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THE ALBERTA EMEND PROJECT: RECIPE AND COOKS' ARGUMENT

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ABSTRACT

The EMEND (Ecosystem Management by Emulating Natural Disturbance) project has materialized through joint efforts among scientists at the University of Alberta, Northern Forestry Centre, Forest Engineering Research Institute of Canada, Alberta Research Council, representatives of the Alberta Lands and Forest Service, and foresters working for Canadian Forest Products Ltd. and Daishowa-Marubeni International Ltd. The basic rationale of the project, *i.e.*, to fill significant information needs of modern industrial forestry through multi-disciplinary, collaborative research, was developed through a series of meetings and field excursions aimed at development of an experiment to improve understanding of the responses of a northern mixedwood forest to natural and anthropogenic disturbances. We worked to assure high probable levels of academic and intellectual payoff and excellent opportunities for graduate students. The overall objectives of the EMEND project include ecological, economic and social elements and their integration in the context of forest management appropriate specifically for the northern mixed-wood ecosystem of Northwestern Alberta. EMEND is now being established NW of Peace River, Alberta as a large-scale alternative harvest and stand structure experiment. The basic structure of the experiment is described.

INTRODUCTION

As described in our first network meeting in October 1995, the Sustainable Forest Management Network of Centres of Excellence (SFMN) encouraged new projects, especially those having scope and integrative objectives not feasible through the usual competitive programs that fund Canadian research. The Network was to provide a chance to do something new, something different from simply extending work already in progress. Such research was further meant to establish new collaborations and to achieve value-added benefits through linkage of excellent work conducted by researchers from a number of organizations. Perhaps most importantly, we were all reminded that SFMN-sponsored research was not to be "follow-your-nose" basic science, but should instead contribute to the applied goal of making the forestry industry a more sustainable proposition in Canada.

The SFMN's specific goal was to focus on evaluation of the "Natural Disturbance Paradigm" as a model for sustainable forest management.

A project, which eventually took the acronym EMEND ('Ecosystem Management by Emulating Natural Disturbance'), was conceived at the first SFMN meeting in an announcement by Frank Oberle that Canadian Forestry Products (CANFOR) and Daishowa-Marubeni International Limited (DMI) would support a large-scale project about ecosystem management. EMEND has met many of the original SFMN goals, as described above, and is in the process of meeting the rest. In this short paper, we describe how the EMEND project was developed and illustrate both the basic structure of the experiment and the nature of the collaboration that it has fostered. Most of the nascent scientific outcomes presently available from EMEND are provided in a companion paper by Volney et al. (1999).

PROJECT DEVELOPMENT

Development of the forestry experiment that is the basis of EMEND began when CANFOR and DMI invited several interested researchers to lead discussion toward scientific work that would better define the limits of ecologically feasible forestry in a northern mixed-wood forest. A project development committee (PDC), chaired by J. Spence, was struck to define appropriate objectives for a project and to work out a large-scale experiment suitable for meeting those objectives. The PDC was composed of research scientists from the University of Alberta (UA), Northern Forestry Centre (NoFC), Forest Engineering Research Institute of Canada (FERIC) and Alberta Research Council (ARC); foresters and ecologists from both CANFOR and DMI; and representatives from the Alberta Lands and Forest Service (ALFS) and the SFMN. From the start, EMEND has involved an unusual level of cooperation among researchers from a number of organizations and the forest industry.

The PDC promoted broad-based planning. After demonstration of significant potential interest at a general "open" meeting for potential participants in November 1995, the PDC held a series of meetings between then and September 1996 to hammer out the basis for EMEND. During the early phases of project development, industry and government representatives worked to agree on a short-list of deliverables desired, and the research personnel helped to mold what resulted into a coherent set of questions that could be approached through experiment. The PDC was assisted by syntheses of information provided by industry analysts and contractors to answer questions about present forest conditions and stand development, when these appeared to be relevant to the committee's deliberations. From the start, EMEND was designed in response to explicitly stated industry needs and with constant input from industrial foresters. This is very different than the usual scenario of a proposal wholly designed by scientists and taken subsequently to industry for financial support.

