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Implementing and testing decision-support tools to evaluate forest management scenarios for SFM: a multiple scale and perspective approach

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SFMN Project

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ABSTRACT

To assist forest managers in balancing an increasing diversity of resource objectives, we developed a toolkit modeling approach for sustainable forest management (SFM). The approach integrates a multi-model strategy into a collaborative adaptive management philosophy that facilitates participation among stakeholders, decision-makers, and local domain experts. The modeling team works iteratively with each of these groups to define essential questions, identify data resources, and then determine whether the available tools can be applied, adapted, or created to fit site needs. The focus of this project is on the process of how SFM modeling tools and concepts can be rapidly assembled and applied in new locations, balancing efficient transfer of science with adaptation to local needs. We use forest planning district 19A in central Labrador, a forested landscape where social and ecological values receive equal priority to economic values, to illustrate strengths and challenges associated with an integrated modeling approach. Principle advantages of the approach include the scientific rigor introduced by peer-reviewed models in combination with the adaptability of meta-modeling. A key challenge is the difficulty of communicating results of complex scientific models to different participatory groups. This challenge can be overcome by frequent and substantive communication among groups at the appropriate times in the model-building process. The toolkit approach holds promise for extending beyond case studies without compromising the bottom-up flow of needs and information to inform SFM planning using the best available science.

Keywords: Forest sustainability, ecosystem management, participatory modeling, scaling, interdisciplinary.

ACKNOWLEDGEMENTS

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RESEARCH QUESTIONS AND OBJECTIVES

The objective of the project, ”messiercimpl10” was to assemble an “SFM toolkit” composed of different modelling tools that are either available now, nearing completion, or can be developed rapidly. To meet this objective ”messiercimpl10” proposed to develop a generalized framework with four components designed to (1) identify the key drivers of forest change and their associated scale in different ecological and socio-economic settings, (2) assign the appropriate tool(s) from the toolkit to model the drivers and their interactions, (3) take advantage of local “domain experts” to rapidly parameterize and calibrate the tools to the new location, and (4) design scenarios that simulate the relevant range of management options and evaluate their effect on forest landscapes relative to desired future conditions.

KEY FINDINGS

The project fostered the continued development of very close working relationships with and among our partners in Mauricie (TRIAD), Labrador and BC that has led to concrete changes in how the forest is being managed. A non-exhaustive list of our scientific achievements to meet our project objectives includes: 1) Development of a spatially-explicit forest state and management model using SELES (Fall and Fall 2001) that has refined the timber supply estimates derived for the original D19 management plan and added the ability to analyze the spatial effects and constraints of different landscape management strategies; 2) Completion of a modelling study of scaling issues that currently challenge SFM objectives (Papaik et al., Ecosystems In Rev.), which led to insights into other modelling issues and a methodology for incorporating more fine-scale process into landscape-scale models without incurring excessive costs in computing speed; 3) Development of a prototype socioeconomic model that evaluates short- and long-term economic consequences simultaneously with risk analysis of habitat integrity for key species such as Caribou (Morgan et al., In Press); 4) A sociological analysis of people’s perceptions of SFM (Berninger et al. In Press) and how their original perceptions changed as a result of this toolkit development process (Berninger, Society and Natural Resources In Rev.); 5) Development of an economic assessment of biodiversity and functional zoning (Khazri, Ph.D. thesis); 6) Integration of the Canadian Fire Behaviour Prediction system with a LANDIS fire model for application in Labrador to investigate synergies between disturbances by fire and management (Simon et al. in prep.); 7) Used a landscape model developed with SELES to (a) evaluate six different TRIAD scenarios for a 400 000 ha landscape in central Quebec (Côté et al., in prep.), and (b) explore the effects of changing management regimes over time on ability to meet SFM objectives (James et al. In Press.); 8) Development of stand-scale succession models for (a) boreal forests of BC using a stand thinning algorithm to simulate thinning of extremely dense post-clear cut stands (Astrup, Ph.D. thesis), and (b) southern boreal forests of western Quebec, using a mixed species adult growth model to improve estimates of biomass dynamics; and 9) Formalization of our toolkit modelling approach within a framework that integrates the three disciplines of sustainable forestry (ecology, economics, and sociology) in the context of scale-specific processes to balance science with local SFM needs (Sturtevant et al. 2007).

