains worthy of international recognition. Continued selection logging in at least part of the World Heritage area could provide an important and successful example of balanced and sustained resource use.

Although we will not know whether rainforest logging will resume until finalisation of current court proceedings on the issue, it is now timely to reflect on the reasons why the dispute escalated to such proportions.

Solutions and symptoms

In the present climate, a forester's response to the question "what should members of the profession learn from this experience?" is usually one of indignation. When asked to enlighten guests at a recent Institute of Forester's function with his views on this matter, Dr. Peter Bridgewater† suggested that Foresters should learn to become better political lobbyists!

Though one could argue that Dr Bridgewater is not the most appropriate authority to consult on

† not a forester, but then of the Commonwealth Dept. of Arts, Sport, the Environment, Tourism & Territories

matters of IFA policy, his opinion on this point at least coincides with the view of a majority of Institutemembers. Almost ninety percent of foresters think that the IFA should take on a greater advocacy role with respect to forest land use and allocation. "Lack of public knowledge about forestry and the forestry profession" is considered the second most important issue facing the profession (Neville and Ellis, 1989). The problem is easily confirmed by an evening television session or a brief read of the daily newspaper.

However in contrast to the opinion of Dr. Bridgewater and most foresters, experience of the north Queensland issue is that public relations campaigns and political lobbying have only limited results, and perhaps no real effect. The problem is that our capacity to win the hearts and minds at this late stage of the dispute amounts only to band-aid treatment of the symptoms. Deeper solutions include a long term public education component. For example the Queensland Forestry Department ForEd kit provides an excellent medium for bringing secondary school students into contact with forestry and conservation issues in an unbiased format.

Through our own efforts on public education, the achievements of Governments and the conservation movement, increased public awareness of forestry and environmental issues has placed the forestry profession under increasing scrutiny. We are now required to articulate management strategies to an audience with an ear unsympathetic to rhetoric. Questions are sometimes uncomfortably precise, for example "What areas will the Department be logging in two years time, and how much timber will they be cutting from each area?" (Wildlife Preservation Soc. Qld., 1986).

We also need to add substance to our case. To achieve this, reevaluation of our attitudes toward assessment and research on the multiple values of native forests will be required. Multi-resource research and inventory should take on the same strength of focus as production oriented research aimed at improvement of silvicultural practices and minimisation of logging damage. Reports on the values and positive uses of our forests must be authoritative and subjected to independent review.

The assessment and research of multiple forest values is a fertile area for the employment of new technologies including Geographic Information Systems. If we are able to embrace the capabilities of these new techniques, the forester will be in a better position to demonstrate that rainforests can be managed for sustainable utilisation with maintenance of conservation values.

In the following discussion, we have drawn on the perspective of events leading to the cessation of logging to give us insight into the appropriate use of new technology.

Twelve years notice

With north Queensland, as in most land use disputes, it is possible to look back in the wisdom of hindsight upon key events which, if handled differently, may have averted the current confrontation.

Within modern history, the sequence of events leading to World Heritage listing of north Queensland's rainforests can be traced back about 12 years. On the not too dusty library shelf is a paper presented at the 1977 IFA conference held in Caloundra. Geoff Stocker, Don Gilmore and Dave Cassells presented "The Future of our Rainforests in the Face of Economic and Political Reality". This paper identified the increasing land use pressures on rainforests including agriculture, mining, recreation, watershed protection, timber harvesting, urban development, and total preservation. The authors recognised the rising community awareness of environmental issues, and laid a challenge for foresters to recognise and balance these requirements. But Stocker and other foresters were unable to predict the uprising of the conservation movement and their success in motivating politicians to act on land use decisions.

The first active displays of the conservation movement's presence were the blockades at Mount Windsor and Downey Creek in late 1982 and mid 1983 to 85 respectively. In response, the Queensland Government approved the implementation of Forestry Department standing recommendations for greater restrictions to be placed on logging operations (QDF, 1983). These environmental guidelines for timber harvesting were based on the hydrological research of Gilmore, Bonell and Cassells in the Wyvuri experimental catchment to the north of Innisfail (eg. Gilmore, 1977). Positive steps were also taken by dedication of Scientific Areas to preserve large reference samples of habitat types.