By early summer 1996, the PDC had defined the general objectives of EMEND as follows: i) to determine which forest harvest and regenerative practices best maintain biotic communities, spatial patterns of forest structure, functional ecosystem integrity in comparison with mixedwood landscapes that have arisen through wildfire and other inherent natural disturbances, and ii) to employ economic and social analyses to evaluate these practices in terms of economically viability, sustainability and social acceptability. We were also well on our way toward developing the suite of practical forest harvest and regenerative practices that would define the domain of the experiment. At this point, several researchers with economic and sociological interests were invited to contribute to project planning. The explicit aim of EMEND is to seek the limits of overlap among ecological feasibility, economic viability and social acceptability.

Adoption of a "natural disturbance" model for boreal forest management will lead away from extensive clear-cutting and toward retention of un-harvested residuals on the landscape (Hunter 1993). General effects of size and distribution of residual patches have been studied in Alberta and others elsewhere. However, the important question of "how much residual is enough to preserve and protect critical aspects of ecosystem function?" has received scant attention, especially in North America. Thus, the PDC found little scientific basis to guide management of stand structure in a northern mixed-wood forest. Retention of either green-tree or dead residuals can be significant for forest regeneration. Therefore, sustainable management depends on connecting harvest patterns and techniques to forest regeneration procedures to promote holistic and ecologically-sensitive silviculture. New procedures are required to accommodate the expanded objectives of sustainable management on public lands that are to be managed extensively, i.e., with a broad range of whole-forest objectives in mind.

It was evident that a large-scale experiment would be required to investigate how development of stand structure was related to natural disturbances for a representative range of forest cover types. However, the PDC recognized that true "landscape level" experiments are virtually impossible at spatio-temporal scales relevant for operational forestry. If landscapes originating from different management practices are to be compared through experiment, replicates of each "landscape element" × "management prescription" combination are required. Opportunities for useful comparisons of pattern and process relevant to landscape-level considerations may arise as a result of forestry activities in the northern mixed-wood. However, executing effective experiments on this scale is both, scientifically tenuous because adequate replication is improbable, and operationally impossible because of business constraints.

Thus, the PDC developed EMEND with a stand level focus under two assumptions. First, we held that future landscapes subjected to forestry activity will be mainly permutations of stand-level prescriptions invoked by forest managers, un-harvested reserves (including naturally disturbed areas), and areas without merchantable timber. As disturbances associated with oil, gas and other natural resource development become more significant, their specific effects also should be factored into rational landscape planning. Second, we assumed that significant landscape outcomes related to forestry activity can be adequately predicted by summation of stand-level effects. Where this assumption is most risky (e.g., with respect to maintaining sparse populations of organisms requiring large tracts of continuous forest) the desired outcomes will likely conflict with most economically viable forest harvesting. Such processes or populations will be best maintained through a system of appropriately sized reserves, though these might be spatially rotated on time scales sufficient for complete regeneration of once harvested forest.

Subsequently the PDC worked to plan an experiment that would involve several harvesting treatments that left green tree residuals, standard clear-cuts, un-cut reserves and experimental burns. The overall plan also called for investment in silvicultural experiments, especially in compartments subjected to innovative harvest prescriptions. Our three main efforts are described below.

1) We worked through an iterative process to finalize the experimental design, as outlined in the next section. Four formal plans, each with some elements of the final design, were proposed and carefully discussed as tempered by broad consultation outside the PDC. All were eventually rejected in favour of a revised design. For example, the working design approved in January 1997 was rejected in May 1997 when a field tour revealed that what logging contractors actually delivered on the ground was rather far removed from what many had imagined around the PDC table. The final experimental design is a compromise. On the one hand, we sought, based mainly on theory and intuition, to study of how to best optimize relationships of a number of response variables indicative of sustainable forestry. On the other hand, to be relevant to managers, we needed to work within the realm of simplicity and practicality that dictates what can be delivered repeatedly on the ground at an operational level.

