Integration Frameworks in Multiple and Sequential Land Use Evaluation

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Abstract Comprehensive Regional Assessments are being undertaken in state forested regions leading to Regional Forest Agreements between the States and the Commonwealth. Currently, there is no appropriate mechanism to integrate these assessments to enable the recognition and consideration of all forest values in forest use decisions. Not all values may be considered in developing scenarios for the decision making process. Integration must consider two main streams of assessment: environment and heritage; and economic and social. An integration framework should have the capacity to consider off-reserve management, resource use, industry development options and enable regional level trade-offs. Successful development of the framework will have implications for the assessment of options in terms of forest sustainability, reserve design and industry structure. The development of an integration framework for forest management should include the provision of real time and reliable tools, optimisation and scenario modelling techniques with credibility, transparency and consistency being valued elements. Such approaches require the integration of quantitative, qualitative and mental models, or a mix of both hard and soft-systems methodologies. The paper describes a prototype integrated framework to assist policy makers approach the resolution of multiple land-use issues for forests. The modelling framework, developed using the Whatif? scenario modelling system, potentially links a number of main components and model types: rule-based models for diversity; land-use allocation models based on linear programming formulations and social perceptions of the acceptability of land-uses; forest growth models based on numeric and empirical information; categorical and lookup table models for the occurrence of mineral resources and their viability; and socio-economic models.

Introduction

Comprehensive Regional Assessments (CRAs) are to be undertaken in state forested regions leading to Regional Forest Agreements (RFAs) between the States and the Commonwealth. Currently, there is no appropriate mechanism to integrate these assessments to ensure the recognition and consideration of all forest values in forest use decisions. Thus, all values may not be considered in scenario development and decision making which may lead to preferred options not being considered.

One approach could involve the "manual" consideration of options. Manual approaches have a number of problems, including the amount of time required for iterations of forest use options, and the difficulty in achieving repeatability, transparency and consistency in advice. There is a need to integrate the development of options, or scenarios, within an information system to provide faster, repeatable and consistent option development. This approach requires testing and vigilance to ensure that the system produces options which are feasible and meaningful.

The development of an integration framework (or system) for forest management should include the provision of real time and reliable tools to enable regional level trade-offs, optimisation and scenario modelling, and have the capacity to consider off-reserve management, resource use and industry development options. Successful development of such a framework will have implications for the assessment of options in terms of forest sustainability, reserve design and industry structure. Credibility, transparency and consistency will be valued elements of the framework [Malafant and Fordham, 1997].

The nature of the CRA/RFA process, and the need to consider the desires and obligations of Commonwealth and State governments and public stakeholders, dictates that a combination of manual and technological approaches are used for the consideration of Ecologically Sustainable Forest Management (ESFM) [Davey et al., 1997]. To make such an approach effective, maximum use must be made of integrated frameworks and decision tools to assist in the rapid reduction of the full range of options to a set of viable options that can be efficiently evaluated in more detail.

Land Use Allocation

One of the most common applications of decision systems is for locating areas that combine a specific set of attributes [Bowyer and Veitch, 1994]. Because of the wide range of aesthetic, economic and ecological values attached to natural resources by society, the complex and potentially opposing mix of these values complicates decisions on how resources should be used or re-allocated [Malafant et al., In Press]. This generates disparities or tensions between groups involved in the decision making process. These tensions arise because [Bowyer and Veitch, 1994]:

- members of society have differing viewpoints on the use(s) to which an area should or can be put, for example conservation versus development;
- there is little consensus on the importance of biophysical, economic and social themes in the site selection process;
- suitability is a complex concept - much more so than the black and white extremes that suitable and unsuitable allow or even suggest.

The need to integrate and simultaneously assess biophysical, economic and social components, while including the user as a surrogate for society, is necessary for effective land use decision-making [Gault et al., 1987; Richards, 1992; Watson and Wadsworth, 1996]. A benefit of incorporating the user is a sense of ownership and involvement leading to decision systems that provide stewardship rather than control. Ironically, the more information made available on the inadequacies and assumptions of the decision-making process, the less contention they attract [Malafant et al., In Press].

The use of hierarchical structures in thinking and the accumulation of knowledge is pervasive and complex procedures, such as the generation of suitability maps, are not exempt from their use [Simon, 1969; Hopkins, 1977]. The hierarchical approach to land use decision-making and site selection outlined by Malafant et al. [In Press] (Figure 1), allows the development of a structured approach to the exploration and analysis of land use and management options. This methodology reflects the way we think and accumulate knowledge; it also provides a clear and transparent methodology for the process.

The first two phases of this hierarchy can be thought of as the strategic analysis component, which is concerned with the short-term suitability analysis. Detailed analysis can then be considered as the tactical analysis component, exploring the long-term sustainability of the selected areas. The consultation and communication phase overlaps both the strategic and tactical analyses.

