

Planning For Sustainability in a Dynamics Landscape

Coastal workshop held March 7th, 2006, Nanaimo, BC

Northern Interior workshop held April 25th, 2006, Prince George, BC

Southern Interior workshop held May 4th, 2006, Kamloops, BC

Related Literature

PDF versions of the articles with an asterisk in front of them have been provided on the land use planning workshop CD. These articles have been provided for education purposes only. They are not for further public distribution.

Adamowicz, W. L. and T. S. Veeman. 1998. Forest policy and the environment: changing paradigms. *Canadian Public Policy* 24(Supplement No. 2): S51-S61.
URL: <http://economics.ca/cgi/jab?journal=cpp&view=v24s2/CPpv24s2p051.pdf>

Abstract: Environmental concerns now play a significant role in the formation of forest policy. In this paper, two approaches to environmental aspects of forestry policy are discussed—a social science approach that attempts to maximize net social benefits by including environmental concerns in the economic calculus, and a more biocentric approach that is based on the “natural disturbance paradigm.” The potential strengths and weaknesses of each approach to forest management policy are examined. The conclusion is that a combination of these approaches is required if we are to successfully integrate economic development of forestlands with environmental concerns.

Ames, D. P., B. T. Neilson, D. K. Stevens and U. Lall. 2003. Using Bayesian networks to model watershed management decisions: an East Canyon Creek case study. Submitted to *Journal of Hydroinformatics*.
URL: http://www.hydromap.com/publications/ames_ecc.pdf

Abstract: An approach to developing and using Bayesian networks to model watershed management decisions is presented with a case study application to phosphorous management in the East Canyon watershed in Northern Utah, USA. The Bayesian network analysis includes a graphical model of the key variables in the system and conditional and marginal probability distributions derived from a variety of data and information sources. The resulting model is used to 1) estimate the probability of meeting legal water quality requirements for phosphorous in East Canyon Creek under several management scenarios, and 2) estimate the probability of increased recreational use of East Canyon Reservoir and subsequent revenue under these scenarios.

*Andersson, M., B. Dahlin, K. Erikers and O. Sallnas. 2005. Multi-objective forest landscape projection modelling: problems and prospects. *Journal of Sustainable Forestry* 21(2/3): 175-197.

Abstract: To be able to make the right decisions in forestry today, the long-term effect of these decisions has to be considered. Multi-objective forest landscape projection models are tools that can be used to illustrate the effect of different management alternatives in a landscape. An integrated approach facilitates multi-objective considerations and decisions. A number of modelling systems has been developed. A modelling system contains numerous sub-models, each one modelling a particular part of the forest ecosystem, the socio-economy or other aspects of interest. Models and data are intimately connected, and different methods for collecting data and

their relevance for different models are examined. The sub-models interact with each other in such a way that the dynamics of a forest is simulated. This article examines different sub-models for tree growth, economy, biodiversity, forest recreation and soil, and various uses for multi-objective forest landscape projection models are suggested and some examples are presented. Most every model is associated with variation, uncertainty, underlying assumptions. Errors in data and models, their origin and propagation through models, are discussed. The future development of forest models and their employment in planning and decision making are considered.

Ascher, W. 2000. Applying classic organization theory to sustainable resource and environmental management. 5th Annual Colloquium on Environmental Law & Institutions. April 27 - 28, 2000. Duke University.

URL: <http://www.law.duke.edu/news/papers/ascher.pdf>

Aslin, H. J., N. A. Mazur and A. L. Curtis. 2002. Identifying regional skill and training needs for integrated natural resource management planning. Bureau of Rural Sciences, Canberra, Australia. 96 pp.

URL: <http://affashop.gov.au/product.asp?prodid=12793>

Abstract: [Executive Summary]

This report investigates the skill and training needs of regional groups responsible for developing Integrated Natural Resource Management (INRM) plans under the National Action Plan for Salinity and Water Quality and the extension of the Natural Heritage Trust. It also considers broader issues related to capacity building for INRM. Report findings are based on a literature review, key informant interviews and responses from members and staff of regional groups to a training needs questionnaire that included a skills template (a listing of skill and knowledge areas relevant to INRM planning).

The report identifies two major approaches to learning: hard and soft systems approaches. The former tends to focus on the need for scientific and technical expertise (specialised knowledge), and often seeks universally generalisable laws and solutions. The second focuses on involving a range of players and different knowledge systems, and tends to emphasise that solutions are context-specific and may need to be re-negotiated over time. A soft systems approach is advocated, focusing on INRM planning and capacity building as human activities taking place in particular social, geographical and institutional contexts.

A range of players has a role in NRM capacity building in Australia. They include agencies like Agriculture, Fisheries and Forestry – Australia and Environment Australia (both of whom have relevant programs and activities outside the immediate policy area dealt with here); the Department of Transport and Regional Services; Department of Education, Science and Training; Murray-Darling Basin Commission; State and Territory NRM and environmental agencies; Research and Development Corporations; and non-government organisations like Greening Australia. The formal education and training system, particularly its Vocational Education and Training sector, has an important role.

Key informants interviewed in the project came from the areas of NRM or integrated planning; community participation in NRM; providing services to rural and regional Australia; and rural education, training, capacity building or extension. Twenty-two informants were interviewed. They were shown a trial skills template containing a list of knowledge and skill areas possibly needed for INRM planning and asked to comment on it. Overall, they tended to stress the importance of groups having general skills like the ability to communicate and raise community

awareness, group leadership, lobbying and negotiation/conflict resolution skills – all social process-related skills. Some key informants indicated that what regional groups most need to effectively participate in INRM planning is a broad general understanding of NRM as well as the ability to integrate and identify the implications of a range of information. They also need to know enough to be able to identify what they don't know, and where to go (or who to go to) to be able to find it. From the perspective of these informants, much of the important knowledge that groups need for INRM planning is process knowledge, knowledge brokering and integration abilities, and the need for highly specialised subject knowledge should not be over-emphasised.

Baran, E. and T. Jantunen. 2004. Stakeholder consultation for Bayesian Decision Support Systems in environmental management. Proceedings of the Regional Conference on Ecological and Environmental Modeling (ECOMOD 2004). Sept 15-16, 2004. Penang, Malaysia, Universiti Sains Malaysia.

URL:

http://www.worldfishcenter.org/projects/bayfish/Baran_Jantunen_2004_Stakeholders_consultation_for_Bayesian_DSS.pdf

Abstract: Environmental management is a field where the number of variables, their interactions and feed-back loops require tools to integrate information, build scenarios and support decision-making. Among the various kinds of Decision Support Systems, Bayesian Belief networks have proven to be quite useful as they can integrate quantitative information as well as qualitative expert knowledge. Beyond knowledge integration, the consultations also help clarifying what is at stake, how variables interact and what are the conflicting interests.

Gathering expert knowledge requires consultations, with a particular approach constrained by modelling requirements. In this paper based on our experience we focus on the technical aspects of such stakeholders' consultation. We describe in detail the steps of the consultation, we analyse the methodology (selection of stakeholders, collective building of a model structure, probabilities elicitation, etc). Then we review the possible pitfalls and problems encountered in the process. We ultimately propose generic guidelines for stakeholders consultation in view of building Bayesian models for environmental management.

Baskerville, G. L. 2002. In search of sustainable forest management. Association of British Columbia Professional Foresters annual meeting. Nanaimo, Association of British Columbia Professional Foresters.

URL: <http://www.rpf-bc.org/download/agmbaskerville.pdf>

*Bettinger, P. and K. Boston. 2001. A conceptual model for describing decision-making situations in integrated natural resource planning and modeling projects. *Environmental Management* 28(1): 1-7.

Abstract: A conceptual model is developed herein for the purpose of stimulating discussions within groups planning and carrying out integrated natural resource projects. We first describe four basic components of integrated planning and modeling efforts: people, databases, technology, and organizational commitment. Second, we provide one view of the relationship between the size of the project's decision-making body and the timing of decisions during a project's life cycle. Finally, these two discussions are combined into a conceptual model describing the dynamics nature of decision-making within integrated projects. The abstractions and generalizations described here are not unique to private industry or governmental organizations and should provide the basis for a discussion of decision-making issues among interdisciplinary professionals embarking on large-scale or complex modeling efforts.

Bettinger, P. and W. Chung. 2004. The key literature of, and trends in, forest-level management planning in North America, 1950 - 2001. *International Forestry Review* 6(1): 40-50.

Abstract: An increase in the use of operations research techniques for forest-level planning, as expressed by publication of papers in peer-reviewed North American forestry journals, is illustrated by the number of papers published that describe a mathematical problem formulation, or model used, and demonstrates an application of the planning process. A shift in planning from a dependence on linear programming to heuristics is evidenced through the literature review, although linear programming and its derivatives continue to be used to demonstrate the development of strategic forest plans, plans without spatial components or relaxed solutions to more complex forest planning problems. Initially, wood production and economic goals dominated the themes of journal articles, but just as the forest management environment as evolved to include an explicit recognition of non-timber goals, so have mathematical programming techniques evolved to support the development of forest plans with non-timber goals. Spatial components within forest planning processes have also increased dramatically in the last decade, as resource goals that key off of the juxtaposition of activities have become increasingly important. Finally, two North American forestry journals, the *Canadian Journal of Forest Research* and *Forest Science*, have become the predominant sources of forest-level planning literature that focuses on forest planning problem formulations and examples of the use of mathematical programming techniques in forest-level planning.

Bettinger, P. and J. Sessions. 2003. Spatial forest planning: to adopt, not to adopt? *Journal of Forestry* 101(2): 24-28.

URL: http://www.findarticles.com/p/articles/mi_qa3941/is_200303/ai_n9177776

Abstract: Habitat fragmentation, the size of harvest units, the cumulative effects of activities, and other forest management issues are prompting a new planning approach focusing on the spatial juxtaposition of forestry activities. Spatial forest planning involves mathematical programming techniques to incorporate both commodity and non-commodity goals with spatial aspects into a forest plan. Among the factors that encourage spatial forest planning are regulations and voluntary guidelines on the patterns of harvest units and wildlife habitat, the desirability of using forestland efficiently to meet various goals, and the need to evaluate and schedule activities across multiple ownerships in landscape-level plans. Factors that discourage its adoption include technological, financial, and personnel hurdles, as well as insufficient data with which to inform the models.

Bormann, B. T. 2004. Options forestry: acting on uncertainty. *Journal of Forestry* 102(4): 22-27.

URL: http://www.findarticles.com/p/articles/mi_qa3941/is_200406/ai_n9436004

Abstract: An increased appreciation of how scientific and societal uncertainty enters management decisions suggests a new approach to forest management—options forestry. We contend that unflinching assessments of uncertainty can often find an array of alternatives that cannot be distinguished with sufficient confidence to permit the choice of one “best practice.” Options forestry responds to uncertainty by diversifying management, emphasizing learning, and integrating research and management. A Siuslaw National Forest project in Oregon demonstrates options forestry as an approach to act on uncertainty to society's advantage.

Boutin, S. and D. Hebert. 2002. Landscape ecology and forest management: developing an effective partnership. *Ecological applications* 12(2): 390-397.

Abstract: Landscape ecologists have been eager to make their research applicable to forest management. We examine how landscape ecology has contributed to shaping the way forest management is currently practiced. Landscape ecology research in forested ecosystems can be divided into two general areas: (1) the study of fragmentation issues, which focuses on the effects of forest fragmentation on species conservation; and (2) the development of landscape projection models, which focuses on patch dynamics and the effects of spatial arrangement of patches on ecosystem processes. Fragmentation issues have become priorities in the minds of forest managers, but research to date has over-emphasized the effects of landscape structure on species conservation. We suggest that the research focus should move toward the study of threshold effects of landscape change on the relative influence of habitat loss and habitat configuration on species conservation in forest-dominated landscapes. Landscape projection models are rapidly becoming important tools in forest management planning, and they hold great promise as a means to bring landscape ecologists and forest managers together. The ability to product future landscapes under different management scenarios and to compare these to landscapes produced by natural disturbance regimes will help to focus both managers and scientists on understanding the key interactions among human activities, landscape features, and ecological processes.

Boyчук, D. and D. L. Martell. 1996. A multistage stochastic programming model for sustainable forest-level timber supply under risk of fire. *Forest Science* 42(1): 10-26.

Abstract: Forest management planning models are highly developed and used extensively, but few explicitly consider the effects of fire and other uncertain losses which can be significant. Previous studies recommended contradictory responses to potential fire loss. We developed forest-level timber management optimization models with deterministic average and stochastic fire loss and used them to develop insight into the impact of uncertainty on forest management planning. Our analysis indicated that producing a stable timber supply requires the establishment of a buffer stock of timber. This strategy reduces the short-term harvest quantity, but increases the expected long-term harvest quantity. Paradoxically, the timber supply is both more stable, and larger. The results are sensitive to the method of regulating timber production: profit maximizing behavior of future producers requires a much greater buffer stock. In addition, bounds on the effect of transportation were developed, conditions where the mean value problem is adequate were identified, and the effect of a downward sloping demand curve was investigated.

*Brody, S. D. 2003. Implementing the principles of ecosystem management through local land use planning. *Population and environment* 24(6): 511-539.

Abstract: While ecosystem approaches to management focus on broad spatial scales, decision makers increasingly recognize that implementation must occur at the local level with local land use decisions. This article examines the ability of local comprehensive plans in Florida to incorporate the principles of ecosystem management. It seeks to understand how comprehensive plans can effectively contribute to the management of ecological systems by systematically evaluating local plans against a conceptual model of what makes for a high quality ecosystem plan. Results measure the relative strengths and weaknesses of local plans to achieve the objectives of ecosystem management and provide direction on how communities can improve their environmental frameworks.

Brooksbank, K. 2001. Choosing the right decision support tools. Assisting Forest Owner, Farmer and Stakeholder Decision-Making, Extension Working Party (S6.06-13) Symposium. October 29 - November 2, 2001. Lorne, Victoria, Australia, International Union of Forestry Research Organizations.

Abstract: [Introduction]

Why do we need Decision support tools?

Rural and natural resource management is concerned with achieving the integrated, productive and sustainable use of biological, physical, social, and financial capital at diverse geographic and temporal scales. As our understanding of the natural resource base has improved, the need for integrated approaches to management has been increasingly widely appreciated. As a consequence, decision-making in rural, natural and environmental resource management has become a more complex process. The intensification of agricultural production and more recent emphasis on holistic environmental management has meant that managers are increasingly expected to address more complex issues (including negative externalities as well as issues associated with productivity) such that a broader domain of information needs to be considered. As the complexity of the decision-making task increases, resource managers (whether farmers, agri-business, Government Agency staff or other managers) are increasingly unlikely to have the necessary expertise, and, therefore, capacity to make resource management decisions that integrate the range of issues that demand consideration (Walker 2000).

Brown, C. 2001. Linking operational and strategic planning (the RCFC story). Completed by Silvatech Consulting Ltd., Extension Report 11 pp.

URL: http://www.forestry.ubc.ca/atlas-simfor/webdocs/extension/RCFC_Story.pdf

Abstract: As regional and sub-regional land use planning processes are completed around the province, numerous strategies for managing the crown forested land base must be implemented by the forest industry. Strategies that typically impact forest-harvesting operations are spatial in nature and require some form of forest cover to be maintained. An example could be: at least 40% of the forested area within an identified caribou zone must be mature at all times (40% > 140 yrs old). This simple rule becomes more complicated as steep slopes are excluded and it must be evaluated separately for each biogeoclimatic zone. It quickly becomes apparent that computer models are a very useful tool for evaluating these types of rules and predicting impacts on timber availability through time. Spatially explicit timber supply modeling is capable of completing this task while also illustrating how it looks on the ground. In order to get realistic implementation direction (harvest blocks) from the model, sound operational planning should drive landscape level strategies for non-timber resources, which in turn drive timber harvest projections (bottom-up approach).

Revelstoke Community Forest Corporation (RCFC) has completed numerous land base assessments and total chance harvesting planning initiatives that allow a bottom up approach to be applied when modeling Tree Farm Licence (TFL) 56. This extension note describes how detailed spatial timber supply modeling was used on TFL 56 to:

- Influence the development of strategic land use decisions in the Revelstoke Forest District, and ultimately,
- Complete the TFL Management Plan Process so that all levels of planning (operational – landscape – strategic) came together to give realistic harvest projections and explicit direction for how to achieve it on the ground.

This report is structured as a chronological series of events or initiatives that represents RCFC's experience with spatial modeling and how it was used to bridge all levels of planning on their land base.

Calbick, K. S. (2003) The use of program theory for identifying and evaluating 'best practices' for implementing land-use policies. Master of Resource Management, Simon Fraser University.

URL: <http://www.rem.sfu.ca/sustainableplanning/publications.htm>

Abstract: Over the past decade, land-use planning in British Columbia has matured into the current, integrated land and resource-planning regime. Such an integrated planning approach attempts to balance environmental, economic, and social objectives to achieve sustainable use of the existing land-base. Moreover, planning activities such as these necessarily encompass a wide range of interests and stakeholders, as well as addressing a multitude of complex issues. All of which lead to the inescapable conclusion that implementing such plans is inevitably a complicated process. Since most of the provincial plans initiated are now completed, attention is turning to the implementation phase, during which these consensus-based plans are instituted on the ground.

This report identifies the best implementation practices that should be used for implementing such land-use policies. Evaluating the best practices used by selected North American agencies—Bay Conservation and Development Commission, Fraser Basin Council, Land Conservation and Development Commission, Puget Sound Water Quality Action Team, and United States Department of Agriculture Forest Service—identifies which implementation practices are most critical to achieving policy objectives. Each of the selected agencies is studied using a variety of methods. Agency programs are first described and characterized, then each agency's impact theory and organizational plan is delineated by applying program theory. Information developed through program theory, particularly the organizational plans, forms the basis for an implementation practices register used to develop a check-rank-evaluate questionnaire. Selected senior program personnel completed the questionnaire and participated in a follow-up interview that provided contextual information and increased understanding of responses.

According to the questionnaire results, the most critical practices are: legislated mandate, administrative rules (regulations and permits), development of guidelines, cooperative and collaborative planning process, adequate funding, enforcement penalties, multijurisdictional cooperation, and providing project financing. Furthermore, these results suggest an 'arch of sustainability' may be an applicable metaphorical model. This model explicitly represents the essential institutional foundation that sustainability efforts require, as well as depicting the importance of the social dimension of sustainability as a keystone component upon which the other dimensions depend.

