Sustainable forest management: from concepts to practice in two Canadian model forests[1]

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Abstract[4]

Over the past decade the Canadian Model Forest program has devoted much of its efforts to translating the concept of sustainable forest management (SFM) into practice. This work has involved a unique and creative mixture of people, knowledge, tools, and processes. Reflecting their particular ecological, social, and economic circumstances, each of the model forests has contributed to the SFM challenge individually. However, common themes of most model forests include building an ecological knowledge base and developing and testing new management strategies and practices.

The McGregor Model Forest (MMF) in central BC has developed a management planning framework and prototype system referred to as "the McGregor Approach to Sustainable Forest Management." The approach includes five integrated tools: 1) an adaptive management (AM) cycle as an overarching management process and philosophy; 2) a comprehensive spatial, tabular, and temporal information system; 3) a scenario planning process; 4) models to forecast future forest conditions; 5) indicator systems; and 6) reporting and visualization techniques.
The Foothills Model Forest (FMF) in west-central Alberta has focused its efforts in different but complementary areas of SFM. For example, it has developed and implemented a comprehensive program to help understand, communicate and integrate into management, patterns and processes of historical disturbance. This work has provided a common conceptual theme and knowledge base which partners can use to make decisions.

In Phase III of the model forest program there is an opportunity to integrate the SFM approaches developed by the MMF and FMF. The anticipated result will be a more complete SFM framework and a set of functional tools to address social and economic values more thoroughly in the context of ecological sustainability.

Introduction

Over the past decade, the Canadian Model Forest Program has contributed significantly to the discussion, definition, and practice of sustainable

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[1] Prepared for and presented at XII World Forestry Congress, September 21 – 28, 2003, Quebec City Canada —
(C) People and Forests in Harmony: Research Technology and Education, Paper No. 1043 (p. 243).
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[4] Keywords: Sustainable forest management, natural disturbance, scenario planning; decision support systems, ecosystem management; landscape ecology, Foothills Model Forest, McGregor Model Forest, biodiversity, adaptive management.

forest management (SFM). Across eleven model forests in Canada, these developments have helped the forest sector improve its understanding of the many dimensions of sustainability as it applies to the values ascribed to particular forestland areas (Brand et al. 1996). This has been achieved through a unique and creative mixture of people, knowledge, experience, information, tools, and processes.

Figures 1 illustrates how these components might work together to form a generalized framework for SFM. Driving the process are our environmental, economic, and social values, and general-level expectations of the forest at a range of scales, from local to global. These collective aspirations are interpreted into a set of high-level goals. Provincially, these might include "to conserve and restore the natural biological diversity of landscapes and terrestrial and aquatic ecosystems." Regionally, a biodiversity goal might be "to maintain old growth forest at the landscape level." These goals must then be translated to specific strategies across a landscape, which, in aggregate, will contribute to achieving the higher-level goals (Gunn 1996). For instance, a strategy for achieving the biodiversity goal stated above might be to "maintain the percentage of old forest within the historical range." The translation of goals to more specific strategies for a defined forest area is a major challenge for agencies trying to adopt SFM ideals, and is the main focus of this paper.

We propose that the success of this translation lies in the degree to which three main elements are developed and brought together. The SFM foundation is represented as the "core" of Figure 1. It includes scientific understanding, expertise, opinions, and information about ecological, social and, economic features and processes, over space and time. We suggest the initial emphasis be placed on ecological knowledge, since in order to sustain system-dependent values, we need a healthy forest.

The second element is a set of tools for organizing, exploring, interpreting, and communicating our collective knowledge about resource values, management objectives, and their interactions. Since we must do all of these things over space and through time, many of these tools must be spatially and temporally explicit. For example, information systems, a scenario planning process, indicator systems, forecasting and interpretive models, and visualization techniques permit the exploration of alternative futures that recognize the inherent natural, spatial, and temporal dynamics of the system being managed. They also ultimately guide management decisions, and help assess their outcomes in the longer term. As stated recently by Gordon Baskerville[5] "The basic principle in planning a temporally and spatially dynamic system, such as a forest, is that while it is not possible to have any one value at one place in the forest all the time, it is possible to have all values continuously available some place in the forest all the time. That principle is deceptively simple. The design, and reasoned implementation of management of a naturally dynamic forest, for consistent temporal/spatial availability of an array of values is an enormous challenge."