But some State and Local Government responses were antagonistic to the conservation movement and to professional forest managers. Construction of the Cape Tribulation to Bloomfield road in late 1983 was a scar on the landscape, a mortal wound to future State Government control over the rainforests, and a symbol to the conservation movement of the type of wilderness destruction that would continue without intervention.

In late 1984 a joint State/Federal Working Group on Rainforest Conservation was set up under the stewardship of Barry Cohen. With significant input from Government representatives, conservation groups, the timber industry, and rainforest experts from academic institutions and CSIRO, the working group tried to come to grips with the problem by a process of reconciliation. The working group presented a report outlining the National Rainforest

Conservation Program in late 1985. Productive steps toward compromise positions were reached on rainforest management and research directions for each State, but the issue of timber harvesting in north Queensland proved to be a stumbling block.

In pursuit of electoral favour during the lead up to the 1987 Federal elections, the Commonwealth Government announced their intention to unilaterally proceed toward World Heritage nomination of the entire Wet Tropics belt in a move to halt rainforest logging.

The major State Government response was to establish the Northern Rainforest Management Agency (NORMA) to draw up a conceptual plan based on the biosphere reserve concept of core conservation reserves with surrounding buffer zones in which sustainable resource use could occur. The two major wings of NORMA were a Public Consultative Committee, which included Local Government and business representatives, and a Scientific Committee of invited scientists from academic institutions and State Government agencies. Conservation groups rejected NORMA as lacking independence from the State Government, and did not participate in the NORMA consultative process.

A confidential and indicative zoning plan produced by the NORMA Scientific Committee was reviewed by State Government Departments with management interests in the region prior to June 1988. After their consideration, a formal State Government plan was released identifying Multiple Use Areas, and Preservation Areas as an alternative World Heritage Area. The State Government Plan and the NORMA scientific report formed the basis of protracted but unsuccessful State/Federal negotiations. A Geographic Information System was used extensively in preparation of the State Government Plan and the NORMA Scientific Committee report, but in the time available, a considerable amount of investigation was carried out using manual scientific procedures.

Federal politicians rejected all Queensland Government zoning proposals and proceeded with successful nomination of almost the full rainforest estate under State tenure. Soon after nomination of the Wet Tropics on the list of World Heritage list, the Federal Government introduced regulations under the World Heritage Properties Conservation Act which outlawed commercial logging operations within the World Heritage Area.

The State Government has since entered a High Court Challenge to the validity of regulations pertaining to the ban on logging on grounds that selection logging on a sustained yield basis does not affect World Heritage values of the area. Hearing of the court case is scheduled to commence within the next few months.

While the logging issue remains unresolved, State and Commonwealth Governments have independently indicated their intention to proceed with unilateral management of the area, and have commenced work on separate management plans for the area. Despite the best intentions of each Government, continuance of this attitude is unfortunate. Results can only be sub-optimal.

However while both Governments pursue diametrically opposed strategies in alleged pursuit of their constitutional obligations, politics will continue to dominate the agenda of forest management in the Wet Tropics region.

Criteria for conservation assessment

At the current stage of proceedings, the north Queensland World Heritage experience provides little guidance on how best to assess conservation values. Observations that current World Heritage *areas* may or may not contain World Heritage *values* has not been of assistance. Neither does the Australian Government's approach stand up under scrutiny. Taking into account the great biological variability and complex history of land use of the north Queensland rainforest area, it is difficult to see that the whole area could possess World Heritage values. Experience from the Tasmanian Lemontyne Inquiry on the delineation of World Heritage areas (Anon, 1988b) does not encourage foresters to seek legal clarification.

But this conjecture is of little use to forest administrators who must develop strategies and develop budget proposals for land use programs and resource inventories.

Outside the World Heritage arena, there is a good deal of consensus on base criteria which should be used for the design and placement of conservation reserves (Margules and Usher, 1981; Miller et. al., 1987, and Mackey et. al., 1988). These criteria appear to be consistent with the assessment of World Heritage values. Forest managers should embrace the need to assess conservation factors of proven importance (Table 1).