2) An executive sub-committee of PDC (EXC, i.e., the authors of this paper) worked between October 1996 and July 1997 to select an appropriate study area and to choose specific stands for the experiment. The PDC had agreed to focus on mature and overmature mixed-wood stands, growing on mesic, upland sites in the "extensive management zone" of the P2 forest management area. With significant support from the SFMN, a 6-person field team led by Project Coordinator Lisa Cuthbertson collected detailed mensurational data from a range of candidate stands located in an area of P2 found to have the mix of cover-types required for our unfolding design. We then selected the EMEND stands with the goal of maximizing similarity among replicates of each cover-type (Spence et al. 1999, see also Volney et al.1999). The stands were partitioned into *c.* 10 ha

compartments by DMI personnel and treatments were cast haphazardly (i.e., without regard for overall spatial configuration of compartments) onto the stands.

3) The EXC, mainly through efforts of M. Weber and S. Luchkow, sought and achieved provincial approval to conduct experimental burns as part of the EMEND experiment. We have worked with ALFS personnel to develop the formal plans for experimental burns. This latter effort has included juggling the position of some burn treatments to maximize fire-proofing based on detailed considerations of site characteristics and fuel loads. Although this latter non-negotiable consideration means that configuration of compartments is not strictly randomized, no particular adjacency relationships have been imposed among compartments.

EXPERIMENTAL DESIGN

The core EMEND experiment includes two driving variables and follows subsequent behaviour of a number of response variables, both without further intervention and under a range of innovative silvicultural treatments (Fig. 1). The silvicultural prescriptions are to be cast on one-ha subplots within specific site by treatment combinations. The specific silvicultural prescriptions are not further discussed here, but questions are referred to either D. Sidders or J. Stewart at the Northern Forestry Centre in Edmonton.

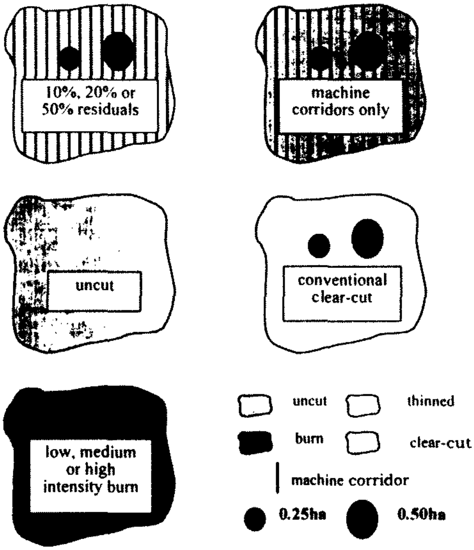

Figure 1. EMEND treatments.

The first driving variable, forest cover-type, was partitioned on the basis of canopy composition of stands before harvest and the classes represent the main categories of merchantable stands that must be managed. These are as follows: 1) conifer dominated (70-95% of canopy coniferous), 2) mixed (conifer and deciduous composition each 35-65%), 3) deciduous dominated with coniferous understory extensive and at least 50% of canopy height, and 4) deciduous dominated (70-95% of canopy deciduous). Levels of the second driving variable, the amount of living residual retained after harvest, are defined for experimental manipulation as follows: a) 0% (clear-cut); b) 10%; c) 25%; d) 50%; e) 75%. Residuals corresponding to harvest prescriptions a-d above are being left in thinned areas between machine corridors. Additionally, all harvested blocks will retain two ellipses of un-cut forest, one *c.* 0.25 ha and the other *c.* 0.50 ha in area, oriented as regularly as possible within compartments. The ellipses provide internal "forest" controls for each compartment, but serve mainly to test their utility in retention of biodiversity. Harvest prescription 'e' will be achieved by cutting machine corridors only; thus, it serves both as a high-residual treatment and a control for the effects of the corridors alone. All treatment combinations are being replicated three times in each cover-type through application of the above harvest prescriptions even as this paper is presented. Analysis of harvesting techniques and their cost is being carried forward under the leadership of E. Phillips (FERIC).

Treatment effects will be interpreted in relation to two types of "controls", each replicated spatially along with harvest treatments: either uncut blocks, or those burned experimentally at intensities representing the range of ground fires observed in each cover-type class. We aim to kill all trees in "high intensity" fires, a substantial number in "medium intensity" fires and only a few in "low intensity" fires. Each control, except those involving high intensity fires, will be replicated three times in each cover type; high-intensity fires will be conducted on only a single block within each cover-type. Fire intensities will be achieved through judicious consideration of fuel-loading and timing windows that set burning conditions in relation to weather. In addition to serving as controls for the overall EMEND experiment, more focused aspects of boreal fire behaviour and impact are being studied with the experimental burns. In particular, the burns will be used to test local fire behaviour models that make predictions about post-fire stand structure and contribute to our ability to predict fire-mediated consequences of climate change (Weber and Stocks 1998).