Cassells, D. S. 2001. Processes for resolving conflict: managing land use change. *International Forestry Review* 3(3): 206-213.

Abstract: This paper examines the nature of environmental conflict and stresses the importance of land use planning. It outlines some of the key requirements for consensus building and suggests that land use planning processes should be structured around the related goals of achieving meaningful social communication and meaningful social choice. To achieve this, it suggests that land use planning processes must:

- embody elements of participatory design which allow the planning and decision-making process to respond to all the social values and interests in particular resource management issues; and
- recognize that the evaluation and weighing of social values that is at the heart of the resource management decision-making process is a political and moral enterprise that should be located in

the political rather than the administrative arena.

This paper reviews some of the key tools that can assist more effective land use planning including integrated catchment management (ICM), the use of GIS and other modern information technologies, stakeholder analysis and conflict mediation. The paper suggests that the decision-making environment facing forestry institutions in the future will be more turbulent, uncertain and ambiguous, with a need to respond to multiple stakeholders, multiple social values and multiple resource use priorities. To remain relevant in these conditions, forestry institutions must evolve into or be replaced by new organizational forms that are characterized by open, learning institutions that are based on participation, collaboration and mutual learning through adaptive management and action research.

Chang, S. J. 1980. Multiple-use forest management by goal programming input-output analysis. USDA Forest Service, Washington, D.C. General Technical Report No 25. 72-78 pp.

Abstract: The goal programming/input-output analysis model is proposed to provide a plausible solution to the problem of multiple use forest management. A hypothetical management problem is analyzed with this technique to determine the optimal allocation of scarce resources. In addition to parametric programming and specification sensitivity analysis, compatibility analysis and trade-off analysis are also performed to allow for the fine-tuning of management decisions.

Cheng, A. S. and S. E. Daniels. 2003. Examining the interaction between geographic scale and ways of knowing in Ecosystem Management: a case study of place-based collaborative planning. *Forest Science* 49(6): 841-853.

Abstract: This article examines the interaction between geographic scale and ways of knowing in the context of collaborative stakeholder participation in ecosystem analysis and management. The examination uses data from a qualitative comparative case study of two watershed councils in western Oregon. The results tentatively support the proposition that geographic scale can significantly affect individual stakeholder ways of knowing. For small-scale places, stakeholder ways of knowing tend to be particularistic and rely on diverse personal experiences and specific place features; for large-scale places, stakeholder ways of knowing tend to be aesthetic and rely primarily on recreational experiences and scientific analyses. However, the results also indicate that geographic scale combines with at least three factors to affect the development of shared ways of knowing: (1) tensions between expert and laypersons; (2) primacy of organizational representation in stakeholder interactions; and (3) discovery of common group identity based on long-term communication and shared on-the-ground experiences, such as field trips.

Cleaves, D. A. 1994. Assessing uncertainty in expert judgments about natural resources. USDA Forest Service, Southern Forest Experiment Station, New Orleans, Louisiana. General Technical Report No SO-110. 17 pp.

URL: <http://www.srs.fs.usda.gov/pubs/viewpub.jsp?index=18>

Abstract: [Summary]

Judgments are necessary in natural resources management, but uncertainty about these judgments should be assessed. When all judgments are rejected in the absence of hard data, valuable professional experience and knowledge are not utilized fully. The objective of assessing uncertainty is to get the best representation of knowledge and its bounds. Uncertainty assessments can be used to compare alternative projects and risks, help prevent use of extreme decision strategies, help communicate and justify decisions, guide research, and establish monitoring programs and improve learning.

Uncertainty assessment is the art and skill of judging the level of knowledge that backs up estimates. Use of structured processes, use of an objective analyst or facilitator, and development of rewards for honesty and introspection in professional judgment can increase the accuracy of assessments. Techniques and performance aids are available for structuring decisions and uncertain elements, guarding against motivational and cognitive biases, and dealing with rare but consequential events. Experience and increased understanding of decision analysis, artificial intelligence, and behavioral decision theory will also enable decision makers to make increasingly accurate assessments of uncertainty in professional judgments.

Cohen Vitale, A., H. Whiffen and R. J. Cooper. Modeling neotropical bird habitat using bayesian statistics and landscape variables in the geographical information system.

URL: <http://www.cobblestoneconcepts.com/ucgis2summer/vitale/vitale.htm>

Abstract: This proposed research addresses problems with multi-resource management, in particular, timber and wildlife management. Timber managers require quantitative information to manage wildlife habitat. Problems begin with the intensive data collection methods required to tailor a management practice for a particular species and area. The technological advances within the areas of remotely sensed and other spatial data, increased computing power for large datasets, and geographical information systems (GIS) may provide us with a means to develop solutions to balance our management goals.

Wildlife models that use satellite imagery and other types of data that can be manipulated in a GIS may eliminate the need for costly and time-consuming measurements that are not used by timber managers. Understanding which images or GIS variables correlate with biological variables for a particular species still needs exploration; as well as the development of methods that allow a model to be applicable across a theme by theme basis. There is also a question of which types of models and statistics are best able to predict the occurrence of a species across a landscape, species diversity, or identify critical habitats.

The objectives of this research are 1) investigate which GIS variables are associated with biological variables for different species of migratory birds 2) use a Bayesian statistics model within a GIS to map potential habitat for the birds, 3) assess model performance using raw reflectance signatures of Landsat (30-m) and Ikonis (4-m) imagery, and 4) compare the applicability and cost factors of wildlife and forestry measurements to the use of GIS variables for land management plans.

Our methods will include bird census points that were conducted during the summer of 2000 and 2001. We connected this census data to a GIS database by using a Global Positioning System (GPS) to reference the location of the points. We then extracted relevant values of GIS variables to create a Bayesian probability model for species presence. Probability maps generated in the models used data sets such as land history, watershed data, Ikonis and Landsat TM imagery, etc. We will evaluate each model using a test data set. The applicability and cost factors of wildlife and forestry measurements to the use of GIS variables for land management plans will be compared.

Connaughton, K. P. and R. D. Fight. 1984. Applying trade-off analysis to national forest planning. *Journal of Forestry* 82(11): 680-683.

Abstract: A trade-off analysis is required for national forest planning. Trade-offs between outputs can be computed with the same linear programming model of the forest used to prepare

land-management alternatives. By systematically varying the objectives for one of the outputs of an alternative, the resulting trade-off with the output measured by the objective function of the linear program is determined. Trade-offs cannot be reliably computed from the differences between land-management alternatives. Trade-offs may be overstated when inputs such as land are manipulated instead of outputs. A similar overstatement of trade-offs may occur when a sufficiently wide range of management regimes is not provided to the model. Since a trade-off analysis is only as good as the fundamental production relationships on which it is based, misleading trade-offs can result for alternatives producing a mix of outputs outside the range of historical experience and supporting data.

*Constanza, R. 2000. Social goals and the valuation of ecosystem services. *Ecosystems* 3: 4-10.

Abstract: [Introduction]

Ecosystem services are obviously important in sustaining human life on earth (Daily 1997; Costanza and others 1997a). The big questions include: how important? Over what temporal and spatial scales? What are the limits of humanity's ability to substitute for them? At what levels of stress do they flip to some other (less desirable) state? All of these questions require the ability to understand and model the interconnected, coevolving system of humans and nature (Costanza and others 1993, 1997b). In addition, the answers to these questions are not purely academic. We humans have to make choices and trade-offs concerning ecosystem services, and this implies and requires "valuation," because any choice between competing alternatives implies that the one chosen was more highly "valued." That the alternatives are "competing" is important, because if we can find a "win-win" solution then no real choice is required, and we can avoid valuation. But most environmental decisions involve the problem of having to weigh and aggregate the myriad different kinds of "benefits" of a proposed action against its "costs." In most cases, these benefits and costs are both poorly understood and poorly quantified. In addition, the future vision and social goals that define the degree to which something is a benefit or a cost are themselves evolving and changing. In doing valuation of ecosystem services, we need to consider a broader set of goals that include ecological sustainability and social fairness, along with the traditional economic goal of efficiency.

Day, J. C. and T. I. Gunton. 2003. The theory and practice of collaborative planning in resource and environmental management. *Environments* 31(2): 5-19.

Abstract: [Document Summary]

There is widespread agreement that assessing the strengths and weaknesses of collaborative processes, and identifying best practice guidelines for collaborative planning, requires comprehensive empirical evaluation of case studies ([Caton Campbell, Marcia] and Floyd 1996; Sipe 1998; Innes and Booher 1999; Andrew 2001; [Leach, W.D.] et al. 2002; Beierle and Cayford 2002; Caton Campbell 2003; [Frame] et al. 2003). Unfortunately, empirical evaluations of collaborative planning are challenging because of the difficulty in comparing the performance of a control group of non-collaborative processes to collaborative processes. The two processes do not exist side-by-side and there are too many confounding variables and disagreement over evaluative criteria to provide definitive results. Consequently, while there have been many individual case study assessments, there is a dearth of systematic, empirical evaluations of collaborative processes. Recent developments in collaborative planning, however, are encouraging.

3) The study by Leach et al. (2002) examined 44 cases of collaborative watershed planning in California and Washington. Data were collected by phone surveys of between three and six stakeholders per case study and a mail survey of the entire 1,185 stakeholders with a response

rate of 65%. The study measured the performance of the collaborative processes using three broad criteria: affect on watershed conditions, achievement of social capital benefits, and reaching agreement. Stakeholder perceptions from survey data were used to measure the impact of collaborative planning on 12 indicators of watershed conditions. The results show that the impact on watershed conditions was generally positive, with 39 of the case studies recording overall improvement. The study also found that the processes were successful in achieving social capital benefits and agreement. Within these broad findings, Leach et al. found several important trends. First, the success of collaborative planning was strongly correlated with the length of time of the process, with four-to-six years required to achieve any significant measure of success. Leach et al. cautioned, therefore, against premature evaluation of collaborative processes. Second, contrary to the criticism that collaborative planning avoids tough problems in an effort to achieve consensus, the study found that the collaborative processes focused on mitigating the most serious problems in the watersheds.

While these evaluations of collaborative planning all have their self-confessed limitations, they do provide an impressive research record that provides strong endorsement of the benefits of collaborative planning. The studies show that collaborative planning is more effective than other planning models in resolving disputes, meeting the interests of stakeholders and generating additional secondary benefits such as improved stakeholders relationships and knowledge. Evaluation results also show that collaborative planning is able to address the major challenges raised by its critics. Successful application of collaborative planning to complex environmental planning problems involving fundamental differences in values challenges the allegation of limited applicability. Indeed, the findings that collaborative planning addresses the most serious problems, challenges the allegation that consensus processes avoid the tough issues and seek second-best solutions. The involvement of a large number of diverse stakeholder interests, and the retention of final decision making by democratically accountable authorities, challenges the allegation of collaborative processes reflecting only narrow special interests that are not accountable. Increasing use of collaborative processes combined with high rates of satisfaction from stakeholders challenges the allegation that collaboration dominated by more powerful stakeholders. As Gunton and Flynn (1992:15) observed, collaborative planning "simply opens up what is normally a backroom lobbying process to a broader array of stakeholders subject to greater public visibility and review." In sum, the research illustrates that while collaborative planning faces challenges, it has been remarkably successful. The key to success is effective design and management of the collaborative process, which we will address next.

Day, J. C., T. I. Gunton and K. H. Albert. 2003. Achieving effective implementation: an evaluation of a collaborative land use planning process. *Environments* 31(3): 51-68.

Abstract: [Document Summary]

The documentation of the disparity between plans and implementation by Pressman and Wildavsky stimulated additional research on implementation. Sabatier and Mazmanian (1983) made an important contribution to the evolution of implementation theory in their review of the California Coastal Commission efforts to manage coastal zone land use. Contrary to the Pressman and Wildavsky (1973) study, Sabatier and Mazmanian (1983) concluded that the California Coastal Commission was relatively successful in implementing its objectives. They then identified criteria that explained this successful outcome and tested the criteria on a number of other case studies of policy implementation (Mazmanian and Sabatier 1989). They summarized their findings by identifying six key criteria determining implementation success: clear and consistent objectives; causal linkages between objectives and actions; designation of a sympathetic agency with adequate resources and authority to implement the plan; skilled and committed implementation managers; public and stakeholder support; and, a supportive

socioeconomic and policy environment (Mazmanian and Sabatier 1989: 268-9). Following the Mazmanian and Sabatier analysis, other researchers tested and elaborated on the criteria for successful implementation (Goggin et al. 1990; Vedung 1997).

Effective implementation is an infrequent event in resource planning (Margerum 1999; Talen 1996). Therefore, the implementation of the KLRMP provides a rare opportunity to evaluate a successful implementation process. Assessments in Table 2 show that twenty-three implementation criteria were ranked as important to very important by stakeholders in achieving this success. This finding illustrates that implementation of a land use plan is a complex undertaking that requires attention to a broad range of issues to achieve implementation success. These range from developing useful indicators and dealing with scientific uncertainty to building respect and trust between individuals from widely divergent backgrounds. The twenty-three criteria in Table 2, therefore, provide a good checklist for assessing planning implementation strategies. Responses in the open-ended sections of the survey also highlighted aspects of these twenty-three criteria that needed special attention in the implementation process. These include: clarification of intent of objectives, continuity of membership, orientation and training for new table members, confirmation and consistency of government commitments, ongoing information sharing between participants, and improvements to the monitoring framework and timetable

Evaluation of plan implementation is a relatively neglected field in planning research. This paper has helped address this deficiency by reporting results from a comprehensive evaluation of the implementation of a unique plan. This study is unique in that it relies on both objective data on implementation and survey data from stakeholders. The results show that the plan was successfully implemented. The survey of actors engaged in implementation of this plan supports the findings in the implementation literature that there are a large number of criteria that must be met to achieve successful implementation. Underpinning all the other factors critical to implementation is the use of a collaborative planning process to develop the plan and to monitor the plan's implementation. Other studies have documented the benefits of CP in increasing the probability of developing a plan in the public interest and in stimulating additional social capital benefits related to improved stakeholder knowledge, skills, and relationships. This study documents further benefits of CP in achieving successful plan implementation. Implementation is a complex undertaking requiring attention to many variables. Although more research on implementation is required to produce definitive results, this study suggests that one key aspect of a successful implementation strategy is collaborative planning.

Day, J. C., T. I. Gunton and K. S. Calbick. 2003. Land use planning implementation: a 'best practices' assessment. *Environments* 31(3): 69-82.

Abstract: [Document Summary]

Instructions to participants contained a technique designed to help agency personnel sort through the check-rank-evaluate questionnaire. After initially checking the applicable practices, respondents were instructed to first select their highest priority practice and rank it with a '1', then to select their lowest priority practice and rank it as '25'. The procedure continues iteratively as respondents determine their next highest priority and next lowest priority practices and rank them as '2' and '24' respectively until all checked implementation practices are ranked. Since most agencies do not employ the full gamut of implementation practices presented in Table 1, a gap usually appears in the rankings requiring adjustment of questionnaire responses. Simply subtracting the value of the gap's range from the lowest priority implementation practices accomplishes this adjustment and eliminates the gap. For example, suppose an agency used 20 of the 25 implementation practices ranked. The value of the gap's range would be five and the ranking of the lowest priority practice would be adjusted from 25 to 20. This re-ranking process is

applied to all the lowest priority implementation practices until the gap disappears.

Once the questionnaire responses were adjusted, implementation practices were assigned to one of three categories. The top third of each agency's applicable implementation practices were categorized as 'first priority', the middle third were classified as 'second priority', and the last third were considered 'third priority'. When ties were encountered during this process, all tied practices were considered of equal importance and were all included in the indicated category. Consequently, several of the adjusted rankings are not divided as symmetrically as the above description implies.

To circumvent the fact that all agencies do not use the same set of implementation practices, and still retain the capacity to differentiate the relative importance of various practices, the following approach was adopted. Individual aggregate scores for each implementation practice were determined by applying a few simple rules. Each agency's first priority implementation practices were assigned a value of '1', second priority practices were assigned a value of '2', and third priority practices were assigned a value of '3'. Summing the values across each practice and dividing by the number of agencies that used a particular practice determined aggregate results (Figure 1).

Day, J. C., T. I. Gunton and T. M. Frame. 2003. Toward environmental sustainability in British Columbia: the role of collaborative planning. *Environments* 31(2): 21-38.

Abstract: [Document Summary]

The new Act gave CORE two related mandates. The first task, completed in 1995, was to catalyze rural sustainability by means of a number of related initiatives. These included the development of a provincial strategy, land use plans, and local planning processes that aimed to: balance social, economic, and environmental interests; coordinate programs within and between governments; and introduce a high level of public participation to make the transition successful (B.C. 1992: sec. 4). The commission's second mandate was to provide ongoing surveillance through its responsibility to advise government in an independent and public manner on land use and related resource and environmental issues pertaining to sustainability, and on the need for related legislation, policies, and practices (B.C. 1992: sec. 3). This mandate was supported by full public inquiry powers to hold hearings and compel testimony (B.C. 1992: sec. 6). This continuing role to serve as an ombudsperson was a key component of the sustainability strategy. Cancellation of CORE in 1996 left a critical gap; subsequently an overarching monitor was not available to observe and integrate the complex and interconnected aspects of sustainability initiatives throughout rural areas of the province ([Owen] 1998: 15).

Concurrent with the efforts of CORE was the initiation of the Land and Resource Management Planning (LRMP) process to develop strategic land use plans for the rural areas of the province not covered by CORE. The LRMPs, which were managed by government ministries, were based on the same collaborative principles used to develop CORE plans. In January of 1994, the government established the Land Use Coordination Office (LUCO) as a central agency to manage the LRMP process. LUCO and regional interagency management committees, made up of senior representatives from provincial ministries with land and resource-use-related mandates, coordinated the work of the LRMP tables. In June of 2001, following a provincial election, the new provincial government created the Ministry of Sustainable Resource Management (MSRM) with a mandate to "... to provide corporate leadership to the development of sustainable policies, plans and supporting information systems for land use planning and policy" (B.C. Office of the Premier 2001). LUCO became a part of this new ministry.