Information for multi-resource management

Terminology

The philosophy of multi-resource is best illustrated by example. "In a timber cruise ... at least two variables are measured or observed; species and size or basal area. Though the inventory was conducted for a single purpose, the resulting data could be reinterpreted for a variety of other uses. A wildlife biologist may reinterpret the species and basal area data to derive some habitat values. Thus,

Table 1. Criteria for the Conservation Assessment of Natural Areas †

Scientific criteria	Analysis approach
Representativeness	The composition of a regional landscape analysed in terms of different successional stages, vegetation types, degrees of human impact etc. Determination of how a regional reserve can best represent the patterns characteristic of a region.
Diversity	Analysis of species diversity patterns across the region (with emphasis on rare and endangered species for the critical taxa). Analysis of the dominant and critical environmentaldiversity patterns (eg. climate. topographic, geologic, etc.)
Rarity	Determined from regional species distribution patterns or from previously existing government and private listings of rare species. A definition of the scale of rarity will need to be made.
Naturalness	Historical and current land use records used to determine the various levels of human impact experienced by regional landscape components.
Species/area	Analysis and determination of species area patterns for taxa under consideration.

(† from Miller et.al. (1987)

a timber cruise could be considered a multi-resource inventory."

Full integration of multi-resource information is an important objective (Figure 1). Models developed by Lund (1986) to describe the integration of inventory data are equally applicable to the integration of all geographically referenced data.

Multi-location integration requires that basic management units or survey units must be able to be compared or aggregated. Locations must be mutually exclusive (ie. boundaries of units do not overlap). *Multilevel integration* requires that data at a large scale must be fully compatible with and linked to data at a smaller scale. Decisions may range from those needed to curb acid depositation on a global basis, to those needed to set the selling price for timber on a 2 hectare tract of land. *Temporal integration* requires measuring of the same variables at the same location over time to observe changes and thus to predict trends. Vanclay (1989) outlines an inventory strategy using temporary and permanent plots to achieve integrated multi-resource assessment.

Resource attributes and uses

The relative importance of resource attributes and uses in any management process will vary from one region to the next, and will vary with time. Greatest attention should be paid to those resources of highest value, and those of potential conflict. But because of the need for complete integration of the information collection and reporting processes, a minimum set of resources for natural resource management should be identified after consultation with associated organisations.

Resource attributes (Figure 2) can be grouped into those pertaining to the physical environment (topography, geology and soils, climate), the biotic environment (vegetation, fauna), and the human environment (roads, boundaries).

Resource uses are defined by human interpretation of resource attributes. Resource uses include the actual and potential use for production of; timber, wildlife, recreation, mining, agriculture, educational significance, visual significance, and conservation significance.

A multi-resource decision support system

There are at least three emerging trends which affect attitudes toward the collection of information and the use of technology in multi-resource management.

- Technology (including Geographical Information Systems (GIS) and remote sensing) is providing many interesting possibilities for more rapid and efficient assessment and monitoring, but it is not without some often considerable "up front" costs.

- There is an increasing pressure to supply more detailed information over larger areas and multiple resources.

- Assessment and monitoring programs are being challenged to become more efficient as labour costs rise, availability of funds diminish, and terms