The third integrative element is the AM cycle, forming the outermost circle in Figure 1. This is now accepted almost universally as an essential process and overarching philosophy to support SFM. As a philosophy, it acknowledges the fact that SFM knowledge is imperfect and that management activity, therefore, serves as an opportunity to learn and improve practices over time. As a tool, adaptive management helps to structure management uncertainty and apply the best available knowledge to test alternative practices.

The model forest program in Canada has contributed significantly to the development of various aspects of the three basic SFM elements described above. Furthermore, a number of these elements have been integrated to form prototype SFM management "systems." This paper focuses on summarizing developments in these areas based on the experiences of the McGregor Model Forest (MMF) and Foothills Model Forest (FMF), and how combining their efforts may lead to a more robust system of deriving landscape-specific objectives from high-level goals.

McGregor Approach to SFM

The MMF's 180,000-hectare landbase is located in the sub-boreal ecological region near Prince George, BC. Managed under as a Tree Farm License on provincial Crown land, the MMF Association was formed in 1993 as a non-profit society representing over thirty partners, all with an interest in SFM. In addition to research and development on the model forest area, a number of pilot projects were also conducted elsewhere

[5] Presented in a talk to the McGregor Model Forest Association at a partnership meeting, June 27, 2002, Prince George, BC.

around BC (Wolfe 1994). Beginning in April 2002, the MMF program expanded to encompass the 7.7 million hectares Prince George Timber Supply Area, and currently involves a partnership of over 40 organizations.

The following discussion outlines the McGregor Approach to SFM, with a focus on four of the seven SFM tools shown in Figure 1. Descriptions of the information systems and indicator systems, along with other MMF program accomplishments, can be found in *The McGregor Story — Pioneering Approaches to Sustainable Forest Management* (MMFA 2001). The natural range of variation tool is described in the FMF section.

Adaptive Management Cycle

The McGregor Approach to SFM adopts the six-step AM cycle developed by the BC Ministry of Forests (Nyberg and Taylor 1995). As a framework it serves as an overarching management process and philosophy. AM here is described as "a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. The key characteristics include: acknowledgement of uncertainty about what policy or practice is 'best'; selection of the policies or practices to be applied; implementation of a plan of action designed to reveal the critical knowledge; monitoring key response indicators; evaluation of the outcome against the original objectives; and incorporation of results into future decisions." (modified after Nyberg 1998).

Scenario Planning

The scenario planning process provides support to the first two AM steps (Figure 1 and 2) as "a disciplined method for imagining possible futures" that creates a series of narratives about how different futures might unfold and appear (Schoemaker 1995). It helps stakeholders to assess opportunities jointly, identify alternative future forest conditions, and design and chose a management strategy that meets their collective objectives. The process benefits from varied perspectives of the participants, including the public, to narrow-in on issues that are most significant. Unlike more data-driven analytical approaches, scenario planning considers a number of factors simultaneously, drawing upon shared human experience. By addressing the problems of both under- and over-prediction, it strikes a balance between circumstances we feel we understand and elements for which there is uncertainty.

Scenario planning formally includes a number of steps, as detailed in Figure 2. Some of the key processes used by the MMF include defining the scope; engaging key stakeholders in the process; assembling the databases; identifying key values; developing management objectives and indicators; considering major trends, and uncertainties; formulating "initial themes"; constructing contrasting "learning scenarios"; running forecasting models; and refining management options down to one or two final "decision scenarios." Learning scenarios portray futures that are plausible with a particular management bias towards, for example, intensive forestry, wildlife, or recreation.

Figure 3 illustrates the current condition of the MMF area in comparison to two scenarios, intensive forestry and BC Biodiversity Guidebook (Parminter 1995), at year 2100. The scenarios are illustrated using a visualization for a portion of the MMF area, and a planimetic map for the entire forest. Indicators are also shown for timber volume, mature seral stage forest, and large patch sizes. During the exploration stage much was learned about inter-relationships between resource values, management objectives, future trends and uncertainties and their effects on outcomes. Once final decision scenarios were prepared, the participants had a broad appreciation for different resource interests and for spatial and temporal forest dynamics. They were able to "see", literally, how different sets of objectives could realize acceptable tradeoffs when considered across the entire MMF area over timeframes exceeding 200 years.