Frame, [Thomas I. Gunton], and Day (2002, 2003) prepared an evaluation of the collaborative planning process based on a survey of stakeholders involved. The study shows that the processes were relatively successful in achieving agreement among stakeholders. Twelve of the 15 LRMP processes achieved full consensus, two achieved consensus-minus-one, and the final LRMP achieved consensus on the majority of plan recommendations. The four CORE processes were less successful. All four CORE plans failed to reach consensus and CORE staff were required to prepare land use plans to submit to government for approval. The failure of the CORE tables to reach a consensus was in part due to the fact that they were dealing with the most contentious regions of the province and were developed early in the process under stricter time constraints. However, although stakeholders initially opposed these plans, the government was able to synthesize agreements through subsequent informal mediation that the stakeholders would accept. Given the high level of conflict over land use, the achievement of strong stakeholder agreement on the final CORE and LRMP land use plans was a remarkable achievement.

Day, J. C., T. I. Gunton and P. W. Williams. 2003. Evaluating collaborative planning: the British Columbia experience. *Environments* 31(3): 1-11.

Abstract: [Document Summary]

The research occurred in three major stages. The first phase, conducted between 1989 and 1992, examined various aspects of regional land use planning, including analytical methods for evaluating land use options, new institutional structures for land management, and an evaluation of the British Columbia resource planning system (Gunton and Vertinsky 1990a, 1990b; Gunton 1991; Gunton 1992; Gunton and Duffy 1992; Gunton and Fletcher 1992; Gunton and Flynn 1992; M'Gonigle et al. 1990; M'Gonigle et al. 1992). This research assisted in the development of the new CP approach adopted in British Columbia in early 1992. The second phase of the research program consisted of a preliminary evaluation of a subset of the earlier CP land use plans completed up to 1996 (Cardinal and Day 1996; Duffy et al. 1996; Flynn and Gunton 1996; Wilson et al. 1996; Gunton 1997, 1998; Cantwell and Day 1998; Like and Day 1998; Penrose et al. 1998; Williams et al. 1998; Williams et al 1998; Duffy et al. 1998; Tamblyn and Day 1999). The third phase of the research, commenced in 2001, involves a comprehensive evaluation of the British Columbia experience by evaluating the process for developing and implementing regional land use plans. This volume of *Environments* reports on the third phase of research.

Day, J. C., T. I. Gunton and P. W. Williams. 2003. The role of collaborative planning in environmental management: the North American experience. *Environments* 31(2): 1-4.

Abstract: [Document Summary]

The first article in the volume by [Thomas I. Gunton] and Day describes the emergence of collaborative planning as a logical evolution of advocacy and mediation planning models, which developed in response to demands for increased public participation. Gunton and Day review arguments for and against collaborative planning. Then they review recent evaluations of CP, which they conclude provide strong empirical documentation of the merits of collaborative planning relative to other planning models. Gunton and Day conclude by identifying ten keys to successful management of collaborative processes. These include:

Day, Gunton, and Frame present a comprehensive evaluation of the B.C. experience based on an extensive survey of participants. The results from the evaluation show that the CP process was successful in achieving consensus land use plans in almost all cases. Given the intensity of value-based conflict among stakeholders, the achievement of consensus land use plans for most of the provincial land base is a remarkable outcome that illustrates the benefits of collaborative planning relative to previous processes that were unsuccessful. The CP process also produced important

additional benefits including improved skills, knowledge, and stakeholder relations. Participant responses show that these additional benefits were the most successful component of the processes, confirming that the most valuable contribution of CP may be the generation of social and political capital, not the plan. Day, Gunton, and Frame conclude by identifying major lessons from the B.C. experience for collaborative planning.

The article by Yaffee and Wondolleck documents what they term a fundamental shift in planning paradigms in the United States from the expert, centralized model to the collaborative model. This shift, they argue, is due to four factors: decline in the legitimacy of experts and agencies, better and more accessible information, changes in the perceived complexity of planning problems, and stronger legal options available to challenge processes and outcomes. Yaffee and Wondolleck note that the new collaborative paradigm has been challenging to implement due to confusion over the role of stakeholders and agencies in decision making, the resistance of agency personnel to a change in their role, and the caution expressed by environmental groups which are concerned that getting involved in lengthy CP processes will tax their limited resources. Yaffee and Wondolleck conclude by outlining an agenda to strengthen collaborative planning by building institutional capacity, strengthening legal structures that provide incentives to collaborate and using adaptive management to learn from CP processes and make adjustments as required.

de Steiguer, J. E. 2003. Multi-criteria decision models for forestry and natural resources management: and annotated bibliography. Northeast Forest Experiment Station, USDA Forest Service, General Technical Report No 307.
URL: <http://www.treesearch.fs.fed.us/pubs/5437>

Abstract: Foresters and natural resource managers must balance conflicting objectives when developing land-management plans. Conflicts may encompass economic, environmental, social, cultural, technical, and aesthetic objectives. Selecting the best combination of management uses from numerous objectives is difficult and challenging. Multi-Criteria Decision Models (MCDM) provide a systematic means for comparing tradeoffs and selecting alternatives that best satisfy the decisionmaker's objectives. In recent years, the use of MCDM in forestry and natural resources management has generated a substantial body of literature. This annotated bibliography includes 124 important references ranging from theoretical studies to real-world applications of MCDM.

Di Stefano, J. 2001. Power analysis and sustainable forest management. *Forest Ecology and Management* 154: 141-153.

Abstract: This paper discusses power analysis in the context of sustainable forest management. It is suggested that a priori power analysis should be formally incorporated into the planning stage of all experiments designed to test whether forestry practices are sustainable. A priori power analysis enables researchers to estimate the probability of making a Type II error (i.e., finding no significant difference when one in fact exists). This information is critical in the statistical assessment of sustainable forestry, as unwittingly accepting a Type II error could result in poor management decisions. In addition, it is proposed that statistical assessments of sustainable forestry objectives can be more relevant if alpha is liberated from its traditional value of 0.05. It is argued that in the context of sustainable forestry, making a Type II error can be more costly than making a Type I error. Consequently, it often makes sense for beta to be small (say 0.05) and alpha to take on a larger value. In other situations the cost of making a Type I error may be more important, thus a procedure which enables researchers to determine a locally relevant alpha:beta ratio is recommended.

Failing, L., G. Horn and P. Higgins. 2004. Using expert judgment and stakeholder values to evaluate adaptive management options. *Ecology and Society* 9(1): 1-13.

URL: <http://www.ecologyandsociety.org/vol9/iss1/art13/main.html>

Abstract: This paper provides an example of a practical integration of probabilistic policy analysis and multi-stakeholder decision methods at a hydroelectric facility in British Columbia, Canada. A structured decision-making framework utilizing the probabilistic judgments of experts, a decision tree, and a Monte Carlo simulation provided insight to a decision to implement an experimental flow release program. The technical evaluation of the expected costs and benefits of the program were integrated into the multi-stakeholder decision process. The framework assessed the magnitude of the uncertainty, its potential to affect water management decisions, the predictive ability of the experiment, the value of the expected costs and benefits, and the preferences of stakeholders for alternative outcomes. As a result of the analysis, the initial experimental design was revised, and a multi-stakeholder group reached consensus on a program of experimental flow releases to test the response of salmonids to flow. The approach treats adaptive management as a policy alternative within a broader decision problem, and it demonstrates the utility of combining expert judgment processes and stakeholder values with adaptive management to improve the likelihood that proposed experimental approaches will deliver net value to society.

Farcy, C. and F. Devillez. 2005. New orientations of forest management planning from an historical perspective of the relations between man and nature. *Forest Policy and Economics* 7: 85-95.

Abstract: The increasing trend towards a less utilitarian approach to nature justifies the urgent need to define new principles of forest management planning, a discipline which is still based today on concepts linked primarily to wood production organisation. The following study involves an historical and comparative analysis of man's perception of nature and of laws which govern his relationship to land. Focussed on Wallonia, a densely-populated, forested area, its aim is to define the causes of present-day disquiet regarding forest management planning on the one hand, and to contribute to the emergence of new principles on the other. The study shows how biological, physical and socio-economic systems, which have been constrained to particular paradigms for a long time, have been the subject of specific approaches within the framework of distinct spatio-temporal models. As a turning point, the traditional discipline of forest management planning played an important and well-defined role within this framework. The progressive break with this position is described; it results in an acknowledgement of complexity and leads to new principles of forest management planning requiring work models incorporating a transverse component. This would allow the identification, structuring and hierarchical ordering of co-existing systems, their components, their levels of spatial organisation, their dynamics and their purpose in relation to the rights and responsibilities of the parties and major players involved. The analysis of respective characteristics of systems involved would then allow the proposal of models and tools with full knowledge of the facts and according to the level of complexity.

Frame, T. M. (2002) Shared decision making and sustainability: an evaluation of land and resource management planning in British Columbia. Masters of Resource Management, No. 296, Simon Fraser University.

URL:

<http://www.rem.sfu.ca/sustainableplanning/NewFiles/Tanis%20Frame%20Masters%20Thesis.pdf>

Abstract: A major challenge in achieving sustainability is resolving conflicts between competing

stakeholders over the use of natural resources. Recent literature on land use planning proposes the use of innovative shared decision-making (SDM) or collaborative planning models to resolve planning disputes. British Columbia (B.C.) is the only jurisdiction that has applied SDM approaches in a systematic way for land and resource use planning on Crown land. This program provides a unique opportunity to evaluate these new approaches.

The purpose of this research is to assess the effectiveness of the SDM approach used to develop the B.C. Land and Resource Management Plans (LRMPs). Based on a literature review of dispute resolution, collaborative planning, and shared decision making, a comprehensive evaluation methodology for assessing SDM processes is developed including 14 “process criteria” and 11 “outcome criteria”. The evaluation is based on a review of LRMP documents and a survey of participants in 17 completed LRMPs.

The LRMP process was successful in meeting both the process and outcome criteria. The research identifies key strengths, weaknesses, and ways of improving the LRMP process to better meet multiple resource use objectives in a manner that reflects the interests of all relevant stakeholders.

Almost all processes achieved consensus and significant changes in land use designations resulted, including a doubling of protected areas in the province. Participants feel the process was successful. Participants are very positive about the efficacy of involving the public in land and resource decisions, and the use of consensus-based processes. The process produced other benefits including improved relationships, increased understanding, and networks among diverse stakeholders. Significant learning took place, and information and knowledge shared. Participants also developed skills and an understanding of collaborative tools for future decision making.

This study reveals that there is no single factor that determines the success of a shared decision-making process. A checklist for successful SDM process design and management identifies a number of factors that are critical to creating successful processes and outcomes.

Gauthier, S. and L. De Grandpre. 2003. The ecological basis of ecosystem management in the eastern boreal forest of Quebec. Sustainable Forest Management Network, Project Report URL: http://sfm-1.biology.ualberta.ca/english/pubs/PDF/PR_200304gauthiersdeve6_en.pdf

Abstract: It has long been considered that secondary disturbances only play a marginal role in boreal forest dynamics, since fire was regarded as the principal disturbance of this ecosystem. However, the variability in fire regimes observed among boreal forest regions suggests that some regions are rather strongly influenced by secondary disturbances. In Quebec’s eastern boreal forest, where the fire cycle is relatively long, dynamics seems to be controlled more by secondary disturbances, such as insect outbreaks and windthrows, than by fire. Such a disturbance regime generates gaps of various sizes, small gaps of only a few square meters, resulting from single-tree mortality, as well as gaps of several hectares, ensuing from major windthrows or severe insect outbreaks. This results in a complex mosaic of structures in the forest landscape. The maintenance of such a spectrum of composition and structure in the landscape of Quebec’s eastern boreal forest is of prime importance for biodiversity conservation. For instance, the forest caribou could be particularly sensitive to the spatial structure of the forest landscape, since this species moves through immense territories. Therefore, in a sustainable forest management perspective, it has become essential to consider structural diversity in the development of silvicultural scenarios, which should reflect the pattern imposed by secondary disturbances on the landscape. The variability of the disturbance regime requires a diversification of silvicultural approaches.

*Gregory, R. S. 2002. Incorporating value trade-offs into community based environmental risk decisions. *Environmental Values* 11(4): 461-488.

Abstract: Although much attention has been given to the role of community stakeholders in developing environmental risk-management policies, most local and national initiatives are better known for their failings than their successes. One reason for this continuing difficulty, we contend, is a reluctance to address the many difficult value trade-offs that necessarily arise in the course of creating and evaluating alternative risk-management options. In this paper we discuss six reasons why such trade-offs are difficult and, for each, present helpful techniques from the decision sciences along with case study examples of successful applications.

*Gregory, R., J. Flynn, S. M. Johnson, T. A. Satterfield, P. Slovic and R. Wagner. 1997. Decision-pathway surveys: a tool for resource managers. *Land Economics* 73(2): 240-254.

Abstract: This paper introduces an experimental "decision pathways" survey technique that builds on insights from behavioural decision theory. The approach presents respondents with a set of linked questions that encourage the deliberate construction of expressed values in the course of selecting a preferred resource-management alternative. By selecting one pathway and avoiding others, important information is revealed about respondents' key trade-offs and about their reasoning process. A general discussion of the approach is followed by the results of a 1994 survey in Ontario, Canada, of public support for a range of forest vegetation management alternatives.

Grumbine, R. E. 1994. What is ecosystem management? *Conservation Biology* 8(1): 27-38.

Abstract: The evolving concept of ecosystem management is the focus of much current debate to clarify discussion and provide a framework for implementation, I trace the historical development of ecosystem management, provide a working definition, and summarize dominant themes taken from an extensive literature review. The general goal of maintaining ecological integrity is discussed along with five specific goals: maintaining viable populations, ecosystem representation, maintaining ecological process (i.e., natural disturbance regimes), protecting evolutionary potential of species and ecosystems, and accommodating human use in light of the above. Short-term policy implications of ecosystem management for several groups of key actors (scientists, policymakers, managers, citizens) are discussed. Long-term (>100 years) policy implications are also reviewed including reframing environmental values, fostering cooperation, and evaluating success. Ecosystem management is not just about science nor is it simply an extension of traditional resource management; it offers a fundamental reframing of how humans may work with nature.

Grzybowski, A. G. S. and D. S. Slocombe. 1988. Self-organization theories and environmental management: the case of South Moresby, Canada. *Environmental Management* 12(4): 463-478.

Abstract: This article presents a new approach to the analysis and management of large-scale societal problems with complex ecological, economic, and social dimensions. The approach is based on the theory of self-organizing systems - complex, open, far-from-equilibrium systems with nonlinear dynamics. A brief overview and comparison of different self-organization theories (synergetics, self-organization theory, hypercycles, and autopoiesis) is presented in order to isolate the key characteristics of such systems.

The approach is used to develop an analysis of the land use controversy in the South Moresby area of the Queen Charlotte Islands, British Columbia, Canada. Critical variables are identified for each subsystem and classified by spatial and temporal scale, and discussed in terms of information content and internal/external origin. Eradication of sea otters, introduction of black-tailed deer, impacts of large-scale clearcut logging, sustainability of the coastal forest industry, and changing relations between native peoples and governments are discussed in detail to illustrate the system dynamics of the South Moresby "sociobiophysical" system. Finally, implications of the self-organizing sociobiophysical system view for regional analysis and management are identified.

Gunton, T. I., P. W. Williams and R. Edwards-Craig. 2003. Backcountry tourism perspectives on shared decision making in B.C. land use planning. *Environments* 31(3): 31-50.

Abstract: [Document Summary]

SDM approaches to LRMP planning emphasized "the importance of equal access to information and equal opportunity for input and scrutiny of issues and concerns by all participants, thereby creating a constructive environment for problem solving" (Duffy et al. 1996). Facilitated participation, consensus building, collaboration, interest-based negotiation, and mediation are SDM principles that are designed to generate more inclusive, representative, and respectful resolutions to disputes (Cormick et al. 1996, Susskind and Cruikshank 1987, Darling 1991, NRTEE 1993). While not suited to all situations, SDM is appropriate in circumstances where conventional approaches to conflict resolution have failed and alternative techniques are needed (Bacow and Wheeler 1984, Gunton and Flynn 1992). Such situations are often associated with land use disputes involving multi-stakeholder interests and conflicts over natural resource allocations. Such disputes were particularly prevalent in B.C. throughout the 1990s, and SDM mechanisms were employed to address these conflicts in the context of the province's CORE and LRMP initiatives. SDM mechanisms were believed to be suited to creating process and planning outcomes that were more creative and reflective of public interests. They were also thought to be capable of increasing the planning capacities of the participants (Frame 2002). (A more detailed summary of the principles and guidelines associated with SDM processes as well as the potential outcomes they may produce is provided in Tables 1 and 2.) The extent to which these are implemented in SDM processes, and subsequently provide benefit, offer a useful basis for assessing the efficacy of such procedures in land use planning situations.

A tangible measure of the ability of SDM processes to incorporate tourism values is reflected in the amount of LRMP land designated to tourism use. LRMP lands most inclusive of tourism values are designated as special management zones (SMZ) and protected area zones (PAZ). Table 3 highlights the percentage changes in PAZ and SMZ land use areas designated for potential tourism use as a result of individual LRMP decisions. The figures show that PAZ doubled from 5.6 percent to 12.5 percent of the province and new SMZ were created covering 16.4 percent of the land base. The figures also reveal that while there are substantial variations in the amount of land allocated for tourism use within the LRMP regions, each planning process resulted in a significant increase in areas available for tourism use. This suggests that SDM processes were effective in integrating the perspectives of tourism stakeholders into the LRMP processes.

Gunton, T. I., P. W. Williams and D. Finnigan. 2003. Planning in the public interest: an evaluation of civil society participation in collaborative land use planning in British Columbia. *Environments* 31(3): 13-29.