KEY DELIVERABLES

As part of the development of HQP, one of our post-docs co-organized a special session at ESA 2005 titled "Insights, Challenges, and Future Directions in Modelling Forest Dynamics at Multiple Scales". This full-day session was very well attended with an average of over 120 people per talk. Two of our post-docs and one collaborator organized a full symposium at the 2006 annual conference of the International Assocation of Landscape Ecology (IALE) titled "Crossing scales and disciplines to achieve forest sustainability: A framework for effective integrated modelling". The symposium consisted of 14 speakers doing similar studies from other forested ecosystems around the world and is the basis for a special issue of Ecology of Society the papers for which are currently in review. Research at one of our node sites (Mauricie area), which makes use of the TRIAD concept, has been endorsed by the Quebec provincial government as one of two major case study sites in support of sustainable forest management objectives outlined in the Coulomb Report. All information regarding the progress and status of this project can be accessed from our web site: http://www.lfmi.uqam.ca

Seminars

October 4-5, 2005 at the Landscape Ecology Lab at the University of Toronto. Speaker: Michael Papaik. Topic: Scaling forest processes between stands and landscapes in the boreal forests of Labrador. Attendees were the students of Marie-Josée Fortin, a PI on this project.

Messier, C. Seminar on ecosystem management and the TRIAD concept. Centro tecnologic forestal de Catalunya, Espagne, June 2007.

Messier, C. Seminar on resiliency in forest ecosystems. North American Forest Ecology Workshop (NAFEW), Vancouver, June 2007.

Messier, C. Seminar on ecosystem management in Canada. Naturvetenskap University, Sweden, September 2007.

Messier, C. Seminar on complexity management. Freiburg University, Germany.

Messier, C. Seminar on Functional Zoning. UofT, Fac. Forestry, October 2007.

Messier, C. Seminar on the new challenge in Forestry. Keynote, Institute of Forestry of Canada meeting, October 2006.

Messier, C. Seminar on the boreal forest of Canada. Canada-Russia forestry meeting, Ste-Petersburg, Russia, March 2006.

Messier, C. Seminar on Forestry at different scales. Congrès INTECOL et ESA, August 2005.

Messier et al. Poster on TRIAD. Carrefour de la recherche forestière, October 2007.

Rheault H. et Messier, C. Seminar on TRIAD project in LaTuque. Bilboa, Spain, September 2006.

David Paré, Jean-François Dupuis, Luc Guindon, Mireille Bouchard, Suzanne Brais, Louis Duchesne et Jean-Pierre Saucier. Estimation du potentiel de productivité des sites. Carrefour de la Recherche, Québec, October 2007.

Berninger, K., Kneeshaw, D. et Messier, C. Forest values and attitudes of interest groups in three regions. 13th International Symposium on Society & Resource Management, 17.-21.6. 2007, Park City Utah.

Berninger, K., Kneeshaw, D. et Messier, C. Comparing forest management preferences of different interest groups across a gradient of management intensity. 12th International Symposium on Society & Resource Management, 3.-8.6. 2006, Vancouver.

Aguilar, C, Berninger, K et Mai Hô, V. Affiche sur les aspects socio-économiques de la TRIADE. Carrefour de la recherche forestière, October 2007.

Berninger, K., Kneeshaw, D. et Messier C. Poster on the forest values. Colloque du CEF, March 2007.

Beaulieu, N. Exposé sur le projet TRIADE en Mauricie. Colloque dans le cadre du Carrefour de la recherche forestière. October 2007.

Messier, C. Exposé sur les aires protégées : un complément essentiel à l'aménagement écosystémique. Colloque dans le cadre du Carrefour de la recherche forestière. October 2007.

Messier, C. Exposé sur la TRIADE et l'aménagement écosystémique. Colloque organisé par l'action boréale du Québec. March 2007.
Hô, V.M. et Gélinas, N. Exposé: Economic Valuation of Biodiversity in a Context of Forest Management Zoning in Quebec. Canadian Society for Ecological Economics (CANSEE), Halifax. July 2007.

Gélinas, N., Hô, V.M., Aguilar, C.,Berninger, K., Kneeshaw, D. et Laserre, P. 2007. Les aspects socio-économiques de la TRIADE. Affiche présentée dans le cadre du Carrefour de la recherché forestière. October 2007.

Plusieurs sorties sur le terrain avec les gens du Forestier en chef, les gens du Ministère des ressources naturelles et des intervenants locaux entre 2005 et 2007.