Models

Models play an essential role in supporting the scenario planning process. Since initial scenario development draws upon collective experience, it is difficult to know the feasibility of different scenarios, and their ability to achieve the desired outcomes. Comprehensive geographic information system (GIS) databases are developed to "run" the scenarios using spatially and temporally explicit forecasting models with selected indicators. The two main models used are a treatment model and a scheduling model. The treatment model automates the delineation of potential treatment units based on species composition, slope, and other spatial

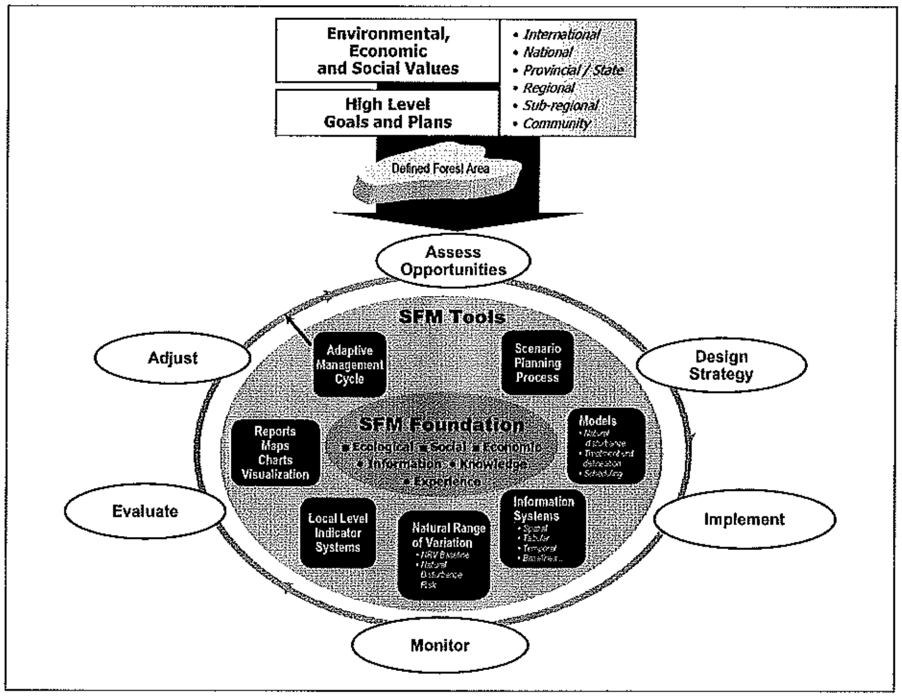

Figure 1. A proposed SFM framework for translating high-level goals into landscape-specific objectives comprising three integrated components: an SFM foundation, SFM tools, and an encompassing adaptive management cycle.