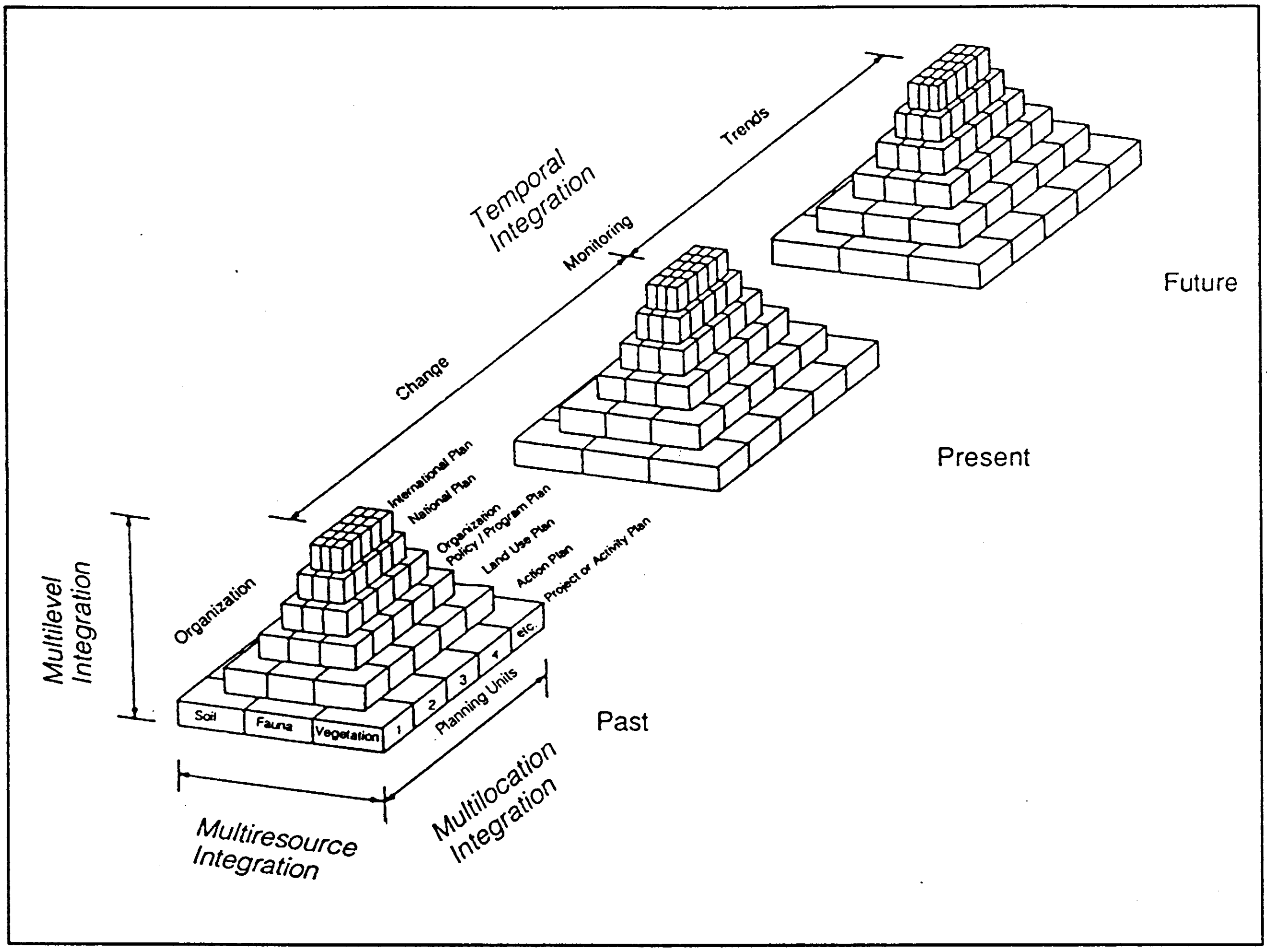

Figure 1. Information Integration for Multi-Resource Management (source, Lund, H. Gyde, 1986)

of reference become progressively broader.

The movement of multi-resource information through the process of collection, analysis, and output can be viewed as a model incorporating familiar computer components. This model can be implemented to form a Decision Support System when used in a management problem solving environment (Figure 3). Covington et. al. (1988) have developed a decision support system (TEAMS) as a tactical planning system to aid forest managers in developing site specific treatment schedules. At an early stage in the construction of such a system, a decision must me made as to the level of detail necessary for identification and analysis of features and attributes of interest.

From this perspective, it still remains that information required for multi-resource management must be identified, before (or if) it is collected. In the formulative stage of a multi-resource project reliant on computer techniques, it is important to clearly define between the types of data required. Information can be grouped into four categories

(i) source data,

(ii) resource attributes and uses produced by analysis and integration of data sets,

(iii) information used as rules to identify resource use conflicts and management options,

(iv) information required as results or outcomes of different management options.

(i) Source data

The first consideration of data collation is the identification of non-divisible and homogeneous planning units. Covington (1988) uses a forest stand as the primary unit of analysis, where a stand is defined as a contiguous area that is relatively homogeneous in terms of site, structure, age class, and density. Forest stands can be combined to form larger management units. Mackay (1988) highlights the problems with delineation of ecological units for a poorly described but diverse resource, and advocates that planning units should only be allocated after modelling of primary attribute data.