Workshops
October 11-14, 2005 SELES programming workshop held at the University of Quebec at Montreal. Organizer, Michael Papaik; workshop leader, Andrew Fall. Topic: Introduction to landscape model development using SELES. Objective: Train attendees how to do basic programming using the SELES model development language. The primary target was this SFMN project, but several additional persons attended. Project members who attended: Michael Papaik (PDF), Neal Simon (PDF), Daniel Kneeshaw (PI), Patrick James (PhD), Kati Berninger (PhD), Pascal Côté (MSc).

February 28- March 4, 2005. SORTIE-ND programming workshop. Organizer: Michael Papaik; workshop leader, Lora Murphy principal programmer for SORTIE-ND. Introduction to programming SORTIE-ND in C++. Objective : train attendees in the organization of the code and write a small, but functional new behaviour for the simulation model. Project members who attended: Michael Papaik (PDF), Mark Vanderwell (PhD), Pascal Rochon (research assistant) and Daniel Lesieur (research assistant).

Communication with the general public

Kati Berninger – interviewed by the local newspaper and local radio station in Goose Bay, Labrador.

Christian Messier, Luc-Alain Giraldeau and Béatrix Beisner. Newspaper article for Le Devoir publicizing the ESA conference. Article title : "L'écologie est une science en perpétuelle transformation." 7 Août 2005.

BENEFITS TO PROJECT PARTNERS AND OTHERS

In many respects the SFM toolkit approach is the same as any integrated modeling effort, hence previous experience and advice on communication across disciplines (Côté et al. 2001, Kinzig 2001, Bradshaw and Bekoff 2001, Lele and Norgaard 2005) and working as part of integrated teams (Nicolson et al. 2002) all apply. The key difference lies in the assembly of models designed for different purposes into a cohesive system that collectively informs the SFM planning process. This difference poses both unique opportunities and unique challenges to the modeling team. Chief among the advantages is that the cumulative science and experience underlying currently available models can be brought to bear on a specific planning initiative (in our case the D19A Forest Management plan). A primary challenge is the complexity associated with coupling models designed for different domains (see Appendix). The scientific advantages of the approach can be realized so long as the strengths and limitations of the tools are well understood (especially when the number of tools is large), and careful attention is paid to the pipelining strategies used to transfer information from one tool to the next.

A perpetual challenge during the assembly of the meta-model is finding the right balance between re-use and/or adaptation of existing tools and creating new ones. When using an existing tool, there is always a risk of a mismatch between the tool and the conceptual model. This risk must be weighed against the time required to create and evaluate (Rykiel 1996) a new custom tool. In our case, most tools were modified versions of pre-existing models. Modern programming practices, such as modular architecture (Maxwell and Costanza 1997, Groenwold and Sonnenschein 1998, Scheller et al. 2007), simplify adaptation of existing models. As a case in point, the interaction between succession, harvesting, and fire disturbance could be realistically simulated in LANDIS-II by creating a new fire extension, but retaining other model components that fit the conceptual model of the case study. Similarly, simulation support tools such as SELES will continue to make customized modeling and meta-model assembly easier and more accessible to a broader audience. In time we envision a more general SFM toolkit applicable to boreal systems that can expand as new tools are added, key parameter ranges are defined, new issues are addressed, and new insights are gained from both individual and comparative modeling initiatives in the region.

The modular architecture of a meta-model allows progress to be made on multiple fronts simultaneously without waiting for results from the entire collection of models. We divided our team into working groups to make efficient use of effort, to ensure a parsimonious set of elements that address project needs and to focus attention on appropriate tools for each element. Preliminary, domain-specific modeling is an important form of prototyping that is essential for the iterative, two-way communication at all levels of participation (Fig. 2; Fall et al. 2001, Nicolson et al. 2002). However, there are inherent dependencies built into the modeling process (i.e., project definition, data identification, model selection, indicator development, etc.). If these dependencies are ignored the process can easily degrade into an uncoordinated set of modeling exercises and the opportunity for true synthesis will be lost. Our experience suggests that strong leadership, in combination with a structured framework, is essential to the success of a toolkit approach.