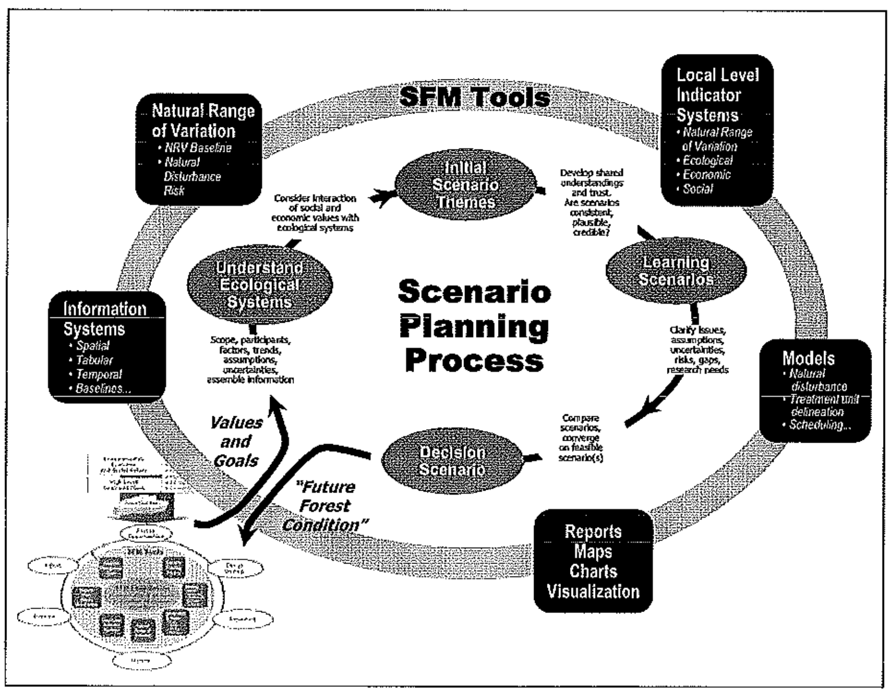

Figure 2. A proposed scenario planning process for translating high-level goals to landscape-specific objectives, and to serve the "assess opportunities" and "design strategy" steps of the adaptive management cycle.

and operational constraints. For fragmentation, a software program aggregates treatment units into patches.

The scheduling model creates a sequence of treatments and portrays future conditions, by specified periods, for several rotations. The models have been applied to areas as large as 6 million ha. The scheduling model approximates dominant ecological processes and management interventions, thereby enabling different scenarios to be projected and compared. Since the modeling does not compromise the spatial representation of the scenario, spatially sensitive values such as wildlife or recreation can be accommodated. Competing management objectives can be addressed through an integral optimization technique. Near-optimal solutions are found by performing thousands of model runs for any particular scenario, then evaluating multiple values, objectives, and constraints against desired outcomes. Many of the constraints relate to regulatory rules such as the Forest Practices Code (FPC) (BC Ministry of Forests 1994). For locating and timing the treatment units, the scheduling model considers spatial relations, special management area requirements, treatment unit size, adjacency and green-up constraints, and visual quality objectives. Outputs from the model include spatially explicit schedules and associated reports for all treatment units.

The scheduling model lets the user change objectives interactively, and view the effects instantaneously. The system uses a Java interface for both entry of parameters and real-time display of results. In an educational environment, this is valuable for studying the dynamics of forest estate planning. Figure 3 shows the model interface and a result chart. The model can support management planning requirements from the strategic through to the detailed operational level. Maps of forecasted futures are critical for communicating the results of a proposed plan and for validating the assumptions (Figure 3).

Reporting Future Outcomes

With large forest areas and long timeframes, being able to convey alternative future scenarios effectively is a challenge. This is especially difficult for SFM participants, who are most familiar with timeframes of a single human generation. While GIS tools can generate many useful reports and maps, a key MMF accomplishment has been the development of visualization techniques referred to as Future Landscape Interpretation (FLI). The FLI tool provides tangible visualizations of future conditions, much like a motion picture time machine. It can also be used to "fly" virtually over an entire area, by integrating remote sensing images, 3-D digital elevation models, and GIS and rendering tools. Figure 3 shows three visualizations from a fixed location for the current condition, and two future scenarios at year 2100.

The FMF Approach to SFM

Foothills Model Forest

At over 2 ½ million hectares, the FMF is one of the largest model forests in Canada. It is also one of the most diverse, including portions of the Foothills, Montane, Sub-alpine and Alpine ecological zones (Beckingham et al. 1996). The landbase includes 1,000,000 hectares of working forest, (managed by Weldwood of Canada Ltd, Hinton Division) although the majority of land is managed by federal, (e.g., Jasper National Park) provincial (e.g., Willmore Wilderness Area), and municipal governments. The management goals for the FMF landbase are understandably diverse.

The difficulty of developing a single SFM system for all partners at the FMF is obvious. Given the diversity of partner needs, the FMF approach to SFM was to develop a wide range of tools available to, and valuable for all partners. For example, the FMF has been involved in research on a wide range of species including grizzly bears, caribou, and Harlequin ducks. As well, it has conducted intensive inventories of fish populations, implemented experimental prescribed burn programs, and coordinated the creation of a provincial biodiversity monitoring program (Foothills Model Forest 2001).