Abstract: [Document Summary]

Collaborative planning is defined as a "collective process for resolving conflicts and advancing shared visions involving a set of diverse stakeholders" (Carr et al. 1998: 768). In collaborative planning, stakeholders become involved in tackling contentious natural resource issues together. By identifying and developing common goals, stakeholders can create practical solutions through consensus (Wondolleck 1988; Yaffee and Wondolleck 1995; Wondolleck et al. 1996; Wondolleck 1998a, 1998b; Wondolleck and Ryan 1999; Wondolleck and Yaffee 2000). Such collaborative processes usually result in solutions that better reflect the public interest by seeking a consensus-based solution that meets the goals of all stakeholders. Plans developed by CP are more likely to be successfully implemented because stakeholders, who can otherwise impede implementation, are more likely to support implementation because they were involved in the process to develop the plan. CP can also generate additional benefits such as improved stakeholder relationships, stakeholder skills, and knowledge. These benefits, which are sometimes referred to as "social capital" increase community capacity to solve other problems. While some planning theorists espouse the benefits of collaboration, others caution against promoting the approach as a panacea (Amy 1987; Gray 1989; Gunton and Flynn 1992; Caton Campbell and Floyd 1996). Gunton, and Day (2003), for example, list potential challenges to CP including logistical issues such as time and cost of managing diverse stakeholder groups, difficulties in reaching consensus for the large proportion of issues involving value differences, second best solutions based on vague compromises, and inequalities in power between stakeholder groups that impede effective representation. Moreover, achieving the benefits of CP has been seen as contingent upon effective representation of all stakeholder interests in the planning process. Disagreement on the benefits and challenges inherent in collaborative planning highlights the need to study these types of processes comprehensively and systematically.

What are the implications of the findings from this study for the arguments for and against civil society stakeholder participation in collaborative planning? First, the findings confirm that CP provides important opportunities for civil society to affect resource and environmental decisions. Civil society stakeholders agreed that they were able to affect the outcomes and the design of the planning process and a majority agreed that the process was a success and achieved the public interest. Second, the findings confirm that there are significant social capital benefits to the participation of civil society stakeholders in CP - including improved knowledge, skills, and relationships with other stakeholders - that ultimately enhance the role of civil society stakeholders in other facets of resource and environmental management beyond the specific preparation of an LRMP. Third, these stakeholders were able to overcome the "two table" problem of participating in a multi-stakeholder land use table and their own constituency table. There was strong agreement from them that they were able to obtain direction and were accountable to their own organizations. Fourth, the findings confirm that these stakeholders face a greater handicap in resources to participate in CP than other stakeholders. Interestingly, inferior resources do not seem to reduce civil society effectiveness in cooperative planning. Civil society stakeholders felt that they had more influence than other stakeholders on the design of the planning process and just as much influence on the outcomes. Further, they were also as satisfied as other stakeholders with the outcomes of the process. This conclusion of the benefits to civil society participating in collaborative planning is further shown by stronger support from these stakeholders than from other stakeholders for CP processes and their overwhelming agreement that they would participate in a similar process again.

Haeuber, R. 1998. Ecosystem management and environmental policy in the United States: open window or closed door? *Landscape and Urban Planning* 40: 221-233.

Abstract: Ecosystem management is a recent policy alternative proposed to address a new generation of environmental issues. At least 18 federal agencies are currently exploring the

concept of ecosystem management and its implications for their activities. Each of the major regulatory, land and natural resource management agencies has drafted policy guidance regarding ecosystem management. And federal sector efforts are just one layer of a wider nationwide phenomenon: similar activities are occurring at state and local government levels, as well as within the nongovernmental sector. This paper addresses two questions: What is ecosystem management? Will ecosystem management endure as a land and resource management policy?

Hartig, J. H., M. A. Zarull, T. M. Heidtke and H. Shah. 1998. Implementing Ecosystem-Based Management: lessons from the Great Lakes. *Journal of Environmental Planning and Management* 41(1): 45-75.

Abstract: Under the US-Canada Great Lakes Water Quality Agreement, a Remedial Action Plan (RAP) Program was formalized to identify and implement actions needed to restore beneficial uses in the most polluted areas of the Great Lakes (i.e. Areas of Concern). It was further required that individual RAPs embody a systematic and comprehensive ecosystem approach (ie an approach which accounts for interrelationships among land, air, water and all living things, including humans, and involves user groups in comprehensive management). Careful review and analysis of the RAP Program offers an opportunity to gain a better understanding of ecosystem-based management for other watersheds, and to identify important principles and elements which contribute to effective implementation. Principles which are considered essential for effective implementation of ecosystem-based management include: 1) broad-based stakeholder involvement; 2) commitment of to leaders; 3) agreement on information needs and interpretation; 4) action planning within a strategic framework; 5) human resource development; 6) results and indicators to measure progress; 7) systematic review and feedback; and 8) stakeholder satisfaction. The Great Lakes RAP experience with ecosystem-based management also demonstrates the need for a transition from a traditional, command-and-control, regulatory approach of governmental agencies toward a more cooperative, value-added, support-based role. Review of RAPs in all 42 Areas of Concern provides compelling evidence that successful application of ecosystem-based management is dependent on broad-based stakeholder involvement in decision making, along with strong partnerships which encourage collaboration, cooperation and adaptability in management actions.

Haynes, R. W., T. M. Quigley, J. L. Clifford and R. A. Gravenmier. 2001. Science and ecosystem management in the interior Columbia basin. *Forest Ecology and Management* 153: 3-14. URL: <http://www.fs.fed.us/pnw/pubs/journals/haynes-eco-management.pdf>

Abstract: Significant changes over the past 150 years in aquatic, terrestrial, landscape, and socioeconomic systems have altered biophysical systems in the interior Columbia basin. Changes and conflict in public policy concerns, such as resource use vs. restoration vs. conservation are especially evident in more than 34% of total forest and rangeland in the United States that are federally administered. In the last decade, design and implementation of complex land management strategies has become an issue for public land managers. In turn, the scientific community is often challenged to develop approaches for management of complete ecosystems. This paper discusses the use of science in the assessment and evaluation phases of one large-scale (multi-region) ecosystem management effort on federal lands in the Columbia river basin, the Interior Columbia Basin Ecosystem Management Project (ICBEMP), and briefly describes the evaluations of three alternative management strategies which are detailed by other papers in this issue. This paper contends that understanding the context of land management decisions is essential to defining the veracity or applicability of alternative land management strategies. Evaluating the alternatives is a complicated science process, which requires understanding the effects of each set of direction over both the short and long term, projecting the effects of those

directions, making assumptions about pieces not yet developed, and modeling resource change.

Holmgren, P. and T. Thuresson. 1997. Applying objectively estimated and spatially continuous forest parameters in tactical planning to obtain dynamic treatment units. *Forest Science* 43(3): 317-336.

Abstract: Forestry planning is usually approached as the problem of combining and scheduling stand treatments. Stands are assumed to be homogeneous and spatially static and are usually delineated and described by subjective surveying methods. Because, in reality, stands vary internally, only subsets of the possible management alternatives will be considered in stand-based planning. As price expectations and other planning parameters change over time, it is likely that optimal locations, extensions, and schedules for forest operations change. This paper proposes a method whereby timber volumes and treatment priorities are estimated on objectively inventoried geo-referenced circular plots. Kriging interpolation and image analysis of scanned aerial photographs are then used to predict the variables in a spatially near-continuous raster. Treatment units are dynamically formed, based on price-expectations, and objectives defined by the forest owner. Given strategic goals, tactical plans are produced for two wood price situations, and compared with a plan based on conventional stands. The results imply that forest management planning should, perhaps, not be based on static stands if economic efficiency and planning flexibility are desirable.

Holt, R. 2001. An ecosystem-based management planning framework for the North Coast LRMP. B.C. Ministry of Forests, Victoria, B.C. Background Report 20 pp.
URL: <http://www.citbc.org/b-EcoManFra-Holt-Mar01.pdf>

Abstract: [Executive Summary]

Ecosystem-based management plans consistently have the strategic goal of maintaining or restoring ecological integrity within the planning area. Broad principles have been defined by a wide range of authors that are predicted to increase the probability of meeting this general goal. In addition, many authors generally agree on key steps that should be included in an ecosystem-based management planning framework.

However, there remain discrepancies as to how the broad goals and principles of ecosystem management should be operationalised. This variation in how ecosystem management has been applied to existing land bases has raised skepticism and concern from many of the original proponents of ecosystem-based management. This variation is due, at least in part, to a use of ecological terms without a full appreciation of the scope of their ramifications, and without expressly stating assumptions and risks associated with decision-making. The key to successful ecosystem management may be to ensure that goals are fully agreed to and understood by all parties and that assumptions regarding risks to the environment and to social and economic values are made explicit throughout the planning process.

The aim of this report is to provide clarity around some key concepts of ecosystem-based management, and to highlight some others that are more controversial. The report summarises goals, broad principles and key steps of an ecosystem-based planning framework, as suggested by the literature. In particular, the report uses a potential planning framework to highlight the key decisions needed to successfully operationalise the plan. Key ecological components of an ecosystem-based plan are also summarised. Implicit in the report is that in order to be successful, the LRMP should explicitly state planning approaches, management goals and assumptions, and set targets at regional, landscape and stand levels in order to allow both implementation and effectiveness monitoring of the plan. This approach coupled with adaptive management should

provide a robust and flexible approach to land use planning.

*Hunt, L. and W. Haider. 2001. Fair and effective decision making in forest management planning. *Society and Natural Resources* 14: 873-887.

Abstract: Creating a fair and effective decision-making process in forest management planning is more than a lofty public policy goal; it is increasingly becoming a legal requirement. An integral component of a fair and effective decision-making process is an effective public involvement process. By increasing public involvement, both the process and outcomes from the process should be perceived as fairer and, consequently, more effective. This study examines the utility of applying the social psychology paradigm of procedural fairness to decision-making processes in forest management planning. Specifically, we examine whether the involvement level that resource-based tourism operators have with Ontario's forest management planning process influences their evaluations of the process and outcomes from the process. The study also contributes toward identifying effective and measurable indicators to assess fair and effective decision making in forest management planning, which could serve in a criteria and indicator framework of forest sustainability.

Innes, J. L., G. M. Hickey and B. Bilson (eds.). 2000. International perspectives on streamlining local-level information for sustainable forest management. Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C. Information Report No BC-X-400. 109 pp.
URL: <http://dsp-psd.pwgsc.gc.ca/Collection/Fo143-2-400E.pdf>

Abstract: The world's forests have an impact on atmospheric conditions, species extinction, soil condition, water quality, landscape diversity, aboriginal communities and the economic well-being of nations. It is commonly acknowledged that these are just some of the problems associated with sustainable development that need to be addressed by the international community. The rates of change in indicators designed to monitor human progress toward sustainable forest management will be directly affected by human population characteristics, socio-economic demands and the value systems associated with forest resources in a particular country. Although historically the term "forestry" was primarily concerned with timber production, today it involves the management of multiple values, from recreational opportunities to the preservation of wildlife habitats.

This report aims to facilitate the exchange of information on sustainable forest management. The report presents stakeholder perspectives from a range of geographic locations on sustainable forest management information issues at the local, national and international level. Many of these manuscripts were submitted to the conference "Streamlining Local-level Information for Sustainable Forest Management" held by the Faculty of Forestry at the University of British Columbia in August, 2000. This report is not intended to be conference proceedings; hence not all submitted manuscripts have been included. It presents a selection of papers that describe information issues associated with sustainable forest management in a range of jurisdictions.

Jacobson, M. and A. Long. 1999. Ecosystem management (EM) as a basis for forest stewardship on private lands. University of Florida, Cooperative Extension Services, Institute of Food and Agricultural Sciences, FOR No 60. 4 pp.
URL: <http://www.sfrc.ufl.edu/Extension/fweco.htm>

Abstract: Concepts of forest management have steadily evolved through the 1900s. Over the last decade or more, the most significant shift in thinking and planning has been toward an "ecosystem-based" management approach. Most public land management agencies have adopted

some form of ecosystem management (EM). Private forest industries, through their Sustainable Forestry Initiative (SFI), incorporated aspects of EM into their practices. In fact, today it is common to consider many forestry situations in the context of EM. Given all this activity in EM by public and industrial forest owners, how can non-industrial private landowners apply EM on their forest land? To answer this question the paper first explains what EM means, and then provides examples of forest landowners incorporating aspects of EM on their lands.

Jeakins, P., N. Robinson, C. Pearce and P. Field (eds.). 2004. A framework for sustainable forest management. 65 pp.

URL: <http://www.sfmportal.com/>

Abstract: [Executive Summary]

Throughout the world, forestry has been moving steadily toward a multi-value approach to sustainable development and management – an approach that promises to revolutionize the way we think about, plan and implement forest management. Since the mid-1980s, when the terms sustainable development and management were first coined, there has been growing global recognition of the need to improve how we develop and manage the world's natural resources. In response, forest management practices throughout the world have shifted toward adopting approaches aimed at balancing economic, ecological and social interests.

In British Columbia, changing forest management legislation and policies, along with increased public and marketplace expectations of both industry and government, have called for the development of a stable, robust planning system.

Since 1998, Slocan Forest Products has designed and tested a Sustainable Forest Management Framework to support efficient and effective implementation of this new forestry paradigm in its forestry operations. The development of the Framework was a collaborative endeavour that brought together knowledge gained from various pilot projects, other forest licensees, a multidisciplinary team of academic experts and scientific researchers from the University of British Columbia and other institutions, as well as stakeholders.

The SFM Framework is made up of three major parts: this introductory document, which describes the broad rationales and assumptions for the Sustainable Forest Management Framework; the Scientific Foundation comprising of the background research, reports and papers on which the rationales are based; and the SFM plan, which describes implementation of the Framework at the local level.

The overall goal of the SFM initiative has been the creation of a scientifically defensible, data-driven, locally derived, hierarchical approach to SFM that is operationally feasible. The resulting SFM Framework is an alternative conceptual model to traditional forest management; one that facilitates the planning, implementation and measurement of forest management activities intended to sustain a range of forest values over time. The notions of “balance” and “concurrency” are pivotal to the SFM approach. Sustainability is achieved by forest management planning and practices that seek to concurrently balance the three categories of forest values within a defined management unit.

Six “first principles” have guided the development of the SFM Framework, serving as the conceptual pillars on which the Framework is built. These cardinal principles are continual improvement through adaptive management; a rigorous scientific basis; linkage between strategic issues and operational realities; public involvement; respect for First Nations rights; and a corporate framework that facilitates flexible local implementation.

Each of these first principles is rationale-driven. For example, adaptive management is a core element of this approach. The need to recognize knowledge gaps, and opportunities to examine and address these gaps, exists at each level of the Framework and underscores the significant commitment to information management, monitoring and reporting required.

Under the SFM Framework, adaptive management involves a clearly defined cycle comprising of problem assessment and design, implementation, monitoring and evaluation and adjustment. Given the complex natural environment, shifting policy, changing public values, and growing knowledge base related to forest management, continual improvement through adaptive management is a requirement of any successful SFM approach in B.C.

Similarly, a rigorous scientific approach was utilized in order to achieve credible, fully defensible forest management objectives and practices. The scientific foundation of the SFM Framework represents the best available expertise and encompasses a wide range of activities including literature reviews, criteria and indicators, led scenario design, pilot testing of quantitative decision support tools, a solid grounding in data through spatially based analysis and forecasting of current and future conditions.

Built on the foundation of multi-value sustainability, the Framework uses criteria and indicators as the guideposts for balanced, transparent forest management decisions. Specific target outcomes are defined for each forest value, wherever feasible, to help monitor the movement towards and achievement of sustainability. With clearly defined spatial and temporal management criteria and indicators, the Framework allows resource managers to focus on achieving measurable and effective results for identified values. Thresholds are used to specify acceptable upper or lower limits for indicators, providing an early warning system that alerts managers to the needs for immediate action.

The Framework is based on a hierarchical planning structure to identify balanced and achievable objectives and practices at a variety of spatial and temporal scales. The hierarchical levels of strategic, tactical and operational planning are interactive and, starting at the strategic level, the information and tasks at each level result in the definition of progressively more specific management outcomes. The three levels are linked to existing government land use planning objectives to facilitate efficient implementation.

In addition, a suite of decision support tools is available to assist forest managers in implementing the Framework, affording operational staff the flexibility to identify the appropriate decision support tools at each planning level for each management unit. These tools include comprehensive stakeholder analysis, techniques for identifying and mapping indicators, forecasting changes in indicator conditions over time, multi-criteria and trade-off analysis, scenario design approaches and natural disturbance strategies.

Development of the SFM Framework would have been impossible without extensive networking. Partnerships involving multi-disciplinary expertise (including licensees, academics, resource specialists, government agency staff and other related organizations) make the SFM Framework a viable alternative to current forest management planning in the Interior of British Columbia and these partnerships will remain essential to its success.

Implementation of the SFM Framework offers several immediate and future benefits and linkages when it comes to addressing a wide range of forest management-related issues. These include effective strategic land use planning (Higher Level Plans, Land and Resource Management Plans,

Regional land use Plans); implementation of the Forest and Range Practices Act and Defined Forest Area Management policy; meeting professional due diligence requirements; and providing a mechanism for interaction with other resource industries.

Implementation and further development of this Framework is currently underway through forest products certification processes in selected management units, in partnership with other licensees and BCTS. There is also ongoing application of the Framework to provide rationales for variances to existing land use objectives. A scientific and operational peer review is planned for later this year (2004), while applied research continues to refine key components of the Framework.

The SFM Framework will help promote innovation, secure marketplace recognition for B.C.'s forest industry and reduce information management costs. It can serve as an objective mechanism in the AAC determination and timber supply review process, help devise strategies to address natural disturbance events such as the mountain pine beetle epidemic and foster collaboration and positive relations with ENGOs.

Jeffreys, I. MO-DSS Tools for multiple objective planning to manage catchments and natural resources. Brisbane, Department of Natural Resources and Mines, Natural Resource Sciences.

URL: <http://www.coastal.crc.org.au/modss/papers.html>

Jonsson, B., J. Jacobsson and H. Kallur. 1993. The forest management planning package. Theory and application. *Studia Forestalia Suecica* 189: 1-56.

Abstract: The Forest Management Planning Package is an existing forest management planning system based on two inventory phases, and is used in practical forestry in Sweden. It integrates economic theory, objective inventory measurements and accurate growth forecasts. The core of the system is a chain of models representing the production possibilities of a forest holding. Detailed growth forecasts and economic calculations with high resolution (individual trees) permit analysis of various silvicultural treatment options in all types of Swedish stands. A non-linear objective function and mathematical optimization result in a compromise between maximum net present value and sustained net-revenue profile. Application of the system contributes to a much improved economic result through the removal of uncertainties concerning the real production possibilities.