Source data for important resource attributes and uses is usually collected during inventory using plots or points where certain parameters of resource attributes (eg. vegetation, soil, or climate) are measured using prescribed measurement rules and procedures at specific locations. These data are

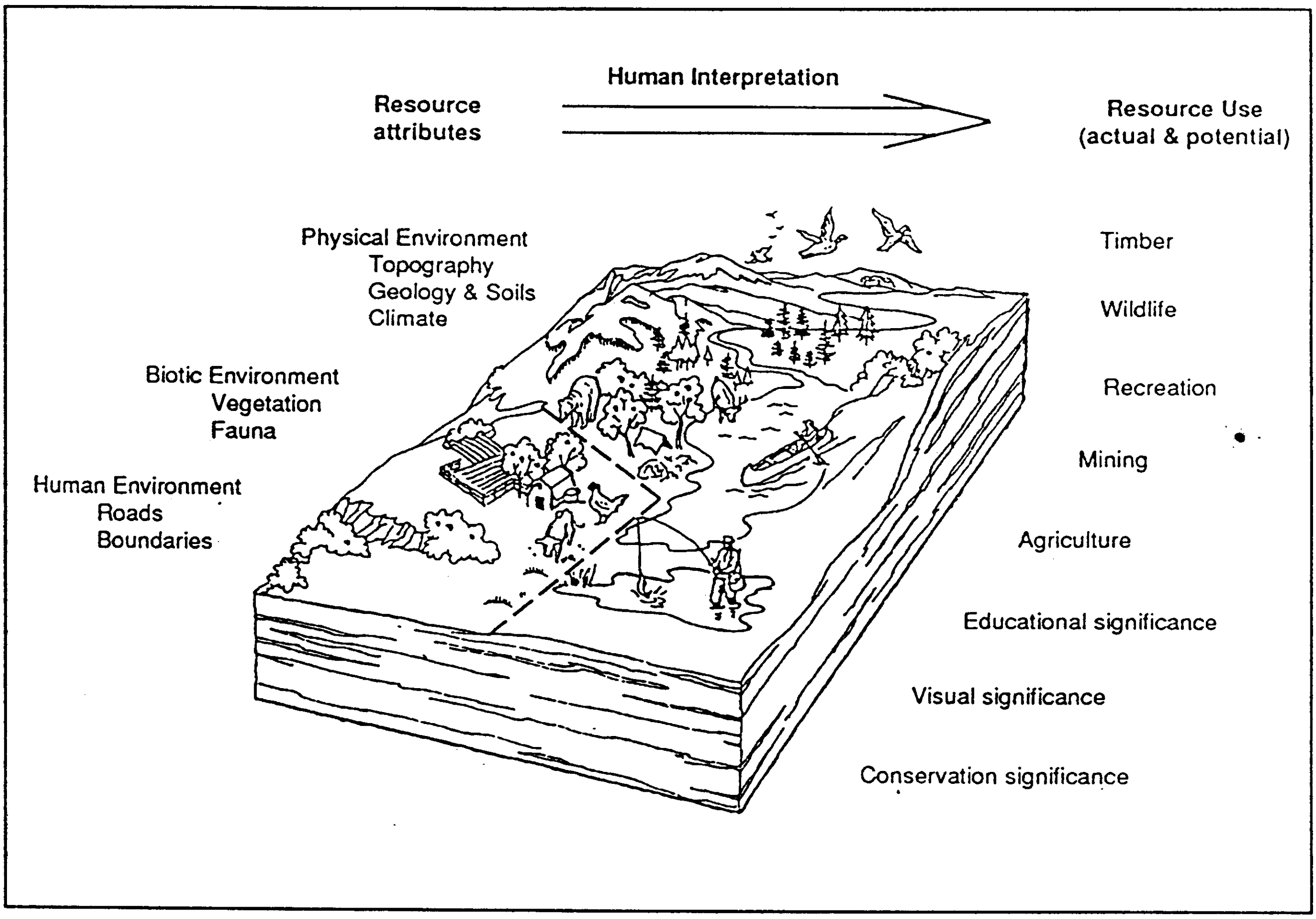

Figure 2. Resource attributes and uses(based on Lund, H. Gyde, 1986)

usually available in raw format (eg. diameter and species of a tree at a specified location) but sometimes also represent qualitative or synthesised data (eg. accessibility, landscape value).