The Natural Range of Variation (NRV) Strategy

One of the cornerstones of the FMF Phase II program has been the Natural Disturbance Program. Understanding natural disturbance as an ecological process has been gaining favour across Canada as an alternative way of managing biodiversity values. The more traditional species (or "fine filter") approach to understanding and managing biodiversity values has served us well until now, and the FMF has invested heavily in this type of research. However, the number of species is (for all intents and purposes) limitless, and

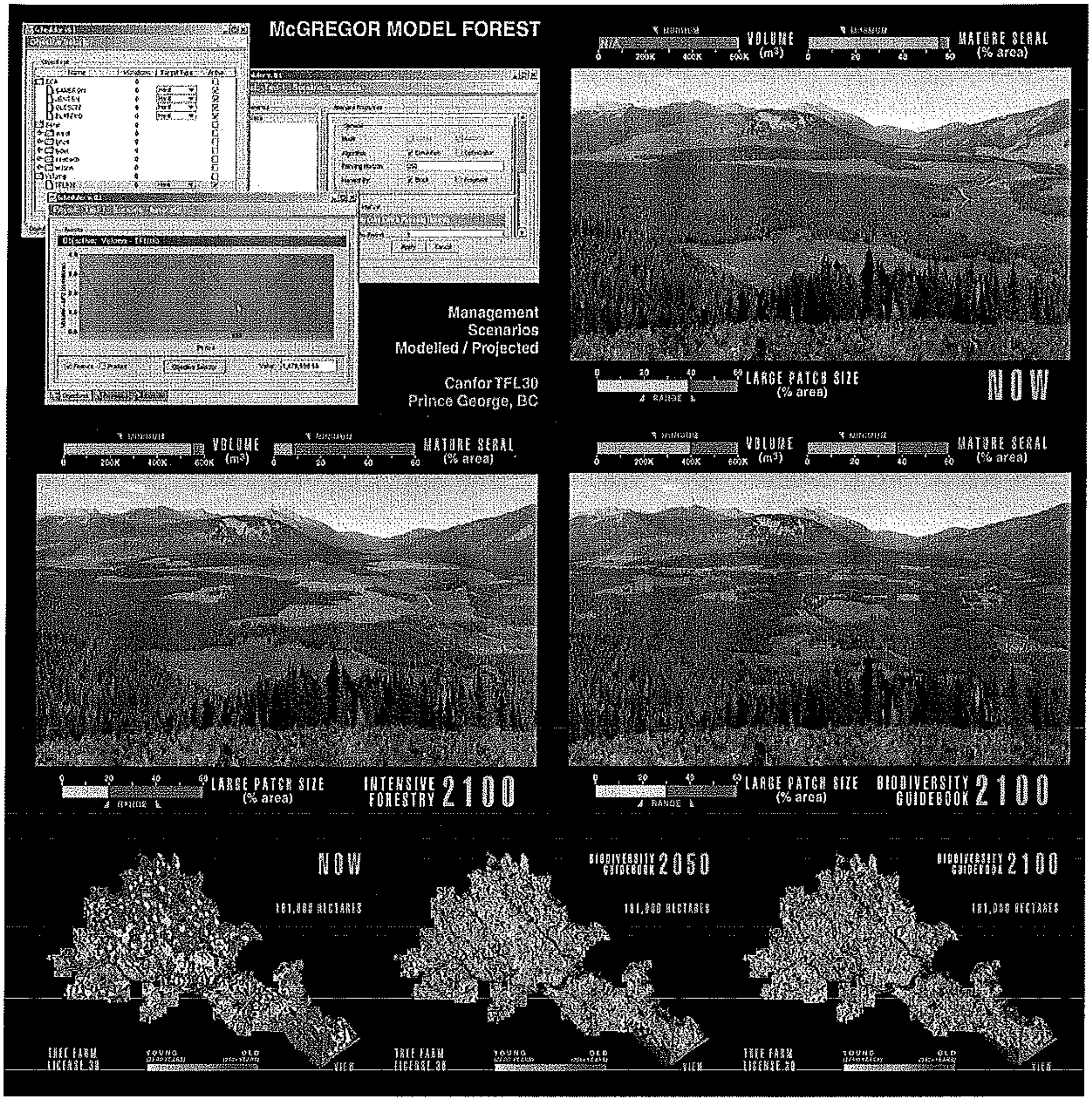

Figure 3. McGregor Model Forest composite graphic showing the scheduling model interface (top left) and landscape visualizations, maps, and indicators for the current forest condition and two scenarios at the year 2100.

maximizing the needs of one species often comes at the cost of minimizing or eliminating others. Furthermore, local extinctions, periodic high mortality levels, and other perturbations are a part of natural cycles (Bunce and Jongman 1993). The danger of adopting fine filter strategies alone is that this may result in biodiversity becoming a constantly moving, subjectively defined goal.