Joseph, C. T. R. B. (2004) Evaluation of the B.C. strategic land-use plan implementation framework. Masters of Resource Management, Report No. 355, Simon Fraser University.
URL: <http://www.rem.sfu.ca/pdf/joseph.pdf>

Abstract: Land-use plan implementation is a complex process influenced by a multitude of factors. In all, eighteen factors are identified as key to implementation. Key factors include strong stakeholder support, sound land-use plans, and a supportive institutional structure that draws heavily on a collaborative design. However, focusing solely on any single factor or group of factors will undermine the implementation process. Robust and effective systems require careful attention of all factors. Government support lays the foundation for many of these factors. If government demonstrates a commitment to implementation—particularly through collaboration—then other stakeholders get on board, and successful implementation is likely.

The strengths of the B.C. strategic land-use plan implementation framework include the collaborative planning process that developed the plans, plan clarity, flexibility, innovative

leadership, stakeholder involvement, and adequately understood problems. The only major weakness of the framework is the prevalence of unfavorable stakeholder characteristics. However, there are numerous deficiencies in B.C. plan implementation systems. While strategic land-use planning has succeeded in implementing the Protected Areas Strategy and a number of other plan recommendations, much remains to be achieved to reach social, economic, and environmental sustainability. Strategic land-use planning can be an effective tool for achieving sustainability, but to do so, it must be better supported by government and meet all eighteen factors for effective implementation.

*Kangas, A. S. and J. Kangas. 2004. Probability, possibility and evidence: approaches to consider risk and uncertainty in forestry decision analysis. *Forest Policy and Economics* 6: 169-188.

Abstract: Uncertainty is an important issue in the support of any forestry decision. Forestry decision making today typically involves objectives and information concerning ecological, economic and social issues. The consequences of alternative forest management programmes might be hard to assess, and predictions and assessments always include uncertainty. Forestry decisions also often concern large areas, long time horizons and multiple stakeholders, which further complicates forest management planning and increases uncertainty involved in it. This paper deals with different definitions and classifications of uncertainty, sources of uncertainty, and theories and methodologies presented to deal with uncertainty. The aim is to provide readers with an overview of alternative approach for coping with uncertainty, especially from the viewpoint of forestry and natural resource management applications. Generally taken, there are two main conventional approaches, namely classical (frequentist) and Bayesian probability theory. These lead to either classical or Bayesian decision theory, respectively. In addition, uncertainty can be dealt with, for instance, using the fuzzy set theory. This theory mostly deals with uncertainty due to the ambiguity of concepts. So far, in decision support tools, probability and fuzzy set theory are the most common approaches. However, the possibility theory and the evidence theory, for instance, can also be relied upon when managing uncertainty. These theories deal with subjective beliefs and expert judgments. They are able to deal with partial information and pure ignorance. The counterparts to the classical decision rules based on these theories are presented, as well as some decision support methods designed using the approaches presented. Because of the manifold sources of uncertainty, all these approaches have application in the support of forestry decisions.

*Kangas, A., J. Kangas and J. Pykalainen. 2001. Outranking methods as tools in strategic natural resources planning. *Silva Fennica* 35(2): 215-227.

Abstract: Two outranking methods, ELECTRE III and PROMETHEE II, commonly used as decision-aid in various environmental problems, and their applications to decision support for natural resources management are presented. These methods represent 'the European school' of multi-criteria decision making (MCDM), as opposed to 'the American school', represented by, for instance, the AHP method. On the basis of a case study, outranking methods are compared to so far more usually applied techniques based on the ideas of multi attribute utility theory (MAUT). The outranking methods have been recommended for situations where there is a finite number of discrete alternatives to be chosen among. The number of decision criteria and decision makers may be large. An important advantage of outranking methods, when compared to decision support techniques most often applied in today's natural resources management, is the ability to deal with ordinal and more or less descriptive information on the alternative plans to be evaluated. Furthermore, the uncertainty concerning the values of the criterion variables can be taken into account using fuzzy relations, determined by indifference and preference thresholds.

The difficult interpretation of the results, on the other hand, is the main drawback of the outranking methods.

*Kangas, J. and A. Kangas. 2005. Multiple criteria decision support in forest management—the approach, methods applied, and experiences gained. *Forest Ecology and Management* 207(1-2): 133-143.

Abstract: We discuss the benefits of using multiple criteria decision support (MCDS) methods in forest management, briefly present some MCDS methods recently applied in forestry, and summarize experiences gained from MCDS applications in forestry. Applications of MCDS methods of varying characteristics can be found in the management planning of multiple-purpose forestry. However, the tool to be used should be chosen to fit the planning process at hand. When choosing a method, compromises must often be made. For instance, simple and easily understandable methods may mean loss of attainable information and, correspondingly, deficient analyses. More versatile methods enable deeper analyses and more complete exploitation of available data, but typically they are hard to use and understand. Simple and straightforward MCDS methods are needed in participatory approaches and in planning via information networks. Some recent studies indicate that, especially for behavioural reasons, it would be useful to use more than just one MCDS method, or hybrid approaches, in many planning situations. A further conclusion has been that interactive use of the methods greatly improves the efficiency of the planning process.

Kangas, J., J. Hokkanen, A. S. Kangas, R. Lahdelma and P. Salminen. 2003. Applying stochastic multicriteria acceptability analysis to forest ecosystem management with both cardinal and ordinal criteria. *Forest Science* 49(6): 928-936.

Abstract: Multi-criteria decision analysis is applied to ecosystem management planning in a forest landscape. Ten alternative action plans were evaluated employing five criteria. For some criteria, cardinal measures with their associated uncertainties were obtained. For other criteria, only ordinal (ranking) information was available. The Stochastic Multi-criteria Acceptability Analysis with Ordinal criteria (SMAA-O) method was used, as it accommodates both cardinal and ordinal data. This is the first application of SMAA methods to forest management. SMAA-O represents inaccurate or uncertain cardinal criteria measurements by a joint probability distribution. Ordinal data is converted into stochastic cardinal data by simulating mappings between ordinal and cardinal scales that preserve the given rankings. At the same time, the unknown or partly known preferences of the decision maker are simulated by choosing weights randomly from appropriate distributions. The main results of the analysis are "acceptability indices" that describe the variety of different weights that support an alternative for a given rank. The special characteristics of SMAA-O are best utilized in problems involving uncertainty and where both cardinal and ordinal data are to be employed. It also serves well as an analysis tool in interactive planning processes, especially when criteria weights are not known or they are difficult to assess.

Kangas, A., J. Kangas and J. Pykalainen. 2001. Outranking methods as tools in strategic natural resources planning. *Silva Fennica* 35(2): 215-227.

Abstract: Two outranking methods, ELECTRE III and PROMETHEE II, commonly used as decision-aid in various environmental problems, and their applications to decision support for natural resources management are presented. These methods represent 'the European school' of multi-criteria decision making (MCDM), as opposed to 'the American school', represented by, for instance, the AHP method. On the basis of a case study, outranking methods are compared to

so far more usually applied techniques based on the ideas of multi attribute utility theory (MAUT). The outranking methods have been recommended for situations where there is a finite number of discrete alternatives to be chosen among. The number of decision criteria and decision makers may be large. An important advantage of outranking methods, when compared to decision support techniques most often applied in today's natural resources management, is the ability to deal with ordinal and more or less descriptive information on the alternative plans to be evaluated. Furthermore, the uncertainty concerning the values of the criterion variables can be taken into account using fuzzy relations, determined by indifference and preference thresholds. The difficult interpretation of the results, on the other hand, is the main drawback of the outranking methods.

*Kant, S. 2003. Extending the boundaries of forest economics. *Forest Policy and Economics* 5: 39-56.

Abstract: The existing forest economic models, rooted in sustained yield timber management systems and neo-classical economic framework, are subject to many limitations. Social, economic, and ecological features of sustainable forest management (SFM) are different than that of sustained yield timber management. Hence, the economics of SFM will be based on different economic principles. The two main requirements of the economics of SFM are the economics of multiple equilibria, and a consumer choice theory that incorporates heterogeneity of agents, context specific and dynamics of preferences, distinction between needs and wants, and the subordination of needs. These requirements will need the extension of the boundaries of forest economics. Five basic principles—principles of 'both-and', 'existence', 'relativity', 'uncertainty', and 'complementarity' will work as a foundation, and the economic principles, developed by evolutionary, institutional, ecological economists and economists from other new streams of economics, will be the useful tools to extend these boundaries.

Kant, S. and S. Lee. 2004. A social choice approach to sustainable forest management: an analysis of multiple forest values in Northwestern Ontario. *Forest Policy and Economics* 6: 215-227.

Abstract: The management of forests has dramatically changed in the past few decades. Forest managers no longer can prepare and implement forest management plans in isolation of other resource values and local citizens. Today, the economic, ecological and social values are blended together into sustainable forest management. Finding a balance among these values in Newfoundland and Labrador is done through local district planning teams. The team participants need to understand the principles of sustainable forest management and the overall planning process. A primary focus of the Western Newfoundland Model Forest has been to support planning teams through the development of management tools to enhance management of the Province's forest ecosystems. The Model forest program will continue to test, document and transfer new and innovative management options to forest managers.

Kay, J. and E. D. Schneider. 1994. Embracing complexity, the challenge of the ecosystem approach. *Alternatives* 20(3): 32-38.

URL: <http://www.iaia-wnc.ca/pdf/Kayetalpaper.pdf>

Abstract: [First Paragraph]

As environmental degradation and change continues, decision makers and managers feel significant pressure to rectify the situation. Scientists, in turn, find themselves under pressure to set out simple and clear rules for proper ecosystem management. The response has been one of frustration. Michael Soule and Laurence Slobdokin both loudly complain that ecology is an

intractable science, immature and not very helpful. Kristin Shrader-Frechette and Robert Peters reproach ecologists for not producing simple testable hypotheses. Meanwhile policy makers and managers clamour for a measure of ecosystem integrity whose value in different situations can be predicted by simulation models. The question on everyone's mind is "what does ecosystem science identify as the main, simple, basic, universal laws which will allow quantitative prediction of ecosystem behaviour and what are the resulting rules for ecosystem management?"

Kijazi, M. H. and S. Kant. 2003. Conformance of Ontario's forest management planning with criteria and indicators of sustainable forest management. *The Forestry Chronicle* 79(3): 652-658.

Abstract: Prescriptions of the Forest Management Planning Manual (FMPM) for Ontario's Crown forests are examined for conformance with the elements of the Canadian Council of Forest Ministers (CCFM) Criteria and Indicators (C&I) of sustainable forest management (SFM). The examination identifies gaps and highlights forest management planning aspects that require gap-bridging interventions at the forest management unit (FMU) level. The three levels (parts) of the FMPM—Management Planning, Annual Operations, and Reporting & Monitoring—are examined. Gaps are categorized in three groups—major, intermediate, and minor gaps. Major gaps are recorded for five out of 22 elements of the CCFM C&I framework, and these gaps indicate inadequate prescriptions for the corresponding elements at all the three levels. Minor gaps are also recorded for five elements, and these gaps indicate inadequate prescriptions at the monitoring level. Intermediate gaps are recorded for 11 elements, and depending on the specific element and indicator, inadequacy of prescriptions may only be for operations, reporting and monitoring, or may also include the planning level. The main findings of the gap analysis are that none of the six criteria of SFM has been fully incorporated in the FMPM; Part C (Reporting and Monitoring) has the highest degree and Part A (Plan Contents) has the lowest degree of non-conformity with respect to CCFM C&I framework; at the criterion-level the Global Ecological Cycles has major gaps while three criteria—Soil and Water Conservation, Multiple Benefits, and Society' Responsibility—have intermediate gaps; and the changes in the FMPM have been incremental while the shift in the concept of forest management from Sustained Yield Timber Management to SFM was a drastic change.

Konisky, D. M. and T. C. Beierle. 2001. Innovations in public participation and environmental decision making: examples from the Great Lakes Region. *Society and Natural Resources* 14: 815-826.

Abstract: Public participation has become a standard component of environmental decision making processes. Frequently used methods of public involvement, such as public comments and hearings, however, are too often reactive in nature, involve insufficient deliberation, and engage only a small number of participants. This article describes a set of "innovative" participatory processes - study circles, citizens juries, round tables, and collaborative watershed management efforts - and considers their relative strengths and weaknesses through the use of a common comparative framework. The analysis shows that these innovative processes offer some different and potentially valuable advantages relative to the public involvement methods commonly used today. While the processes standing alone are not likely to replace traditional methods, preliminary analysis suggests that they may be effective if applied strategically, and in combination with other innovative or traditional processes.

L.P. Atherton & Associates. 1999. Incremental silviculture strategy for British Columbia: concepts of strategy and planning, proposed planning framework (draft 3). B.C. Ministry of Forests, Forest Practices Branch, Victoria, B.C. Working Paper No No. 2. 29 pp.

URL: <http://www.for.gov.bc.ca/hfp/PUBS/silvstrategy/Doc2.pdf>

*Lahdelma, R., P. Salminen, and J. Hokkanen. 2000. Using multicriteria methods in environmental planning and management. *Environmental Management* 26(6): 595-605.

Abstract: In environmental planning and decision processes several alternatives are analyzed in terms of multiple non-commensurate criteria, and many different stakeholders with conflicting preferences are involved. Based on our experience in real-life applications, we discuss how multicriteria decision aid (MCDA) methods can be used successfully in such processes. MCDA methods support these processes by providing a framework for collecting, storing, and processing all relevant information, thus making the decision process traceable and transparent. It is therefore possible to understand and explain why, under several conflicting preferences, a particular decision was made. The MCDA framework also makes the requirements for new information explicit, thus supporting the allocation of resources for the process.

Lawrence, P., R. Shaw, L. Lane and R. Eisner. 2000. Participatory multiple objective decision making processes: emerging approaches with new challenges. *Watershed Management 2000 Symposium*. Ft. Collins Colorado USA, American Society for Civil Engineering (ASCE). pp. 12 pages.

URL: http://www.coastal.crc.org.au/modss/papers/Lawrence_ASCE.pdf

Abstract: [Introduction]

For effective watershed management, data, technology and science need to be integrated with social, environmental and economic elements while recognising spatial and temporal variability. In Queensland, Australia, the direction in natural resource management is towards transparent, multi-objective, multi-stakeholder partnerships between government, industry and community groups for the allocation and use of watershed resources. This means holistic, transdisciplinary approaches to the sustainable, multiple use of resources are required, and that the process of engaging watershed stakeholders is both effective and efficient.

The move towards a systems-based approach to evaluate management options has been facilitated by the development of multiple objective decision support systems (MODSS) to evaluate trade-offs between numerous and possibly conflicting objectives. However, the implementation of such tools requires a methodology to maximise participation by stakeholders and to ensure the decision making process is equitable, constructive and effective.

This paper describes the process and initial outcomes where a multi-stakeholder, participatory decision making approach is used to evaluate and prioritise proposed water infrastructure developments in northern Queensland, Australia. This study examines four possible dam sites, each with three spillway heights, and is promoted by the Queensland Department of Natural Resources (QDNR). What emerges from this study is that the outcomes are dependent on the process of facilitation as much as the utility of a multiple objective decision support systems. In addition, there is a better opportunity for the stakeholders to identify a "consensus" option when they are involved early in the process, and there is sufficient time to allow the stakeholders to explore scenarios in order to satisfy their concerns and preferences.

Liu, G. and L. S. Davis. 1995. Interactive resolution of multi-objective forest planning problems with shadow price and parametric analysis. *Forest Science* 41(3): 452-469.

Abstract: Forest management planning is a joint process of decision synthesis and tradeoff analysis. We present an interactive method of multi-objective linear programming for supporting

the planning process. In the proposed procedure, emphasis is placed on reducing uncertainty that surrounds the resolution of goal conflicts. Parametric analysis is iteratively performed to shed insights into the question of what happens to goal tradeoffs if a particular criterion is achieved at alternative levels. The composite objective function guiding the parametric analysis is updated as decision maker replaces a previous choice with an improved one. Central to this step is the induction of criterion weights implied by a decision instance, through the use of shadow prices. Finally, ordinal goal priority is employed to generate initial solution and decompose a multi-objective planning problem into more tractable sub-problems. The interactive procedure is illustrated by a land-use planning model containing five forest-related outputs, including noncommercial grazing, commercial grazing, timber, camping, and profit.

Low Choy, D. L. 2003. Enhancing the planning process through science and adaptive management. 2003 Georgia Basin/Pugit Sound Research Conference. March 31 - April 3, 2003. T. Weyman Droscher and D. A. Fraser (editors), Vancouver, B.C., Puget Sound Action Team and the Georgia Basin Action Plan Partners.
URL: http://www.psat.wa.gov/Publications/03_proceedings/PAPERS/ORAL/2f_choy.pdf

Abstract: The paper outlines the results of an environmental planning research project that examined various planning processes utilised by private and public sector managers for the development of plans, policies and management actions seeking community water quality objectives for a region's waterways and coastal embayments. The planning agents included:

- Local government in the preparation of their statutory planning schemes and their environmental policies;
- State government agencies in the preparation of plans and policies; and
- Landowners (Freehold tenure) in the preparation of property management plans.

A generic cyclic planning process comprising two distinct phases, a plan-making phase and a plan-implementation phase, has been proposed. The latter phase includes an adaptive management approach that facilitates broader community involvement in the planning process. The project has also raised the notion of the introduction of civic science into the planning process alongside of the greater utilisation of conventional science. In this latter regard, the project has developed "roadmaps" for the enhancement of a range of statutory and voluntary planning tools through the incorporation of biophysical science.

Low Choy, D. L., R. Fearon, R. H. Worrall, J. Robinson, B. Sargeant, S. Ryan and J. Bennett. 2002. Chapter 4 Opportunities for incorporating science into planning. *In* Environmental Planning Project: Volume III - Incorporating science into planning. CRC for Coastal Zone Estuary and Waterway management, Technical Report No 4. 44-50 pp.
URL: http://www.coastal.crc.org.au/environmental_planning/documents/EP_V3_Ch4.pdf

Low Choy, D. L., R. H. Worrall, J. Gleeson, P. McKay and J. Robinson. 2002. Chapter 2 Protecting environmental values through planning. *In* Environmental Planning Project: Volume I - Management frameworks, tools and cooperative mechanisms. CRC for Coastal Zone Estuary and Waterway management, Technical Report No 4. 26-38 pp.
URL: http://www.coastal.crc.org.au/environmental_planning/documents/EP_V1_Ch2.pdf

Low Choy, D. L., R. H. Worrall, J. Gleeson, P. McKay and J. Robinson. 2002. Chapter 6 Towards a framework for integrated and cooperative planning and management. *In* Environmental Planning Project: Volume I - Management frameworks, tools and cooperative mechanisms. CRC for Coastal Zone Estuary and Waterway management, Technical Report No 4. 150-176 pp.