One useful contribution to multi-resource assessment that could be made during timber inventory is in the collection of additional information regarding species distribution. Firstly, this can be advanced by collecting specimens of unusual species, or common species in unusual locations, and lodging these with herbariums specifying detailed locational and habitat data. In the course of their work, many forestry field staff spend more time in the field, and explore much larger tracts of country than many botanists and taxonomists can aspire to. Secondly, timber inventory staff could record the species of unmerchantable trees as well as merchantable species. At present it is common practice to book unmerchantable tree species as MIS (Miscellaneous) or NFS (Non Forest inventory survey Species). Thirdly, more information about habitat and non-tree vegetation could be recorded. Habitat information should include particulars of the terrain, and soils or geology. Physionomic characteristics of all plant life forms should be recorded, including details on ground cover of importance to remote sensing. Physionomic information is an important factor in determining fauna habitat. Finally, complete species lists could be compiled for inventory plots or for an expanded perimeter area.

Implementation of these procedures would require careful design of inventory procedures, recording forms, and reporting systems. Additional training of forestry inventory staff would be required in plant and soil taxonomy. The reliability of plant identification would need to be recorded for each inventory. One way of addressing this would be to test the inventory officer on his capacity to recognise tree species. The accurate recording of plot locations is critical. If plots are to be used by more than one agency or organisational section, locational reliability must be recorded.

These additional functions of timber inventory appear fair and reasonable at first glance, but they would add significantly to current costs. Before any moves are made in this direction, two factors would need to be resolved.

- Multi-resource attributes must be measured from parameters which can be objectively and quickly sampled without the need for specialist expertise or costly or cumbersome equipment.
- Additional costs must be justified in the long term.

Source data of spatial information can also be represented in map form if point observations (often