Alternatively, landscapes can be managed through an understanding of the available resources provided by a dynamic landscape over time and space (Merriam and Wegner 1992). By first understanding, and then managing for, the natural range in variation of the ecological processes most active on a landscape, the risk of losing biological function is minimized, since the rate, intensity, and magnitude of the processes are familiar to the landscape (Noss 1994). In northern forest landscapes, structural and compositional dynamics are predominantly a function of natural disturbance activity. Thus, wildfire, flooding, windthrow, and insect outbreaks are the ecological processes that largely define landscape dynamics. In practical terms, this suggests that a tenable strategy for forest management is to approximate the range of structures that natural landscapes exhibit through an understanding of natural disturbance processes and patterns (Gauthier *et al.* 1995). This more holistic approach to biodiversity is commonly known as a "coarse filter" strategy, although the term "natural range of variation", or NRV, is often used synonymously.

The FMF Natural Disturbance Program

The FMF Natural Disturbance Program was designed as a package to include NRV research, related ecological research, communications, and integration (Figure 4). This more integrated strategy was designed to specifically address several specific partner needs as they relate to SFM (Andison 2001). First, it generates for all partners a defendable, quantifiable foundation of knowledge of how forest landscapes operate as systems. As illustrated in Figure 2, the first step in any SFM decision-making process is gathering the best available knowledge, but such knowledge also informs policy, operational guidelines, and even monitoring efforts.

Second, the program has demonstrated (through talks, tours, workshops and reports) how integral disturbance is to forests. Seeing forest landscapes as "dynamic" entities is a difficult concept, and decades of "Smokey the Bear" messages are well ingrained in people's thoughts. For example, Jasper National Park has used the research to help design and defend prescribed burn programs meant to reduce extremely high fuel-loads caused by decades of fire control.

Third, the investment in the natural patterns study has provided an objective, easily measurable foundation on which to build sustainable management planning scenarios. For example, Weldwood used seral-stage NRV output from a simulation modeling exercise as the natural "baseline" against which various management alternatives were compared in their most recent long-term forest management plan (Andison 1998, Weldwood of Canada, 2001). This tool is also represented in Figure 2.

Fourth, because NRV research output is usually expressed in terms of vegetation pattern, it is ideally suited to defining indicators and targets for monitoring programs. For example, patch sizes, area disturbed, and even the structure of a disturbance edge, are all ecologically meaningful, and are easily quantifiable coarse-filter indicators. An Integrated Resource Management pilot study in west-central Alberta has used the FMF natural disturbance work to identify monitoring indicators, and will be using the methods and indicators developed at the FMF to define natural baselines for the region.

While the FMF has been successfully studying natural patterns, and integrating them into forest management in various ways, the full potential for using this information within a more formal SFM system has not yet been realized. For example, while the integration of a scenario or visualization models are part of the long-term plan (Figure 4), they have not yet been developed. Similarly, the direct integration of local-level indicators has not yet occurred. On the other hand, FMF partners can now benefit from the work already done by the MMF on these and other initiatives, using the NRV work as the foundation.

Integration of MMF and FMF Sustainable Forest Management Approaches

Different Emphasis in MMF and FMF

The different settings and priorities of the McGregor and Foothills Model Forests led to a different emphasis in each case in addressing the SFM challenge. The MMF had a strong focus on developing a new approach to forest planning within a dominantly industrial forestry setting. Up until recently, the resource management regime was prescriptive in nature and strongly dictated by BC's FPC. When coupled with multiple planning levels and mandates, management occurred within a complex and relatively inflexible policy, planning, and regulatory framework. In response, the MMF focused its attention on developing innovative and flexible planning approaches aimed at striking a balance between meeting the stringent requirements of the FPC and aligning with the intent of higher level plans.