Team selection is critical when applying an SFM toolkit because the diversity of tools familiar to team members often defines the tools in the toolkit. Both off-the shelf models and model-building software require knowledge, experience, and/or training prior to their use, and learning new complex tools may be at odds with project timelines. Hence the team leader or leaders bear a large responsibility to assemble the right team to match a local SFM need. That is, to overcome the “chicken and egg” dilemma, where “until you define the problem, you cannot assemble a team; and until you have a team, you cannot really define the problem” (Nicholson et al. 2002, page 378), team leaders must go through a high-level iteration of the collaborative process and also have at least a cursory understanding of available modeling tools, as was our case in Labrador, before assembling the team. The conceptual model can then be refined by subsequent iterations with the newly assembled team. We further learned that including a local representative on the core modeling team vastly improved communications among the major groups (i.e., modelers, domain experts, planners, and stakeholders).
The need for model transparency in participatory modeling initiatives is well-recognized, but can also conflict with the use of research models designed for science rather than transparency. For example, Mendoza and Prabhu (2005, pages 146-7) suggest:

> *…for participatory modeling to be embraced at the local level, it must be configured in a form that is simple, transparent, and stripped of the typical complexity that often characterizes many models. The modeling paradigm must be such that stakeholders with little or no formal training in modeling can grasp the modeling process, feel comfortable in sharing their input and knowledge, and are able to contribute their expertise with relative ease.*

Does this mean that published research models that are generally not transparent to the general public have no place in the collaborative modeling arena? Bypassing such models in favor of simplistic alternatives may restrict the flow of scientific knowledge into the planning process. A key to resolving this dilemma is effective two-way communication between the modeling team and the other participant groups at the appropriate time. For example, we found that stakeholder confidence in modeling results was greatly enhanced through frequent formal and informal communication with their experts. The modeling team should therefore work with local experts to ensure that they understand the strengths and weaknesses of tools applied to their domain. As domain experts often have their own tools, they may request model comparisons before they will begin to trust a new tool. Once satisfied that the implemented model is consistent with the formal conceptual model (Fig. 2), local experts can work with the modeling team to develop output that is accessible and easily understood by stakeholders.

Direct two-way communication with local stakeholders is also essential. In Labrador, long-term and large spatial scale comparisons of different management scenarios were shared with different publics following organization of meetings with outside experts by local domain experts. All parties gained important insights from this process (e.g., Fig. 6). Local stakeholders need to have their views heard, and discussed, and incorporated at several stages of the process. The scientists should make clear what the models are capable of doing and what may be unrealistic. This feedback is inherent in our hybrid approach of top-down and bottom-up flow of information via model analysis, workshops, and transparent discussion.

MANAGEMENT/POLICY IMPLICATIONS

Any attempts to provide analytical support for SFM across different areas must recognize both the commonality and distinctiveness of issues and socio-ecological dynamics. Integrated models cannot be customized to fit every planning situation because there is a lack of capacity for building and applying complex spatio-temporal models. Conversely, no single model could adequately capture all systems and issues, especially since collaborative input from local stakeholders is important for plan acceptance. The toolkit approach has been developed in recognition of these constraints and opportunities, to use resources efficiently to minimize reinvention yet maximize innovation.

A toolkit approach to SFM analytical support is more about perspectives on information flow than on technical details. Certainly expertise and enabling technology are required to allow a team to apply such a framework. However, the essence of this approach is to seek balance between top-down (off the shelf, science-driven) and bottom-up (case-specific, stakeholder-driven) approaches to SFM decision support. We aim to find a pivot point, with adequate information flow from local experts and stakeholders to scientists, while at the same time avoiding “reinvention of the wheel” (e.g., Fig. 1) by making full use of the cumulative experience of scientists and tools they have constructed. The mixture of local experts and stakeholders that understand how the tools work, scientists that are willing and able to communicate their sciences to stakeholders, and integrated analytical tools that can simulate complex spatial and temporal problems will provide powerful and efficient decision support for SFM. Bidirectional information flow between local experts, stakeholders, scientists, and planners is essential for parsimonious, timely, reliable, and adequate SFM meta-models. We have applied the toolkit process in Labrador, but fully recognize that this process will continue to evolve. Our proposal is not fully ripe, and certainly suffers from imperfections, but we believe the trend holds the best opportunity of meeting the challenges facing society regarding forest management.

SUGGESTIONS FOR FUTURE RESEARCH

There are still a lot of work to be done to develop a more easy approach and methodology to link various models. We plan to continue working in making linking various models more easy

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