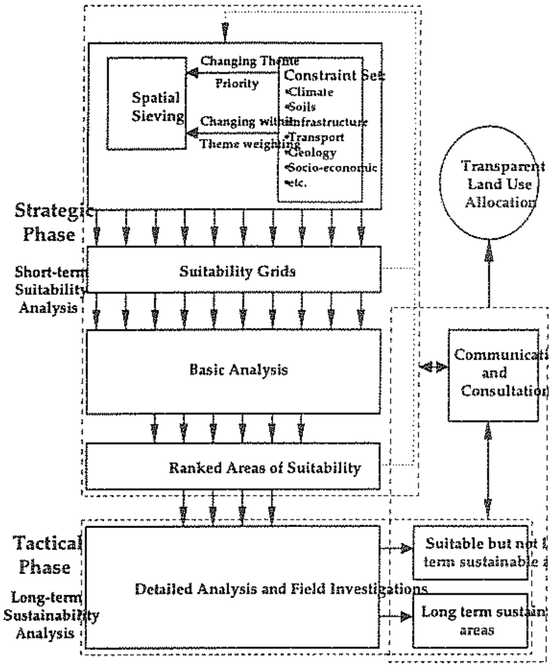

Figure 1. Site Selection Hierarchy Conceptual Diagram [Malafant et al., In Press].

Framework Design

For each forest use system, reserve system plus off-reserve management system, there are a number of values. These include biodiversity, wilderness, social, recreation and forestry values. Depending on the availability of information on the economic and environmental attributes of forests, various decision models may be used to explicitly compare alternative options. The decision models chosen for this purpose must be related to the important issues and concerns of specific CRAs - but the integration framework will need flexibility to cater for variation across CRAs.

The framework is also required to consider the two main streams of assessment: environment and heritage, and economic and social. These considerations require the integration of quantitative, qualitative and mental models, or a mix of both hard and soft-systems methodologies [Pidd, 1996].

The modelling framework (Figure 2), developed using the Whatif? Scenario Modelling System, links a number of main components and model types. Whatif? is an object-oriented scenario modelling package which provides a structured set of tools that enable users to interact, express their ideas and apply information to help resolve economic and ecological resource-related issues. Whatif? provides a modelling framework and reporting toolkit that facilitates the development of scenario modelling tools [Fordham and Malafant, 1995; Malafant and Davey, 1996].

The current framework integrates three major components:

1. On and Off-Reserve Design Systems. A reserve selection method, implemented using a package such as C-Plan [Pressey et al, 1995], identifies conservation priorities and aids in the decision on how to include these priorities in a planned reserve system. Principles that are incorporated in these methods include the reserve concepts of design, irreplaceability, complementarity, adjacency and reserve goals [Pressey et al., 1994].

   The off-reserve design relies on the development of land management guidelines consisting of constraints and priorities for land use and management. Management options need to be traded-off in an efficient and repeatable manner so as to achieve a balanced land use and management allocation, or management plan, for a region.

   The on-reserve design and off-reserve land allocation guidelines can be combined using the LUPIS [Ive, 1992; Cocks and Ive, 1996] landuse planning algorithm. This algorithm provides a landuse allocation dependent on the guidelines and weightings or preferences developed by the user. The method can assist with the identification of preferred management or landuse for particular areas based on user defined inputs and values.

   Alternatively, a GIS-based approach, such as that used by ASSESS, [Veitch, In Press] could be applied to integrate spatial information from diverse disciplines, with the purpose of site selection and land use decision-making. The objective with these systems is to apply a coarse selection sieve to identify areas with a high likelihood of satisfying site suitability and land use decision needs. This is in contrast to a quantitative analysis with the aim of an optimised outcome [Malafant et al., In Press].

2. Resource Production. In this framework these components are typically forest scheduling methods that model yield scheduling, wood resource flow - quantity, quality, species and products - and sustained yield calculations. Other elements may be included that model resources such as grazing, apiary, water, tourism and recreation and other non-wood related resources, environmental impacts and other off-reserve management considerations.

3. ESFM Indicators. The combination of economic models such as FORUM [Hansard et al., 1996] and regional Input/Output models [Powell et al., 1985] for non-wood industries provides an analysis of the direct economic values of land units and a measure of the economic impacts of implementing specific options or scenarios. ESFM indicators covering biodiversity, heritage, ecosystem function, productivity, soil and water values provide additional measurements of viability.