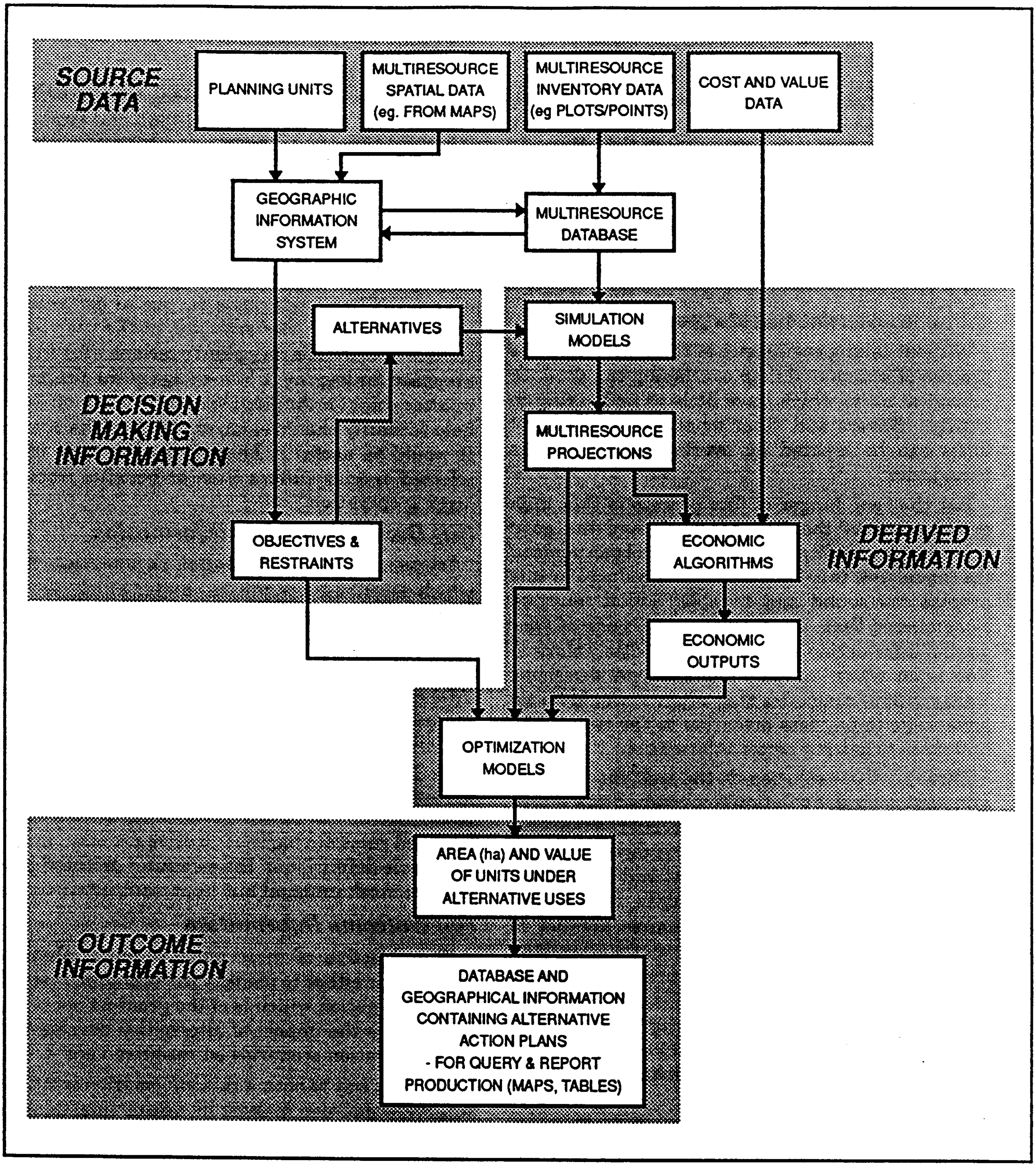

Figure 3. A GIS based Multi-Resource Decision Support System for Forest Management (Covington, 1988)

in the form of hand survey notes) have been extrapolated using aerial photographs, topographic maps, or by analysis using digital remote sensing imagery.

Overlaying of this mapped information has been used extensively in recent years as part of conservation planning, timber resource planning and multi-resource management. This has been achieved either manually, with automated GIS, or with a combination of manual and GIS techniques. Bailey (1988) has identified a number of limitations to this approach which can lead to misinterpretation of results if not properly accommodated.

Firstly, each resource attribute or map is usually compiled by different professionals with different purposes in mind and at different times. The variation in principles and methods, level of detail, and errors in source maps can detract from an integrated ecological picture. Secondly, errors are likely to occur when overlaying maps of different scale containing dissimilar degrees of generalisation. Thirdly, many natural resource attributes vary along a continuum, and are not necessarily composed of discrete natural regions. In practice, boundaries between regions reflect gradual changes and tend to be indistinct and arbitrary. Finally, many important data do not exist in map form; yet they may be critical to understanding of a process.

Without taking cognisance of these problems the process of automated map overlaying can produce ecological units which have little or no bearing to reality. Slivers and other small non-meaningful units can be created by overlapping coincident boundaries.

But the real danger of this process is that high expectations of the GIS approach and the good presentation quality of the GIS product can mislead the casual user to believe that units produced by this process are sound and reliable; and it must be remembered that the machine processing of poor quality information will not produce better information upon which to base management decisions. Bailey (1988) concludes that often it would be an advantage to pay less attention to the technology and more to getting better information.

There are three solutions to the problem. The first and most desirable solution is to conduct new multi-resource inventories. Cost factors could be limiting, there is little point in spending hundreds of thousands of dollars on GIS equipment and only tens of thousands of dollars on reliable data. The second option is for an experienced resource planner to conduct manual synthesis or editing of overlay data. The third approach is to conduct process modelling of natural resource attributes (eg vegetation) using key factors such as climate, topography and perturbation history which have a strong influence on ecological processes. This approach has been adopted by Mackey (1988) and others.

Source data must also be acquired on the basic cost or values of each resource use. If it is not possible to establish the monetary value of some resources, it is appropriate to allocate a relative value index which can be used in the process of conflict resolution and economic analysis.