The system of controls supports a variety of comparisons. Comparisons of burned and harvested blocks will reveal the extent to which harvest-silviculture combinations foster successional trajectories similar to natural processes. These questions may be asked at several levels, *e.g.*, harvested vs. burned compartments, fire skips vs. ellipses. Comparison to uncut blocks will reveal i) if species from a range of indicator groups are threatened by longer term structural changes in harvest-origin stands, and ii) if residual "old-growth" islands are effective sources of colonists for weakly-dispersing species at risk to broad extirpation under large-scale forestry. We note that the comparison to un-harvested blocks has been protected by collection of pre-harvest data during 1998 for most important response variables. Given the size of the experiment (100 compartments, *c.* 1000 ha) and its already-coarse ability to estimate variances in response variables, we exclude additional driving variables. Nonetheless, study of other variables, through smaller experiments on a subset of harvested blocks, will be essential. For example, effects of variation in volume of coarse woody material might be analyzed with a regression approach, using data about natural variation between blocks or, for some questions, data reflecting within-block variation. Experiment-wide or "core" EMEND research focuses on how several ecological state variables and processes are affected by cover-type, harvest treatment and their interaction, and how effects may be modified with silvicultural prescription. The variables being considered in the initial years of the experiment fall into the following categories: i) succession and dynamics of biodiversity; ii) residual structures and nutrient cycling; iii) regenerated structures; and iv) site productivity and growth and yield of merchantable fibre. Below we summarize the issues being considered with respect to each of these foci.

Biodiversity

We seek to develop and test and suites of indicator species and assemblages (McGeoch 1998), especially among invertebrates, fungi and understory plants. The broad-based comparisons of biodiversity required to support development of indicators, will permit a comparison of food webs promoted by different treatments. Resources permitting, we will also develop studies of selected inter-stand processes (*e.g.*, movement of selected taxa across stand boundaries and establishment of self-propagating populations) for models to project landscape effects for the biota.

Residual Structures

Attention is focused on the dynamics of coarse woody debris, including trajectories of snag-to-soil decay for major tree species and study of the biotic communities involved in the decay process. Work on nutrient cycling will incorporate study of litter dynamics and the food web work described above and extend to study of soil processes and development. We are especially interested in the effects of residual green trees on wildlife use and in the general silvicultural implications of stands that approach shelterwoods and unevenaged management systems (Lieffers et al. 1996). Studies of the expression of propagules (*i.e.*, seeds and spores) left in the soil after disturbance are being planned.

Regenerated Structures

Special attention is being given to initial understory development. We are particularly interested in understanding the site features associated with dominance of *Calamagrostis*; and in the trajectories of aspen, pine and spruce recruitment. Thus, this work is linked to the study of residual structures above.

Site Productivity

The data based required to model growth and yield of commercial species is being through pre- and post-harvest assessments of standard mensurational data from six permanent plots in each compartment. Effects of the various treatments on development of shrub biomass, density and species composition is being followed from pre-treatment assessments. Subsequent variation in post-treatment net primary productivity will be connected to studies of trophic structure and to periodic assessments of forest health.

EMEND IN ACTION

The heart of EMEND summer activity for the past two years has been the field camp supported directly by CANFOR and DMI and located *c.* 100 km NW of Peace River, Alberta along the DMI forestry road west of Dixonville. The camp provided a base for the site selection and stand assessment activities conducted during 1997 and for the collection of pre-treatment data by a range of researchers during 1998. The camp provides meals, overnight accommodation and research space free of charge for researchers associated with any approved EMEND project. During 1998, for example, nearly 70 researchers used the camp, logging in more than 2000 camp days and representing eight research institutions. EMEND experiment is being laid out on the ground by harvesting conducted over the present winter (1998-99). It will be the centre for the first bout of post-treatment assessments scheduled for the summers of 1999 and 2000.