URL: http://www.coastal.crc.org.au/environmental_planning/documents/EP_V1_Ch6.pdf

Mabee, W. E., E. D. G. Fraser and O. Slaymaker. 2004. Evolving ecosystem management in the context of British Columbia resource planning. *Journal of Ecosystems and Management* 4(1): 31-41.

URL: <http://www.forrex.org/publications/JEM/archiveVol4iss1.asp>

Abstract: Ecosystem management is an approach to natural resource planning that theoretically places environmental issues on an equal footing with the economic concerns that dominate resource use. This approach recognizes the importance of both a healthy environment and access to natural resources. Each of these factors is an implicit element of human security, a political concept that promotes the protection of human lives and livelihoods. Ecosystem management acknowledges the role of humans as an integral part of the ecosystem; however, it does not define the ways in which humans and the ecosystem interact. This lack of definition makes the practical application of ecosystem management difficult.

In this paper, we examine the application of ecosystem management principles in British Columbia's Clayoquot Sound. We propose that human security can act as an imperative for the expanded consideration of social networks and environmental pathways in the practice of ecosystem management. Theories from the social and natural sciences are supplied to support the science-based application of ecosystem management. These underpinnings enable managers to better define ecosystem boundaries and to integrate expanded social networks into management plans.

Maness, T. 2005 (draft - in review). Tradeoff analysis for decision making in natural resources: where we are and where we are headed. FORREX, Kamloops BC. Project Report 25 pp.
URL: <http://www.forrex.org/publications/other/filereports/Maness.pdf>

*Maness, T. C. and R. Farrell. 2004. A multi-objective scenario evaluation model for sustainable forest management using criteria and indicators. *Canadian Journal of Forest Research* 34: 2004-2017.

Abstract: A multi-objective optimization model was created for medium-term forest development planning for an integrated forest products company located in the East Kootenay area of British Columbia, Canada. First, a set of sustainable forest management criteria and indicators were developed based on information that could be collected from regional geographic information system (GIS) databases and potential outputs from the model. Next, a new forest development planning unit was created (stewardship unit) in which adjacent forest polygons with similar indicator attributes were aggregated. The planning model was designed to determine appropriate harvest levels and management treatments on each stewardship unit to satisfy objectives determined in a participatory process. The mathematical model uses a fuzzy MAXMIN approach, where each indicator represents an objective in the model. Indicators are valued in the model using targets, thresholds, and triggers (called the 3-T approach). A case study is used to demonstrate the use of the model in a sustainable forest development planning context. The results of the case study show that the planning area is highly sensitive to visual quality, old-growth, and community watershed indicators. The paper concludes with a sensitivity analysis that determines the relative opportunity cost of various sustainable forest management indicators on company profits, employment, and tax revenues.

*Marcot, B. G., R. S. Holthausen, M. G. Raphael, M. M. Rowland and M. J. Wisdom. 2001. Using Bayesian belief networks to evaluate fish and wildlife population viability under

land management alternatives from an environmental impact statement. *Forest Ecology and Management* 153: 29-42.

Abstract: We developed procedures for using Bayesian belief networks (BBNs) to model habitat and population viability of selected at-risk fish and wildlife species. The BBN models represent the ecological causal web of key environmental correlates (KECs) that most influence habitat capability, potential population response for each species, and influence of habitat planning alternatives. BBN models represent site-specific KECs, habitat capability at the sub-watershed level, and pattern of habitat capability across all sub-watersheds. BBNs use Dirichlet prior probability distributions and standard Bayesian updating of posterior probabilities. We derived estimates of prior and conditional probabilities from a mix of empirical data and expert judgment, mostly the latter. Sensitivity analyses identified planning decisions and KECs that most influence species outcomes, and can help prioritize monitoring activities. BBN models, however, substitute for neither field studies nor empirical, quantitative population viability analyses of population demography and genetics.

Margerum, R. D. 1999. Integrated Environmental Management: the foundations for successful practice. *Environmental Management* 24(2): 151-166.

Abstract: Integrated environmental management (IEM) is a holistic and goal-oriented approach to environmental management that addresses interconnections through a strategic approach. Although no models of IEM have emerged, practitioners throughout the world are forging ahead with the concept. The literature indicates that stakeholder collaboration and public involvement are central to operationalizing this model, because this interaction produces a more integrated approach and generates support for implementation. However, it is not clear what steps and conditions are necessary for successful translation of IEM into operation. The author draws on twenty-three case studies from the United States and Australia, a survey of 285 Australian stakeholders and the literature to produce a framework for IEM. The framework identifies 20 elements that - if attained - will increase the likelihood of successful operationalization of IEM. These elements address structuring of an integrated approach, operation of stakeholder processes, and outputs and outcomes. The elements do not constitute a formula for success, but a generic set of attributes that constitute a foundation for effective practice.

Mathey, A., E. Krcmar and I. Vertinsky. 2005. Re-evaluating our approach to forest management planning: a complex journey. *Forestry Chronicle* 81(3): 359-364.

Abstract: The evolution of forest values from timber supply to ecological and social values has been leading to the redefinition of the Sustainable Forest Management (SFM) paradigm. In parallel, scientific knowledge is expanding and uncovering the interconnectedness of the various processes that support these values. We thus have many wishes and much knowledge but we have to ensure that we have the decision support tools that will pull them together to promote SFM. After a broad review of the evolution of decision support tools in forest management, this paper presents a case for more holistic numerical planning tools. To illustrate that such tools can be designed, we propose a simple decentralized approach. In this approach, a landscape management strategy evolves based on local decisions, integrating spatial and aspatial, multi-period and period-specific goals. Such tools could become a useful platform for sustainable forest management planning.

McCarthy, D. D. (1996) Ecosystem-based management and the Chesapeake Bay Program. University of Waterloo.

URL: http://www3.sympatico.ca/dkmcCarthy/html/ecosystemapproach_i.htm

Abstract: Reflecting the irreducible and uncertain nature of environmental issues, management and planning within turbulent, interconnected ecological and socio-economic environments must be systems-based, ethical and adaptive. Systems-based in this sense refers to an acknowledgment of macro-level organization (the not just micro-level as implied in an atomistic perspective) inherent in complex, self-organizing systems such as ecosystems as a result the approach must be holistic as well as reductionist, focusing on structure as well as process, and thus, must be integrative and trans-disciplinary. Secondly, the relationship between facts and values must change to reflect the complexity, uncertainty and wide-spread repercussions of environmental issues. A new relationship between science and decision-making must emerge to acknowledge this complexity, resulting in a new form of ethical governance. And finally environmental management must be adaptive. Management organizations must experiment, learn and adjust to a dynamic socio-biophysical context. That is, due to the great uncertainty inherent in ecological and socio-economic systems the approach must be iterative, recursive or adaptive.

McCarthy, D. D. P. 2003. Post-normal governance: an emerging counter-proposal. *Environments* 10(10): 1-8.

URL: <http://www3.sympatico.ca/dkmcCarthy/documents/PostNormalGov.pdf>

Abstract: The purpose of this paper is to attempt to bring together three bodies of interrelated thought (complexity theory, governance and civics) in order to begin to develop the concept of post-normal governance as a counter-proposal to the notion of managerial ecology. Managerial ecology has developed, or co-evolved, with human institutions over the past several decades as a pervasive, but almost implicit, framework for environmental decision-making. It is characterized by top-down, 'command and control', often bureaucratic structures, which can be seen to short-circuit more participative, democratic decision-making. It will be argued, based on insights gleaned from complex systems thinking, that due to the high uncertainty and high decision stakes associated with making decisions within complex systems that a more ethically-sound, 'post-normal' approach to science and decision-making, in which the 'peer community is extended', should be explored. This notion of post-normal science will be contextualized within recent governance literature and related to a civics approach to planning developed by Nelson and others in an effort to explore an extension of Funtowicz and Ravetz' notion of a post-normal science to governance.

McCartney, M. P. 2002. Freshwater ecosystem management: from theory to application. *International Journal of Water* 2(1): 1-16.

URL: <http://www.inderscience.com/storage/f471169128215103.pdf>

Abstract: At the start of the 21st Century, humankind is struggling with many complex issues related to the management of freshwater resources. A key concern is that over-exploitation, in a world of increasing water stress, will result in environmental degradation, and loss of biodiversity and ecosystem services beneficial to humankind. 'Ecosystem management' is one approach to managing natural resources, proffered by its advocates as a way of maximizing long-term socio-economic benefits, whilst simultaneously conserving ecosystem processes and biodiversity. Despite a large number of impediments to implementation, there is an increasing convergence between the philosophical approach advocated by ecosystem management and the actual management of freshwater resources. This paper explores the concept of ecosystem management, the constraints upon it and the ways in which the principles it espouses are beginning to be incorporated in the practical management of freshwater resources.

McElroy, M. W. 2000. Integrating complexity theory, knowledge management and organizational

learning. *Journal of Knowledge Management* 4(3): 195-2003.

Abstract: Chronicles the unfolding convergence of thinking and practice behind knowledge management, organizational learning and complexity theory. Of particular interest are the roles that knowledge management and complexity theory play in this impending consilience of ideas. On the one hand, knowledge management is anxious to rid itself of its overly technology-centric reputation in favor of promoting the role it can play in furthering organizational learning. On the other, complexity theory, a confident solution in search of unorthodox problems, has discovered its own true place in the world, an explanation for the means by which living systems engage in adaptive learning - the seminal source of social cognition in living systems.

Mendoza, G. A. and W. J. Dalton. 2005. Multi-stakeholder assessment of forest sustainability: Multi-criteria analysis and the case of the Ontario forest assessment system. *Forestry Chronicle* 81(2): 222-228.

Abstract: This paper provides an overview of methods for assessing forest sustainability, and describes an extranet World Wide Web forest assessment system. A general assessment approach, multi-criteria analysis (MCA), is briefly described. One of the MCA methods, the Analytic Hierarchy Process (AHP), which is the method used for the computer-assisted assessment system, is described in more detail. The primary MCA/AHP innovation is multi-stakeholder assessment with a stratification process. This web-distributed assessment system, that was designed to meet Ontario's provincial state of the forest criteria and indicators forest health assessment need, may be suitable for use in other jurisdictions with similar conditions.

Mendoza, G. A., P. Macoun, R. Prabhu, D. Sukadri, H. Purnomo and H. Hartanto. 1999. Guidelines for applying multi-criteria analysis to the assessment of criteria and indicators. Center for International Forestry Research, Jakarta, Indonesia. The Criteria and Indicators Toolbox Series No 9. 85 pp.
URL: <http://www.cifor.cgiar.org/acm/methods/toolbox9.html>

Abstract: Multi-Criteria Analysis (MCA) is a decision-making tool developed for complex problems. In a situation where multiple criteria are involved confusion can arise if a logical, well-structured decision-making process is not followed. Another difficulty in decision making is that reaching a general consensus in a multidisciplinary team can be very difficult to achieve. By using MCA the members don't have to agree on the relative importance of the Criteria or the rankings of the alternatives. Each member enters his or her own judgments, and makes a distinct, identifiable contribution to a jointly reached conclusion.

This manual is written for an audience that needs a clear, easy to follow manual that can be used in the field to implement MCA. The information is structured so that the reader is first introduced to the general concepts involved before delving into the more specific applications of Multi Criteria Analysis. The manual reviews the conceptual framework of C&I and introduces the theoretical basis of MCA, and methods such as ranking, rating and pairwise comparisons in the Analytic Hierarchy Process (AHP). It provides an example of how MCA can be applied to C&I in a Forest Certification context both from a 'top-down' perspective as well as in a more 'bottom-up' context.

*Mendoza, G. A. and R. Prabhu. 2003. Qualitative multi-criteria approaches to assessing indicators of sustainable forest resource management. *Forest Ecology and Management* 174: 329-343.

Abstract: Criteria and indicators (C&I) have become primary tools in implementing the principle of sustainable resource management. To carry out this principle, it is necessary to develop methodologies that can holistically and systematically generate relevant indicators for a particular forest or resource management unit. This paper describes some methodologies that can be used as tools to carry out structured analysis of C&I. Multi-criteria analysis (MCA) is used as a decision-making tool to analyze and evaluate multiple C&I under a participatory group decision-making environment. Use of the method enables the generation of C&I, estimation of their relative importance, estimation of the performance of each indicator relative to its desired condition, and assessment of the indicators' combined effect or impact. In addition to generating C&I and estimating their relative importance and performance, the paper also presents a soft methodology, called cognitive mapping which can be used to assess the cross-indicator interaction, linkages, and connectivities of the indicators. The method attempts to evaluate the overall cumulative impacts of all indicators, individually and collectively, as they impact sustainability directly and indirectly through their interactions with other indicators.

*Mendoza, G. A. and R. Prabhu. 2000. Multiple criteria decision making approaches to assessing forest sustainability using criteria and indicators: a case study. *Forest Ecology and Management* 131: 107-126.

Abstract: This paper describes the use of multiple criteria decision making techniques as decision tools for assessing criteria and indicators designed to evaluate sustainable forest management. Three techniques called ranking, rating, and pairwise comparisons are described and used within the framework of a generic set of criteria and indicators applied in a case study involving a forest concession in Kalimantan, Indonesia. For the case study, an assessment team consisting of national and international experts representing various disciplines was chosen to conduct an assessment of the forest concession. The criteria and indicators (C&I) developed by the Center for International Forestry Research was used as a reference. From this generic set of C&I, the assessment team made revisions to make the set more relevant to the prevailing conditions in the forest concession. This modified set was used in the assessment of the concession.

Results from the study indicate that these techniques are effective tools both for selecting sets of criteria and indicators and eventually for prioritizing them. The methods are highly transparent, easy to understand, and offer a convenient environment for participatory decision making. These are desirable features of any evaluation process but most especially for a complex assessment problem such as forest sustainability.

Moore, L. and S. Dolter. 2002. Forest management planning in Newfoundland and Labrador: the western Newfoundland and model forest contribution. *The Forestry Chronicle* 78(5): 655-657.

Abstract: The management of forests has dramatically changed in the past few decades. Forest managers no longer can prepare and implement forest management plans in isolation of other resource values and local citizens. Today, the economic, ecological and social values are blended together into sustainable forest management. Finding a balance among these values in Newfoundland and Labrador is done through local district planning teams. The team participants need to understand the principles of sustainable forest management and the overall planning process. A primary focus of the Western Newfoundland Model Forest has been to support planning teams through the development of management tools to enhance management of the Province's forest ecosystems. The Model forest program will continue to test, document and transfer new and innovative management options to

forest managers.

Murray, A. T. and S. Snyder. 2000. Spatial modeling in forest management and natural resource planning. *Forest Science* 46(2): 153-156.

Nelson, J. 2003. Forest-level models and challenges for their successful application. *Canadian Journal of Forest Research* 33: 422-429.

Abstract: Significant advances have been made that integrate landscape issues in forest-level models. These advanced models are designed to simulate and evaluate economic, ecological, and social goals that are included in the management of forests. The application of multiple-objective heuristics such as tabu search and simulated annealing, combined with remarkable advances in computing power, now allows us to explore highly complex management scenarios over long time horizons and over vast geographic scales. While the power of these decision support systems is highly appealing, and even intoxicating, we still face three sobering challenges on the path towards generating credible forecasts. First, advanced data acquisition and data management systems are needed to support these systems. Data management systems must have high storage capacity, be capable of rapid updates, and accommodate a seemingly endless demand for queries from customers, government agencies, and the public. Planning is an interdisciplinary, hierarchical process, and team members have different data demands, depending on where they fit in the hierarchy. Second, the models must be verified. Multiple objective models have dozens of parameters, and when these are combined with random search techniques, they become difficult to understand and replicate. Thorough sensitivity analysis is needed to test model parameters, goal weights, and assumptions of uncertainty. Finally, our ability to formulate and run large-scale, long-term forecasting models often exceeds the scientific credibility of the data, especially for complex forest ecosystems. In the absence of critical thinking, such powerful models can become dangerous weapons.

Onal, H. 1997. Trade-off between structural diversity and economic objectives in forest management. *American Journal of Agricultural Economics* 79(3): 1001-1012.

Abstract: A measure of divergence (NAD) between the distribution of individuals in a community and a target distribution is presented. When the latter is uniform, NAD measures evenness and exhibits a strong correlation with the widely used Shannon index. However, NAD offers the capability to incorporate an arbitrary composition in an economic optimization model where the Shannon index is not applicable. An empirical application to optimum management of a multi-species forest is presented, and the trade-off between ecological and economic objectives is investigated.

Parkins, J. R., R. C. Stedman and B. L. McFarlane. 2001. Public involvement in forest management and planning: a comparative analysis of attitudes and preferences in Alberta. Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. Information Report No NOR-X-382. 19 pp.

Abstract: This report presents a descriptive analysis of attitudes and behaviors associated with public involvement in forest management in Alberta. Data were collected by mail survey in 1999 from two main groups; the general public and members of forest-industry public advisory groups (PAGs). The survey measured general levels of public interest in forest management, and determined the public's preferred forms of involvement. Sources of information, perceptions of the accuracy of those sources, and perceptions of organizational and community groups influence on forest management were also assessed. Results suggest that PAG members differ from the

general public in terms of socioeconomic characteristics and in terms of attitudes and behaviors associated with public involvement. Furthermore, the findings illuminate two conditions with respect to public involvement. First, the respondents accessed a wide range of information about forest management and had distinct preferences for one source of information over another depending on their geographic location (urban or rural) and their degree of contact with the forest industry (PAG members or the general public). Second, the respondents strongly supported public involvement in general and clearly preferred citizens' committees as a specific mechanism for that involvement. Although the representativeness of PAGs is considered key to effective public involvement, the authors recommend moving beyond the profile of PAG members to evaluating the process within which their deliberations take place.

Patriquin, M. N., J. R. R. Alavalapati, A. M. Wellstead, S. M. Young, W. L. Adamowicz and W. A. White. 2003. Estimating impacts of resource management policies in the Foothills Model Forest. *Canadian Journal of Forest Research* 33(1): 147-155.