(ii) Derived information

Having identified the most important resource uses and geographic attributes for the region of interest, exact formula, models or algorithms must be defined to allow calculation of economic and non-monetary values of each resource, and to model spatial characteristics of resource attributes not available in reliable map format.

Resource attributes amenable to spatial modelling include; climatic parameters (including rainfall and temperature) (Mackey, 1988), the distribution of important species (Busby, 1986), and landscape values.

Resource use parameters amenable to modelling include timber yields (Vanclay & Preston, 1989), and wildlife habitat (Covington, 1986).

Models which describe the functional relationships between resource uses and resource attributes are of basic relevance for use in definition of resource conflict. For example, in the case where the distribution of a rare plant overlaps with an area proposed for logging, a knowledge of the functional relationships for the plant species in question would help to clarify the threatened status of the species. It would be useful to know if the life cycle of the affected species suffers from or benefits from the logging operation.

(iii) Decision making information

Decision making information encompasses rules which describe the conditions under which resource conflict occurs and specifications of alternative management scenarios or treatments. This can be achieved by varying spatial and temporal elements.

Description of this information for management planning reliant on computer techniques requires the precise and exhaustive definition of such rules to a greater extent than in manual or intuitive studies. This arises mostly because of the tendency toward definition of location specific and exception oriented rules during the intuitive process. Incomplete rule definition in the computer oriented process can mask unusual but important interactions.

(iv) Outcome Information

The objective of most multi-resource planning exercises is either to identify the optimum resource use combination which is of the greatest benefit, or to evaluate the impact of alternative development or preservation scenarios on resource values.

The best way to obtain this information is often to interview decision makers by asking questions on: the important issues and concerns; what management decisions are needed; what decisions need to be made about the resources; what is the relative impact or risk (cost) of an incorrect decision; to what area (survey unit or inventory unit) will decisions apply; and what are the monitoring requirements (Lund, 1986).

Answers to these questions allow the planning expert to make important deductions about the level of decisions to be made (eg. national, activity level), the required accuracy of results, the appropriate criteria or units to measure community benefit (eg. socioeconomic value, cubic meters of timber), and the planning horizon over which values are to be measured. The planning expert will also be able to estimate the resources (staff, equipment, time) needed to complete the planning task at the required level of detail and accuracy.

Directions for development of Geographical Information Systems

Geographic Information Systems can be used in a variety of ways to assist in the process of multi-resource management. GIS can be deployed in a simplistic capacity to automatically produce maps at consistent output scale. This approach can be fraught with error unless results are closely scrutinised by local experts.

Manual studies should be considered as a viable option to GIS in some circumstances. Manual studies are often conducted by people with an intimate knowledge of the region and its resources. The intuitive technique also allows ready inclusion of more detailed information to verify possible conflicts in specific locations. This is sometimes difficult or infeasible to achieve in the GIS process if the stages of data input, editing, and re-analysis are not streamlined. The human element often provides a significant advantage over poorly developed or under resourced computer based studies.

The greatest utility of GIS is undoubtedly as a component of a decision support system which integrates point data, spatial data and simulation models using flexible software to allow easy information access, retrieval, and generation of maps and tabular reports on alternate management treatments.

Establishment of the decision support system should only be pursued where the consequences of continued sub-optimal or conflicting resource data is untenable to the organisational goals of the management agency.

In order to be successful, a multi-resource decision support system will require commitment of adequate staff with skills in inventory, forest management, database design, GIS, other expert resource areas (eg. zoologists). The decision support system should also be allocated significant additional computer resources which can be readily linked to existing computer systems.

As already indicated, the "up front" costs associated with institution of a system along these lines are quite considerable. It is inconceivable that the system could be justified on a one-off project basis. The most feasible pathway for implementation of this system is to phase in the assessment of non-wood resource attributes into established timber inventory assessment and modelling systems.

Despite the advantages of the multi-resource decision support system, there is some doubt that forest services in Australia will pursue adoption of this model for GIS use. Ad hoc and lower cost GIS options will be adopted because of uncertainty of this technology. We can but hope that land use conflict and the accompanying loss of timber resources to conservation reserves will one day be recognised as an important balance against the cost of good multi-resource management.

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