The FMF was motivated by a very different set of circumstances. Given the task of having to provide support for a much broader partnership including both working and non-working forest, and responding to the Alberta government's desire to have land management organizations assume greater levels of responsibility, the FMF took more of a bottom-up approach. They defined their role by identifying and developing key individual components of the SFM picture, which were commonly valuable.

Integration of the Two SFM Approaches

We believe that the different approaches taken at the two model forests are complementary and can be integrated to help translate high-level goals into landscape-specific, spatially and temporally explicit objectives. We demonstrate how this might occur by adapting the original SFM framework concept developed by the MMF (Figure 2).

Consistent with "science-based" decision-making (Gilmore 1997), the first task is to form a collective understanding of the ecological systems present (Figure 2). NRV knowledge is a large part of this step, but it should embrace all biological information, including local ecological knowledge. Models, reports, maps, and visualizations are all used at this stage as tools for communication. Indicators are identified and used for tracking and comparing landscape dynamics over time and space. Using this knowledge, an NRV "baseline" scenario can be described which shows landscape patterns when there is no management intervention. Considerable time is required at this point to develop "shared understandings", since disturbance processes often occur over long timeframes and are difficult to envision. In fact, addressing the temporal aspect of SFM effectively is a significant challenge. The payoff from this investment, however, is attaining a common understanding of landscape–ecosystem features and processes, all of which are important for making better-informed decisions.

The next step is to build scenarios by manipulating the landscape using models. For example, we may impose extreme management actions on the landscape to help "bound" the decision-making process. The MMF refers to this step as generating "initial scenario themes;" it involves most of the tools mentioned earlier, and introduces both social and economic factors. This process evolves into the development and testing of more complex, but also more plausible scenarios based on what was learned from the initial scenarios. With the high-level goals and management objectives in mind, various indicator target combinations are tested against each other. While it is important to examine as wide a range of scenarios as possible, to be realistic and feasible, scenarios should consider risks and uncertainties. The NRV baseline scenario serves as a continual reference for historical levels of variation.

One of the advantages of using a scenario method of decision-making is the emphasis on "future forest conditions" as opposed to only choosing among objectives. In other words, stakeholders choose how they want future states of the forest to look and provide values. Since indicators have been used throughout the process, a final "decision scenario" is easily translated into a set of meaningful objectives. Subsequent monitoring and assessment are similarly facilitated using the same indicators and targets.

Elements of the scenario system described above have been outlined by others. Diaz and Bell (1992) differentiate between an "analysis phase" and a "design phase" during decision-making, which essentially parallels our transition from "learning" to "management" scenarios. They also developed a visual abstraction toolbox, which allowed landscape "narratives" to be created as part of the education and understanding phase. Both Yamasaki et al. (2001) and Andison et al. (2002) designed full decision-support "systems" in which NRV is used as an ecological benchmark, and define variations of future forest conditions as the basis of decision-making.

Conclusion

The concept of SFM is noble, and seldom contested. Translating the concept into practice, however, is more of a problem than we could have imagined a decade ago in the model forest program