Abstract: This study examines the economic impact of policy changes in a forested region of the province of Alberta known as the Foothills Model Forest (FMF). The effects of policy changes in various sectors are analyzed in terms of all sectors of the regional economy with particular emphasis on the forestry sector. Unlike most analyses of regional policies, this study uses a computable general equilibrium (CGE) framework rather than a fixed-price framework to analyze economy-wide impacts of land use or forest policy changes. The application of this technique on a regional scale is rare in the scientific literature. Model results indicate that a decrease in forestry output somewhat offsets the positive economic impact generated by increased visitor activity. Failure to consider these trade-off impacts in the analysis will result in erroneous conclusions. The outcomes from three timely policy scenarios are examined in this paper. The results from the CGE framework suggest that policy makers face a greater degree of complexity than in current economic impact frameworks.

Peterson, D. L. and D. G. Silsbee. 1994. A case study of resource management planning with multiple objectives and projects. *Environmental Management* 18(5): 729-742.

Abstract: Each National Park Service unit in the United States produces a resources management plan (RMP) every four years or less. The plans commit budgets and personnel to specific projects for four years, but they are prepared with little quantitative and analytical rigor and without formal decision-making tools. We have previously described a multiple objective planning process for inventory and monitoring programs (Schmoldt and others 1994). To test the applicability of that process for the more general needs of resources management planning, we conducted an exercise on the Olympic National Park (NP) in Washington State, USA. Eight projects were selected as typical of those considered in RMPs and five members of the Olympic NP staff used the analytic hierarchy process (AHP) to prioritize the eight projects with respect to their implicit management objectives. By altering management priorities for the park, three scenarios were generated. All three contained some similarities in rankings for the eight projects, as well as some differences. Mathematical allocations of money and people differed among these scenarios and differed substantially from what the actual 1990 Olympic NP RMP contains. Combining subjective priority measures with budget dollars and personnel time into an objective function creates a subjective economic metric for comparing different RMP's. By applying this planning procedure, actual expenditures of budget and personnel in Olympic NP can agree more closely with the staff's management objectives for the park.

Pierce Colfer, C. J. 1995. Who counts most in sustainable forest management? Center for International Forestry Research, Jakarta, Indonesia. Working Paper No 7. 16 pp.

URL: http://www.cifor.cgiar.org/publications/pdf_files/WPapers/WP-07.pdf

Abstract: This paper proposes a method for identifying and defining the most significant actors in sustainable forest management. A rationale for the importance of differentiating among various forest stakeholders is first provided. Significant stakeholders identified in forest management units in Kalimantan, Cote d'Ivoire, and the USA are described. These descriptions are followed by a discussion of six important dimensions along which groups of people vary in their relations with the forest (proximity, pre-existing rights, dependency, indigenous knowledge, culture/forest integration, and power deficits). Finally, a simple scoring technique is proposed and demonstrated for the three contexts described earlier.

Pollino, C. A. and A. K. White. 2005. Development and application of a bayesian decision support tool to assist in the management of an endangered species. MODSIM 2005 International Congress on Modelling and Simulation. December 2005. A. Zenger and R. M. Argent (editors), Modelling and Simulation Society of Australia and New Zealand. pp. 2089-2095.

URL: <http://www.mssanz.org.au/modsim05/papers/pollino.pdf>

Abstract: Bayesian decision support tools are becoming increasingly popular as a modelling framework that can analyse complex problems, resolve controversies, and support future decision-making in an adaptive management framework. This paper introduces a model designed to assist the management of the endangered Camphora swamp eucalypt (*Eucalyptus camphora*). This tree species is found in the Yellingbo Nature Conservation Reserve (YNCR), an isolated patch of forest in the Yarra Valley (Victoria, Australia).

The eucalypt community provides both habitat and food for a variety of threatened and endangered flora and fauna. Over the last 20 years the *E. camphora* has become increasingly threatened by dieback. In order to maintain and rehabilitate existing trees and encourage regeneration, management strategies and action plans have concentrated on restoring the hydrological regime, which has been altered due to agricultural activities within the catchment. However, research suggests that nutrient enrichment from surrounding horticulture and livestock is having a greater impact on the health of the trees. The Bayesian decision support tool has been used to examine the differences between these two hypotheses. The tool will also promote future integrative and iterative monitoring and research in the YNCR.

This project was undertaken as part of a larger piece of work developing risk-based assessment guidelines for natural resource management, a process known as Ecological Risk Assessment. The Woori Yallock Creek Catchment, of which YNCR is a part, was chosen for the case study due to the high ecological assets identified in the catchment, the diverse land use and activities in the region, and the large body of knowledge and data available. The case study aims to identify environmental assets at greatest risk from ecological degradation in the Woori Yallock Creek Catchment and subsequently identify options for managing these risks.

Phase One of the risk assessment process is problem formulation. Input was sought from a wide range of interest groups via one-on-one interviews and a workshop. The priority environmental assets in the catchment were subsequently identified, along with the hazards that threatened these assets. The Sedge-rich *E. camphora* community within YNCR was identified as one of the priority threatened environmental assets within the Woori Yallock Creek Catchment. For the purposes of this case study the condition of *E. camphora* was identified as the management end point for which YNCR will be managed.

Phase Two (risk analysis) utilised Bayesian networks (BN) to quantify the risks to *E. camphora*. BNs are probabilistic networks that support reasoning under uncertainty. BNs are used to establish causal relationships between key factors and final outcomes, and maintain clarity by making causal assumptions explicit (Stow and Borsuk 2003). They are particularly useful for uncertainty analysis as they have the ability to consider inadequate knowledge or understanding of system processes, inherent randomness, subjective judgment and vagueness in parameter estimation, disagreement, measurement error and sampling error (Morgan and Henrion 1990).

Risks to the condition of *E. camphora* have been prioritised and key knowledge gaps identified, while accounting for predictive uncertainties. Using the networks, the outcomes of a range of management scenarios have also been tested.

The parameters that are most influential in determining *E. camphora* condition according to the model are generally soil nutrients, soil cations, pests or disease and inundation patterns (duration and frequency). The findings show *E. camphora* responses are different for each region in the model, and findings are specific for each survey.

Much of the data used to parameterize the model was patchy and qualitative. This has contributed to significant knowledge gaps. The results of this study should be viewed as a guide to further work.

Randolph, J. and M. Bauer. 1999. Improving environmental decision-making through collaborative methods. *Policy Studies Review* 16(3/4): 168-191.

URL: http://epsru.tamu.edu/pdf/plan641/improving_environmental_decisions.pdf

Abstract: In the past, government agencies with environmental missions rarely allowed public oversight over final decisions. However, faced with loss of control as policy and planning are increasingly carried out by Congress or the courts, some agencies, supported by businesses, communities, and environmental groups, are using collaborative methods in the decision-making process. This emerging paradigm for environmental decision-making is driven by practical necessity rather than by abstract theory.

This article will demonstrate that collaborative management is a process that broadens the influence of all entities concerned with an environmental decision, and is more likely to: (1) include the needs and opinions of affected parties; (2) bring a dialogue on normative values into the deliberative process; and (3) result in decisions that enhance environmental protection.

Rauscher, H. M., F. T. Lloyd, D. L. Loftis and M. J. Twery. 2000. A practical decision-analysis process for forest ecosystem management. *Computers and Electronics in Agriculture* 27: 195-226.

URL: <http://www.srs.fs.usda.gov/pubs/viewpub.jsp?index=1643>

Abstract: Many authors have pointed out the need to firm up the 'fuzzy' ecosystem management paradigm and develop operationally practical processes to allow forest managers to accommodate more effectively the continuing rapid change in societal perspectives and goals. There are three spatial scales where clear, precise, practical ecosystem management processes are needed: the regional assessment scale, the forest-level scale, and the project-level scale. This paper proposes a practical decision analysis process for ecosystem management at the project-level scale. Goals are the focal point of management. To achieve them requires a formal, structured goal hierarchy, desired future conditions, several interesting alternatives, scenario analysis, and monitoring and evaluation of the results. The proposed process is firmly grounded in the body of theory and

practice organized in the scientific literature under the heading of multi-objective decision analysis. An illustrative example of this decision analysis process is presented using the Bent Creek Experimental Forest of the Pisgah National Forest near Asheville, NC as a test case.

Rempel, R. S., D. W. Anderson and S. J. Hannon. 2004. Guiding principles for developing an indicator and monitoring framework. *The Forestry Chronicle* 80(1): 82-90.

Abstract: Sustainable forest management ideally involved five elements: 1) establishing a clear set of values, goals and objectives and, 2) planning actions that are most likely to meet desired goals and objectives, 3) implementing appropriate management activities, 4) monitoring the outcomes to check on predictions, effectiveness, and assumptions, and 5) evaluating and adjusting management depending on the outcome of monitoring. Within this framework, indicators are used to determine whether the outcome of management has met the intended goals. In this paper we provide general guidance for developing an integrated and logical monitoring system, define and differentiate between "evaluate" and "prescriptive" indicators, provide more specific advice on choosing evaluative indicators (including a comparison of types of ecological indicators), and provide more specific advice on defining prescriptive indicators. Our guidelines for developing an indicator and monitoring framework are based on three principles. The first principle is to develop a logical framework, including 1) establishing clear values and goals before setting indicators and objectives, and 2) linking prescriptive and evaluative indicators directly to plan objectives, and to each other. The second principle is to use the framework to learn adaptively by: 1) designing management activities to address specific questions, 2) learning about thresholds, and 3) testing assumptions. The third principle is to create a formal plan for learning.

Rieman, B., J. T. Peterson, J. Clayton, P. Howell, R. Thurow, W. Thompson and D. Lee. 2001. Evaluation of potential effects of federal land management alternatives on trends of salmonids and their habitats in the interior Columbia River basin. *Forest Ecology and Management* 153: 43-62.

URL: <http://www.fs.fed.us/psw/rsl/projects/wild/lee/lee2.pdf>

Abstract: Aquatic species throughout the interior Columbia River basin are at risk. Evaluation of the potential effects of federal land management on aquatic ecosystems across this region is an important but challenging task. Issues include the size and complexity of the systems, uncertainty in important processes and existing states, flexibility and consistency in the analytical framework, and an ability to quantify results. We focused on salmonid fishes and their habitats as indicators of conditions in aquatic ecosystems and used Bayesian belief networks as a formal, quantitative framework to address the issues in our evaluation of land management alternatives proposed for the interior Columbia River basin. Because empirical information is limited at the scales relevant to our analysis, an ability to combine both empirical and more subjective information was key to the analysis. The representation of linkages through conditional probabilities made uncertainty explicit. We constructed two general networks. One represented the influence of landscape characteristics and existing and predicted management activities on aquatic habitats. A second represented the influence of habitat, existing biotic conditions, and for two anadromous species, ocean and migratory conditions, on the status of six widely distributed salmonid fishes. In the long term (100 years) all three land management alternatives were expected to produce positive changes in the status and distribution of the salmonids and their habitats. Trends were stronger for habitat than for the status of salmonids because of greater uncertainty in linking the fish and habitat networks and constraints outside spawning and rearing habitat on federal lands in the study area. Trends were stronger for resident salmonids than anadromous forms because of additional effects of the migratory corridor assumed for the latter. Alternative S2, which

approached ecosystem restoration more conservatively, generally produced the strongest positive changes, and alternative S3, designed to promote more aggressive restoration, the weakest. Averaged across the basin, differences among the alternatives was small. Differences were greater at finer temporal and spatial scales. In the short term (10 years) alternative S3 was expected to lead to further degradation in some areas. By formalizing our understanding and assumptions in these networks, we provided a framework for exploring differences in the management alternatives that is more quantifiable, spatially explicit, and flexible than previous approaches.

Sahajanathan, S., D. Haley and J. Nelson. 1998. Planning for sustainable forests in British Columbia through land use zoning. Canadian Public Policy 24(Supplement No. 2): S73-S81.

URL: <http://ideas.repec.org/a/cpp/issued/v24y1998is2p73-81.html>

Abstract: Economic theory suggests that managing every hectare of forestland for multiple products, which is occurring in British Columbia, is inefficient. Using a case study for the Revelstoke area of the province, we demonstrate that spatially separating commercial timber activities from non-timber ones can lead to higher timber rents, while affording better environmental protection, including protection of critical wildlife habitat. Zoning provides an incentive to invest resources in intensive management in areas dedicated to commercial timber production, while enhancing the flow of other resource values from the unit as a whole. With zoning it is possible to avoid areas where visual and environmental amenity values are particularly sensitive, which is not possible with current, multiple-use management regimes. By focusing timber production, it is possible to reduce the forestland base, required to maintain current levels of harvest, by over 50 percent.

*Seely, B., J. Nelson, R. Wells, B. Peter, M. Meitner, A. Anderson, H. Harshaw, S. Sheppard, F. L. Bunnell, H. Kimmins and D. Harrison. 2004. The application of a hierarchical, decision-support system to evaluate multi-objective forest management strategies: a case study in northeastern British Columbia, Canada. *Forest Ecology and Management* 199: 283-305.

Abstract: Increases in the environmental awareness of global consumers coupled with pressure from regional stakeholders has forced forest managers to demonstrate the potential implications of forest management activities for a broad range of indicators. This paper describes the construction and application of a hierarchical decision-support system for evaluating multi-objective management options for a 288,000 ha forest in northeastern British Columbia. The decision-support system includes a stand-level model, a forest estate model, a habitat model and a visualization model. A set of criteria and indicators, developed in conjunction with a public advisory committee, were used to identify key economic, ecological and social objectives. Indicators include volume harvested, gross profit, active road density, ecosystem carbon storage, age-class distribution, patch-size distribution, snag density, visual aesthetics and backcountry recreation area. A natural disturbance baseline and two alternative harvest strategies that include natural disturbance are projected and assessed within the decision-support system. The first strategy represents a dispersed harvesting approach in which a range of cut block sizes (up to 2000 ha) and shapes is created that more closely follows the distribution of openings generated from natural disturbance events in the region. Spatial and temporal changes in each indicator are presented and evaluated for the harvest strategies, and compared to the natural disturbance baseline where appropriate. The application of the decision-support system for strategic analysis of management options is discussed, including a review of the importance of representing the impacts of natural disturbance and the benefits and risks associated with the use of visualization

techniques for presenting results to stake holder groups.

Selin, S. and O. Saastamoinen. 2001. Participatory planning and forest ecosystem management: lessons emerging from the Finnish and United States Experience. Ecosystem Management in Boreal Forest Landscapes. Koli National Park, Finland.
URL: http://www.joensuu.fi/forestconference/Media/Selin_Saastamoinen.pdf

Abstract: Over the past decade, participatory planning has emerged as a central component in efforts to implement ecosystem management at a landscape level in forested regions throughout the world. The importance of participatory planning is based on the recognition that people are a vital part of forest ecosystems and that ecological, social, and economic sustainability can only be achieved through planning processes that integrate the values and interests of those vested stakeholders (Field, 1996).

In the United States, participatory planning has been codified in the USDA Forest Service Planning Rule recently revised to guide forest planning on the National Forest System (Federal Register, November 9, 2000). It has also been an important element in recent bio-regional assessments such as the Interior Columbia Basin Ecosystem Management Project (Johnson et al, 1999). In Finland, participatory planning has been emphasised in the preparation of strategic National and Regional Forest Programmes for public and privately-owned forests, in the development of Natural Resource Management Plans and Landscape Ecological Plans for state forests (managed by Metsähallitus), and in regional environmental strategies led by the regional environmental centres (Loikkainen, Simojoki, and Wallenius 1999; North Karelian Environmental Centre, 2000).

The purposes of this paper are threefold. First, participatory planning is defined within the context of forest ecosystem planning and management. Second, the current status of participatory planning in selected forest ecosystem management projects is reviewed based on the Finnish and United States experience. Participatory planning objectives and strategies are discussed for these selected ecosystem management projects. And third, based upon this emerging evidence and recent assessments of participatory planning, the authors advance a number of policy, organisational, planning, and management trends and keys to success.

*Sheppard, S. R. J. and M. J. Meitner. 2005. Using multi-criteria analysis and visualization for sustainable forest management planning with stakeholder groups. *Forest Ecology and Management* 207(1-2): 171-187.

Abstract: While there is an increasing demand for active public involvement in forestry decision-making, there are as yet few successful models for achieving this in the new sustainable forest management (SFM) context. This paper describes the special needs of forest managers conducting participatory SFM planning in a sometimes-polarized public context, and outlines criteria for designing decision-support processes to meet these needs. These criteria were used to develop a new approach to public participation in British Columbia, by means of a pilot study using multi-criteria analysis of forest management scenarios while integrating public priorities. Researchers, working with stakeholder groups in the Arrow Forest District, obtained public weightings of criteria and indicators for SFM. Alternative forest management scenarios were presented using realistic 3D landscape visualisations. Modelling-based expert evaluations of the scenarios were weighted according to the priorities of the stakeholder groups, in order to test implications for scenario preferences. There was considerable commonality of results among groups, with general agreement between experts and stakeholder groups on scenario preferences. Based on the results and participant evaluations, techniques such as this appear effective as

decision-support tools in conflict-prone areas. Pilot studies like these can play a vital role in developing a more comprehensive, engaging, open and accountable process to support informed and socially acceptable decision-making for sustainable forest management.

Slocombe, D. S. 1989. History and environmental messes: a nonequilibrium systems view. *Environmental Review* 13(3/4): 1-13.

Abstract: [First Paragraph]

There is increasing support for viewing scientific knowledge not as a representation of nature but as a "socially constructed interpretation with an already socially constructed natural-technical object of inquiry". This is difficult to accept for those who believe, if not in the objectivity of science, at least in there being an objective world which science seeks to describe. But if science is taken to be simply the effort to describe and understand the world around us, then a sociological conception of its role and nature is especially useful for understanding and managing complex environmental problems with strong socio-economic and perceptual dimensions.

Slocombe, D. S. 1990. Assessing transformation and sustainability in the Great Lakes Basin. *GeoJournal* 21(3): 251-272.

Abstract: The Great Lakes Basin is a large, complex, diverse system of highly connected social, biological, and physical components. Its long history has culminated today in a variety of environmental, economic, and social problems and efforts to solve them. The idea of sustainability - meeting societal needs and desires without impairing the ability to meet them in the future - is gaining widespread acceptance as an appropriate goal for management of such systems. This paper shows that non-equilibrium systems theories dealing with chaotic and self-organizing behavior can provide some insight into the dynamics of complex socio-biophysical systems such as the Great Lakes Basin, and their prospects for sustainability.