EMEND research falls into three categories, which are used to determine priorities for access to project resources. Highest priority is accorded to experiment-wide study of the four categories of response variables outlined above. This is the so-called "core" research program and it is executed by a group of 6-8 summer students, known as the "core crew" and supervised directly by the project coordinator. This work, which requires detailed measurements in each of the 100 experimental compartments, is essential to understand the overall impacts of the two driving variables and their interaction on the response variables selected for experiment-wide study. The "core crew" activities have been partly supported by the SFMN during 1997 and 1998, but over the first two years of field activity *c.* 75% of the cost has been borne directly by the sponsoring companies. High priority for use of the camp and access to EMEND resources is also given to SFMN-supported projects that deal with process-oriented work to understand ecological integrity of these forests under the experimental management regimes. Most of these projects are focused on only a subset of the EMEND compartments. Most of the work being carried out by the 8 graduate students and postdoctoral fellows presently associated with EMEND, for example, falls into this category. Apart from camp costs, the researchers involved supply the financial resources for their own projects in the form of SFMN and other grants. However, as core duties permit, such projects are eligible to receive in-kind assistance from the core crew. The lowest priority is given to approved projects that seek to use aspects of the EMEND landscape or infrastructure, but do not contribute directly to the management goals of CANFOR and DMI.

An EMEND home-page (http://www.biology.ualberta.ca/emend/emend.html) has been developed to facilitate broad communication about the project. The web page provides descriptions of the research goals and activities of EMEND and access to data summaries as these become available.

SPECIAL FEATURES OF EMEND

The EMEND project is of particular interest in the context of sustainable forestry because DMI and CANFOR, respectively, hold overlapping tenures for hardwood and softwood harvest from the area chosen for the experiment (the P2 management zone). Thus, the relevant business model seeks to maximize efficiency through cooperation rather than to function in islolation. It is increasingly apparent that economic viability of the Canadian forest industry can be promoted by cooperation among its participating companies to increase efficient use of available fibre, and thus the business planning of EMEND's two main sponsors is relevant to sustainable forestry. We believe that this will provide a forward-looking and interesting twist to the EMEND results.

The approach taken at EMEND will provide data about complex trade-offs, critical for developing and modeling forest management in the light of sustainability criteria. For example, it is not possible to optimize the relationship between retention of biodiversity and forest productivity, nor to understand how this relationship can be affected by long-term changes in nutrient dynamics, unless the relevant variables are measured over the same time frame in a single system. In broad sweep, the EMEND project will provide some of the first rigorous data required to model relationships among ecological feasibility, economic viability and social acceptability in relation to a modern suite of harvest and silvicultural alternatives.

Formal linkage between EMEND research and the forest management plans of CANFOR and DMI is under development in the context of adaptive management. A critical aspect of sustainable management must be the flexibility to adopt new management approaches when new information shows that there are alternatives to present practices. Through development of EMEND, CANFOR and DMI have expressed their commitment to adopt a management framework that includes incorporation of new knowledge. Furthermore, ALFS has been most cooperative in development of the EMEND experiment, and it is hoped that high-quality results of this linkage can provide a model for more effective links between government policy development and the steady attempts of operational foresters to do a better job.

In summary, EMEND is on track to meet the many of the overall objectives of the SFMN. It is a new project, developed entirely since the initiation of the Network, and is promoting and facilitating research collaborations, forged from the bottom-up, among researchers from five universities (Alberta, British Columbia, Calgary, Laval and Lethbridge), three national agencies (CFS, the Canadian Wildlife Service and FERIC) and three provincial organizations (ARC, ALFS, and the British Columbia Ministry of Forests). At the present time eight postgraduate students are involved in EMEND work executed in the collaborative atmosphere provided at the EMEND camp. The work is sure to contribute to the applied goal of making the forestry industry a more sustainable proposition in Canada because the sponsoring companies, CANFOR and DMI, have taken an active interest in participating in project development. Inclusion of experimental burns in the EMEND design and the high level of attention being given to forest health implications of insects and disease provide a rigorous test "Natural Disturbance Paradigm" as a model for sustainable forest management. Where development of harvested stands departs significantly from the paradigm, EMEND will provide ecological, economic and sociological information required to build alternatives that meet sustainability criteria.

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