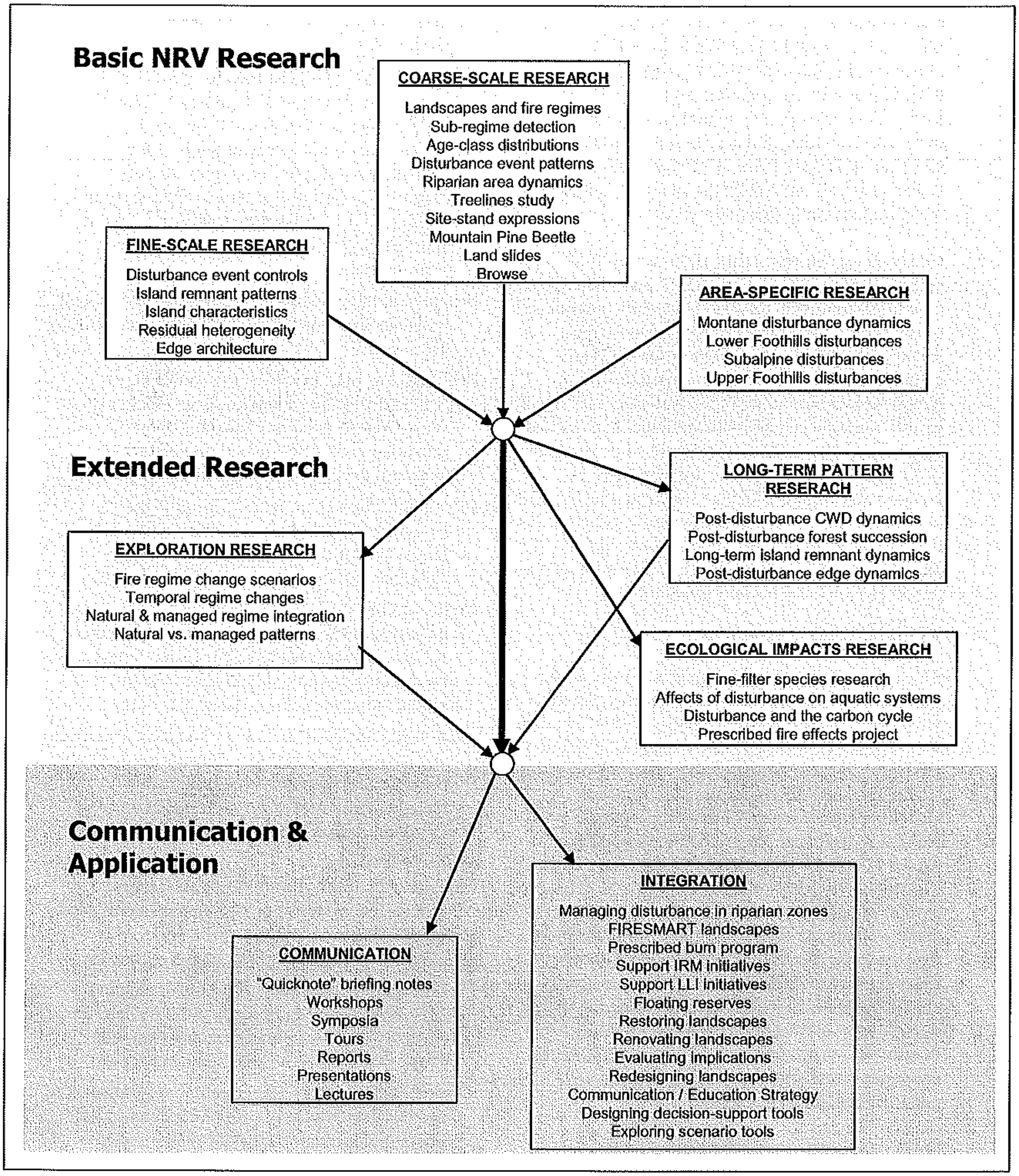

Figure 4. Foothills Model Forest Natural Disturbance Program Long Term Map (adapted from Andison 2001).

and elsewhere. Part of the challenge is due to: 1) the complexity of the problem in its entirety; 2) understanding the dynamics of nature; and 3) developing practical planning and management systems that incorporate natural, spatial, and temporal dynamics, and are tangible to a wide spectrum of stakeholders. Each model forest in Canada has responded to these challenges in often different, but complementary ways.

In this paper, we demonstrated how two SFM approaches developed at the MMF and FMF could be integrated to help resolve the specific challenge of translating high-level goals into landscape-specific objectives. This solution serves as an example of how integrating knowledge, experience, information, tools, and processes into a whole "system" can be more valuable than just the sum of its parts. A framework breaks the problem down into more manageable and concrete components, but also focuses on the connections between them. Ultimately, an integrated system helps to better inform decision-makers and practitioners about forest sustainability options for practices today and far into the future.

Acknowledgements

The programs discussed in this paper were made possible only through the efforts and support of a wide list of individuals and agencies. The Canadian Forest Service, Weldwood of Canada Ltd. (Hinton Division), Jasper National Park, Alberta Newsprint Company, and Alberta Sustainable Resource Development have generously supported the Natural Disturbance Program at the Foothills Model Forest for several years. Likewise, the McGregor Model Forest Association's 30-plus partner organizations have supported the research and development of SFM systems in BC for more than 10 years. We would also like to thank the large number of individuals who have dedicated considerable effort and thought into making these respective model forest programs successful. Finally, we would like to thank Anne Scott and an anonymous reviewer for her helpful edits and comments on this manuscript.

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