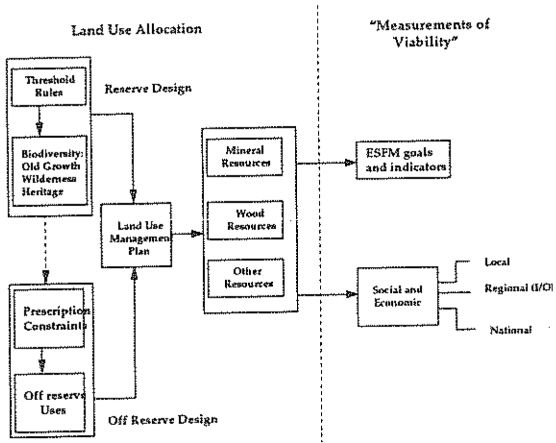

Figure 2. The conceptual diagram for Multiple Use of Forest Framework.

Results

Figure 3 provides an example of a typical land use allocation from the integrated framework. The figure clearly shows the spatial distribution of the alternative land uses, using a simple polygon as the planning unit. The user can interact with the framework by selecting a region in the display and receiving information about the current status of that region - landuse, name and suitability score. Alternatively, the user may wish to alter the landuse of the selected region and observe the effects on the suitability score and other aspects of the framework.

The results from the framework need to be presented to a wide range of clients or users: policy makers, regional resource management organisations, community groups and foresters. There is a need to communicate complex spatial and temporal information. In these integrated applications, scenarios add an extra dimension to the information that needs to be communicated to the decision maker.

Many different levels of information also need to be presented. For some clients, information at the planning-unit scale for different scenarios is required. For policy makers and state agencies, information at the regional level is required. Figure 4 shows the varying impacts of alternative on and off-reserve allocation schemes for selected scenarios in terms of number of planning units in each landuse (4a), area of each landuse (4b), and statistics on the allocation "score" (4c). The interface allows the decision maker to choose the dimensions - spatial, temporal and scenario - of most relevance [Fordham et al., 1997].

Figure 3. Typical Land Use Allocation.

Alternatively, the indirect impacts of land use allocation schemes on the local economy for selected scenarios in terms of output, income, value added and employment could be displayed from the I/O component of the framework. The results of other economic analyses and/or resource scheduling and harvesting models may also be displayed.

Discussion

The development and application of frameworks which integrate information from many different areas is necessary to allow the assessment of management scenarios and to allow the identification of target indicators for the measurement of "success" [Malafant and Fordham, 1996]. The framework provides options for identifying how indicators relate to management strategies, including strategies for complementary off-reserve management, codes of practice and prescriptions, which are necessary to achieve targets for ESFM.

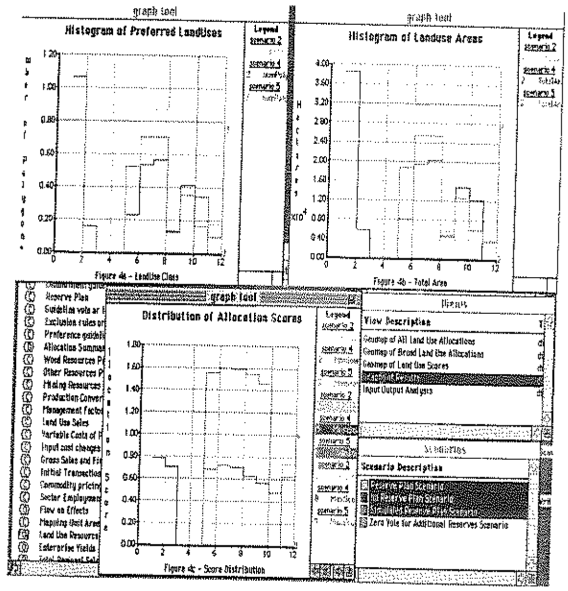

Figure 4. Summary of Land Use Allocation Statistics for varying On and Off-Reserve Scenarios.

A land use and management planning approach has been adopted in which a number of forest and non-forest land units across a region represent a range of ESFM values. On the basis of these values, a number of land use or management options may be identified and allocated to land units, allowing the generation and exploration of different scenarios.

Development of management options and scenarios for ESFM has as a goal the management of forests so that they are sustained in perpetuity for the benefit of society. This can only be done by ensuring that the value of the forests are not lost or degraded for current and future generations. Emphasis must be on the management of the forest resource in such a way as to realise these goals. These management strategies may differ from those that optimise the reserve system in reservation forests or those that optimise the economic sustainability of forest related industries.

Management options will need to be traded-off in an efficient and repeatable manner to achieve a balanced land management plan for a region. To do this we require systems that provide both spatial and temporal analysis or simulation and that are capable of exploring how ecologically sustainable resource use can be achieved. It will be necessary to incorporate corporate knowledge, expert advice and mental models [Pidd, 1996] through the process of "workshopping" [Gault et al., 1987; Grayson et al., 1993]. Alternatively, we may capture the knowledge and intelligence through models and mathematical structures within decision systems.

The current prototype decision system aims to provide the vehicle for achieving this integration and exploration of management options. It is capable of exploring spatial, temporal, environmental resource, economic and social implications of different resource use and management options and will be developed incrementally as new requirements are identified.

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