A methodology for describing and analyzing socio-biophysical systems is outlined, and used to focus on change, critical variables and transformations in the history of the Great Lakes Basin. Non-equilibrium systems theories are used to develop links between system characteristics and sustainability, ecosystem redevelopment, impact assessment and monitoring, and management of Great Lakes resources. An indicative framework for monitoring change, restructuring, and transformation by assessing the nature of change, evaluating system responsiveness, and monitoring the Basin socio-biophysical system, is presented.

Soorvogel, J. and J.M. Antle. 2001. Regional land use analysis: the development of operational tools. *Agricultural Systems* 70(2-3): 623-640.

URL: <http://www.tradeoffs.montana.edu/pdf/regional.pdf>

Abstract: Regional land use analysis plays a key role in the analysis of agricultural policies. However, few operational tools for regional land use analysis are available. Current developments in regional land use analysis are rather ad hoc. More generic methodologies are required to effectively answer questions by policy makers. The analysis may require methods to explore, project and predict agricultural land use. An all-encompassing methodology seems unrealistic. A toolbox for regional land use analysis is proposed. The tools (including e.g. database management systems, GIS and economic models) can be linked in such a way that they can carry out the specific analysis required for the specific conditions of stakeholders. To facilitate linkages between the different tools, data standards need to be developed for both bio-physical as well as

economic data. Discussions with stakeholders in an early phase of the analysis may set priorities and determine the selection of tools.

Results of the analysis need to be presented in such a way that they are appealing to the stakeholders. Only then they can be transferred effectively. The general framework is illustrated with a methodology for regional land use analysis in terms of economic and environmental tradeoffs

Staggs, P. 1999. Strategic planning as a total quality management critical success factor. *Journal of Organizational Leadership* 1(1): 5-17.

Abstract: This paper examines strategic planning as a critical success factor when implementing TQM. Many organizations attempt to implement TQM, but the success rate is poor and the integration of TQM into the organization's standard practices seldom occurs. By linking TQM to strategic planning, the resulting synergy can enhance the probability of successfully implementing both initiatives and integrating them into an organization's culture and practices. Public sector organizations are facing a changing environment with growing citizen expectation, and limited budgets. By linking TQM with strategic planning, the probability of accomplishing the organization's mission in a more effective and efficient manner increases.

Stevens, J. A. and C. A. Montgomery. 2002. Understanding the compatibility of multiple uses on forest land: a survey of multi-resource research with application to the Pacific Northwest. USDA Forest Service, Pacific Northwest Research Station, General Technical Report No 539.

URL: <http://www.treesearch.fs.fed.us/pubs/4393>

Abstract: In this report, multiresource research is described as it has coevolved with forest policy objectives—from managing for single or dominant uses, to managing for compatible multiple forest uses, to sustaining ecosystem health on the forest. The evolution of analytical methods for multiresource research is traced from impact analysis to multiresource modeling, and examples of true joint production of forest products, goods, and services are given. Empirical results from studies related to wood compatibility in the Pacific Northwest (PNW) are compiled. We found that:

- In most cases, joint production research has been too specific or too theoretical to be directly applicable by land managers. Meta-analysis may prove useful for generating general management guidelines.
- Compatibility studies generally demonstrate compatibility between wood production and other uses. This result depends on geographic scale of analysis.
- Increasing sophistication in modeling method and the dramatic increase in data describing interactions among forest uses will likely make future tradeoff analysis more realistic and useful. Current work in modeling timber-wildlife tradeoffs shows promise.
- Compatibility analysis can be useful for policy analysis by establishing standards of efficiency against which to evaluate policy alternatives.

Szaro, R. C., D. Langor and A. M. Yapi. 2000. Sustainable forest management in the developing world: science challenges and contributions. *Landscape and Urban Planning* 47: 135-142.

Abstract: Forests are a global resource and important issues dealing with their use and maintenance cannot be effectively dealt with in an insular fashion. Global participation is mandatory, if these resources are to be sustained and equitably utilized. The seriousness and

urgency of most of the forestry and environmental problems are linked to the inability or means of developing countries to provide appropriate scientific and technical knowledge, effective policy, regulations and planning frameworks to deal with the problems. To fully understand and appreciate the challenges to forest science, it is useful to establish an appropriate background against which they should be viewed, and suggest how to improve our capability to deliver knowledge for a sustainable future. There are three keys to making this a reality: information, innovation, and implementation - all derived from human resources.

Szaro, R. C., W. T. Sexton and C. R. Malone. 1998. The emergence of ecosystem management as a tool for meeting people's needs and sustaining ecosystems. *Landscape and Urban Planning* 40: 1-7.

Abstract: Ecosystem management is an approach that attempts to involve all stakeholders in defining sustainable alternatives for the interactions of people and the environments in which they live. Its goal is to restore and sustain the health, productivity, and biodiversity of ecosystems and the overall quality of life through a natural resource management approach that is fully integrated with social and economic needs. For practical purposes, ecosystem management is generally synonymous with sustainable development, sustainable management, sustainable forestry and a number of other terms being used to identify an ecological approach to land and resource management. Ecosystem management emphasizes place- or region-based objectives, with scopes and approaches defined appropriately for each given situation. Because natural ecosystems typically cross administrative and jurisdictional boundaries, managing them requires interactions among different stakeholders and institutions. Ecosystem management remains an evolving force that must yet respond and adapt to numerous challenges.

Tarp, P., G. L. Paredes V and F. Helles. 1997. A dual approach to policy analysis in multiple-use forest management planning. *Canadian Journal of Forest Research* 27: 849-858.

Abstract: A multiple-use forest management planning system is presented enabling an optimal and efficient incentive or tax (price) level and an ethically justified compensation level combined with an optimal allocation of resources to uses (in an economic, political, and environmental sense). Extensions of the use of linear programming in multiple-use forest management planning are presented with focus on duality and opportunity costs in decision making. A dynamic linear programming model is presented where results are applied in a green account analysis. The model includes political, economic, and biological goal elements. Resource allocation issues related to non-market outputs are addressed. The model encompasses a multi-criteria decision support system applicable in a private environment based on profit maximization as well as in a public setting based on cost/benefit analysis. The green account analysis forms the basis for policy analyses that are applicable at stand, forest, sector/regional, and national levels. Policy analysis pertaining to legislative regulations may be performed on the basis of an evaluation of production costs, producer's surplus, and consumer's surplus. The model bridges the gap between planning philosophy, rational economic behaviour of decision makers, societal concerns, and practical forest management planning, a gap that is often observed in a traditional context.

Tittler, R., C. Messier and P. J. Burton. 2001. Hierarchical forest management planning and sustainable forest management in the boreal forest. *The Forestry Chronicle* 77(6): 998-1005.

Abstract: In keeping with international efforts to encourage sustainable forest management, new legislation, regulations, and certification criteria have been brought into effect across boreal regions of the world in the past decade or less. These initiatives have established hierarchical

systems of forest management planning that consider multiple uses of the forest and various aspects of sustainable forest management at different scales. We describe the systems established in Quebec, Ontario, Saskatchewan, Alberta, and British Columbia, Russia, Finland, and Sweden. Most jurisdictions employ some form of three-level planning framework, in which strategic, tactical, and operational plans and considerations are presented with successively greater detail and spatial explicitness. However, planning scales and time horizons vary considerably, as does the level of consideration given to biodiversity and social concerns. We examine these systems in the context of sustainable forest management, raising a number of questions to be addressed in future research, adaptive management, and policy reform. In particular, we note (1) a need of new landscape and regional planning tools to evaluate the long-term and large-scale impacts of various land uses and (2) a general lack of responsiveness to global carbon and climate change concerns.

Toman, M. A. 1994. Economics and "sustainability": balancing trade-offs and imperatives. *Land Economics* 70(4): 399-413.

Abstract: The concept of "sustainability" has been increasingly invoked in scholarly and public policy debates. Discussion has been hampered, however, by uncertainty and lack of uniformity in the meaning of sustainability. This paper seeks to identify some common ground among economists, ecologists, and environmental ethicists. Two issues seem salient: requirements for intergenerational equity and the definition of "social capital" to be provided to future generations. A concept of "safe minimum standard," which has received at least some recognition in the ecology, philosophy, and economics literatures, may provide the beginnings of a common ground for debate about sustainability.

Van Damme, L., J. S. Russell, F. Doyon, P. N. Duinker, T. Gooding, K. Hirsch, R. Rothwell and A. Rudy. 2003. The development and application of a decision support system for sustainable forest management on the Boreal Plain. *Journal of Environmental Engineering and Science* 2(Supplement 1): S23-S34.

Abstract: Millar Western Forest Products Ltd. manages a forest in west-central Alberta under a Forest Management Agreement (FMA) with the Government of Alberta. Part of Millar Western's planning process brought researchers together to develop a decision support system (DSS) for forest management planning and monitoring programs. Four modules — timber supply, biodiversity, FIRE, and WATER — were built to evaluate, with the help of indicators of sustainable forest management, current and future forest conditions predicted from computer simulations of alternative management scenarios. In the first round of assessment four management scenarios, distinct by their level of silviculture intensification and by the spatial clearcut layout pattern, were compared. Such comparison has demonstrated that (1) the current forest management scenario improved moose habitat at the expense of timber supply, (2) all scenarios had similar fire risk, (3) generated increases in peak flow and water yield of selected watersheds, and (4) slightly impoverished forest biodiversity. All scenarios were examined in light of a computer-simulated natural disturbance benchmark. This led to landscape design scenarios to reduce fire risk and balance biodiversity indicators with timber supply objectives, one of which was eventually selected for implementation. The company's monitoring and research program is also highly focused on improving DSS modules and the underlying data, hence its association with the Forest Watershed and Riparian Disturbance (FORWARD) project, which considers the effects of forest management on aquatic ecosystem indicators.

Van Kooten, G. C. 1995. Modeling public forest land use tradeoffs on Vancouver Island. *Journal of Forest Economics* 1: 191-217.

Walters, L. C., P. J. Balint, A. Desai, R. E. Stewart, B. Chundevalel, N. Kanbar, M. Milne and D. Phillips. 2003. Risk and uncertainty in management of the Sierra Nevada National Forests. USDA Forest Service, Pacific Southwest Region, 33 pp.
URL: http://gunston.doit.gmu.edu/snfpa_risk/finalreport.pdf

Abstract: This report presents results of the activities of the risk and uncertainty panel. The charge to the panel was to inform the Regional Foresters, and others interested in the management of the Sierra Nevada national forests, about the nature of decision-making in a policy environment characterized by multiple and conflicting risks and uncertainties.

In our work, we reviewed the relevant academic and professional literature and offered three workshops for participants in the Sierra Nevada decision process - two for external stakeholders and one for the Interagency Team. At the workshops, we provided information on risk and uncertainty and conducted two exercises to elicit participant preferences with regard to policy choices and outcomes in the Sierra Nevada case. Using this review of the literature and insights gained from the workshops, we evaluated the treatment and communication of risk and uncertainty in the Sierra Nevada Forest Plan Amendment (SNFPA) process. Our assessment, carried out in conjunction with the Regional Forester's review of the January 2001 Final Environmental Impact Statement (FEIS) and Record of Decision (ROD), covered both the development of the 2001 ROD and the review process up through the time we held our workshops in March 2003.

Wang, S. 2004. One hundred faces of sustainable forest management. *Forest Policy and Economics* 6: 205-213.

Abstract: Compared with conventional forest management, sustainable forest management (SFM) is interdisciplinary, heterogenous, less hierarchical, and more socially accountable. The analytical framework for the economics of SFM is characterized by a pluralistic and integrative nature. An adaptive, contextualized knowledge approach is desirable for operationalizing SFM principles. This approach would employ knowledge as a major vehicle in a two-tiered system in which economic incentives and trade-offs dictate resource allocation and management decisions when substitutable products are involved, but precautionary principles would prevail when the integrity of ecosystems is at stake. Several dilemmas impede the implementation of SFM posed by the dilemmas. SFM has 'one hundred faces', and the multiple dimensions call for an integrated, adaptive learning approach that promotes connectivity among various pieces on the forest landscape.

Weintraub, A., G. Saez and M. Yadin. 1997. Aggregation procedures in forest management planning using cluster analysis. *Forest Science* 43(2): 274-285.

Abstract: Typical linear programming models used in forest planning can be very large. It is often of interest to analyze more compact, less detailed versions. One form of reducing the size of the problem is through an aggregation process. One way in which this has been done is through a column aggregation process, where sets of similar columns are replaced by one representative. A second alternative is to aggregate the original data, in which case the stands and management alternatives are grouped before building a model. Typical approaches for the aggregation processes have been analytical. We present an alternative approach for aggregation based on cluster analysis. Computational results for both types of aggregation show that using cluster analysis can be advantageous.

Wilson, B. and S. Wang. 2001. Treading the path to sustainable forestry: new directions in

Canada with particular reference to British Columbia. International IUFRO Symposium - Economic Sustainability of Small-Scale Forestry. A. Niskanen and J. Vayrynen (editors), Joensuu, Finland, European Forest Institute, Torikatu, Finland. EFI Proceedings No. 36, pp. 131-141.

Abstract: In response to the change in social values, sustainable forest management (SFM) is emerging as a defining feature of modern society. Reflecting the value realignment, Canada has made significant progress in shifting towards an SFM paradigm. New national policies and initiatives have been positioned in recent years led by the development of a national forest sector strategy and the endorsement of a set of science-based criteria and indicators (C&I) with their roots in the Montreal Process on the conservation and sustainable management of temperate and boreal forests. British Columbia (BC), with much of the globe's remaining coastal temperate rainforests and one of Canada's largest forest provinces by any measure, has implemented a wide array of policy changes and programs in an effort to further promote SFM. The key components of the BC SFM package include multi-stakeholder land use planning, a commitment to double the protected areas, and the codified prescription of forest management. More recently, BC has re-calibrated the Forest Practices Code in pursuit of operational efficiency, established pilot community managed forest tenures, promoted incremental silviculture and tried to encourage employment in the sector. The emerging paradigm has resulted in new directions in forest practices. In particular, the question of forest renewal and the integration of non-timber values into forestland use have become key issues to policy-makers and sector stakeholders. Given the need to balance social expectations, sustain the forest ecology and work within economic realities, there is little reason to expect that the path to SFM will be prescriptive or without displacement. Transition dynamics can, however, be smoothed, albeit only to a degree, by the rigorous examination of SFM drivers, SFM characteristics, stakeholder perspectives, market signals, and the institutional setting. This paper will examine the SFM policy efforts of Canada and British Columbia.

*Wolfslehner, B., H. Vacik and M. J. Lexer. 2005. Application of the analytic network process in multi-criteria analysis of sustainable forest management. *Forest Ecology and Management* 207(1-2): 157-170.

Abstract: Over the previous decade, sustainable forest management (SFM) has become a highly relevant topic both in forest and environmental policy. Criteria and indicators (C&I) are primarily used in implementing the principles of SFM at national, regional, and at forest management unit levels. In turning SFM from a conceptual framework into applicable guidelines at the operational scale, several limitations have to be acknowledged: (i) partial lack of knowledge, (ii) deficits about dependencies and feedbacks among system components represented by C&I, and (iii) knowledge gaps regarding impacts and related uncertainties. Several methodologies have been proposed to implement C&I-based SFM. Multi-criteria analysis is often used to analyze and evaluate multiple C&I approaches. This study compares two different multi-criteria analysis approaches: the analytic hierarchy process (AHP) with a hierarchical structure and the analytic network process (ANP) with a network structure. Comparisons are made for evaluating sustainable management strategies at forest management-unit level by using a C&I approach based on the Pan-European guidelines for SFM. AHP and ANP are used to compare four different strategic management options with a set of six criteria and 43 indicators. Differences in evaluation results between AHP and ANP are discussed, as well as strengths and weaknesses of both approaches for SFM. Needs and demands are derived for successful future applications in forestry decision-making.

Xu, W., B. R. Lippke and G. J. Perez. 2003. Valuing biodiversity, aesthetics, and job losses

associated with ecosystem management using stated preferences. *Forest Science* 49(2): 247-257.

Abstract: The study performs a joint estimation of the values for three important attributes of forest ecosystem management--biodiversity, aesthetics, and rural employment impacts using a choice-based, stated preference approach. It develops the marginal willingness-to-pay schedule for the three attributes for timber rural, other rural, and urban communities in Washington State. In contrast to the conventional wisdom in neoclassical economics, the public perceives job losses as losses of social welfare in this study. There are differences as well as similarities among the preferences of the three communities for the attributes of ecosystem management. The results show that the overall preferences of the timber rural and urban communities towards ecosystem management are substantially different, while the preferences of other rural community are not statistically significantly different from the other two communities. The estimated environmental and social values make it possible for policy makers and resource managers to compare and assess the trade-offs of different management plans. For example, with the biodiversity index level at 60, where an index of 50 relates current conditions, and rural forest-related job losses at 5,000, each household in urban communities in Washington State is willing to pay \$31.44 annually for an additional unit of improvement of biodiversity, and \$45.97 annually for avoiding an additional 1,000 rural job losses. The trade-off relationship for the given biodiversity and job loss levels suggests each household in urban communities each year is willing to trade 684 additional rural forest-related job losses with one unit of biodiversity improvement, *ceteris paribus*. Similar trade-off relationships for households in timber and other rural communities suggest each is willing to trade 598 and 388 additional rural forest-related job losses, respectively, with one unit of biodiversity improvement, *ceteris paribus*. The trade-off between aesthetics and job losses are 1,229, 452, and 686 additional jobs with one unit of aesthetics improvement for urban, timber, and other rural households, respectively. The trade-off relationships provide important information for improving the efficiency and equity of forest ecosystem management.

Related Web sites

Microsoft Bayesian Network Editor and Toolkit:

<http://research.microsoft.com/adapt/MSBNx/>

Bayesian Knowledge Discoverer:

<http://bayesware.com/>

Tim Haas' Ecosystem Management web system:

<http://www.uwm.edu/~haas/share/>

International Society for Bayesian Analysis (contains a link to the "Bayesian Analysis" Journal):

<http://www.bayesian.org/>

Bruce Marcot's Web Page on Creating Bayesian Belief Network Models in Ecology:

<http://www.spiritone.com/~brucem/bbns.htm>

CRAFT (Comparative Risk Assessment Framework and Tools) Website

http://www.fs.fed.us/psw/topics/fire_science/craft/craft/introduction.htm