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USING OPPORTUNITY COSTS TO ASSESS THE ECONOMIC IMPACT OF SPRUCE BUDWORM DEFOLIATION

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CATEGORY: Decision support

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OPPORTUNITY COSTS AS A MEASURE OF ECONOMIC IMPACT

In 1984 studies were initiated to develop and test a practical methodology to gauge the economic consequences of extensive spruce budworm (*Choristoneura fumiferana* [Clem.]) defoliation, either incipient or anticipated. At that time, development of the methodology was viewed as a two-stage process. The first stage, a pilot study, was completed in 1987. The second stage, now complete, evolved as a collaborative initiative between the Canadian Forest Service (CFS), Sault Ste. Marie, Ontario and Avenor Inc., Thunder Bay, Ontario.

The result of the second-stage work is a methodology (i.e., an analytical framework) designed to facilitate the exploration of "what if" scenarios. Given a choice among alternative integrated forest pest management (IFPM) strategies, application of the framework focuses upon the determination and interpretation of differences in timber recovery costs — in essence, a measure of opportunity costs.

To illustrate the concept of opportunity costs, consider a hypothetical forest and an imminent spruce budworm outbreak. In advance of the anticipated outbreak, assume that forest management options are restricted to a choice between two strategies: (1) to initiate protective measures to counter any deleterious effects of the budworm infestation, or (2) to let the epidemic run its course and accept the consequences of extensive timber mortality. If the epidemic is allowed to run its course and the expected mortality manifests itself, then the consequent loss of commercial timber volumes represents a cost of not having undertaken the first course of action. The resultant commercial timber volumes lost is a measure of the opportunity costs of the decision taken — i.e., the cost of having chosen to forgo the opportunity to initiate protection.

In the presence or anticipation of a spruce budworm epidemic, the consequences of choice (among alternative IFPM strategies) may be expressed as a measure of perceived differences, over time, in the volumes and characteristics of the recoverable timber. Whether or not, and to what degree, such differences might be expected to bear adverse economic effect, will largely be determined by temporal expectations of mill furnish requirements, of price movement in the final goods market, and of the firm's ability to substitute alternative sources of supply.

Figure 1a is a representation of a firm's economic wood supply.[1] Figure 1b contains the same information superimposed upon a second representation, which contains higher average timber recovery costs due to volume losses arising from defoliation-induced mortality. If integrated forest pest management strategies permitted only two alternatives — full protection as indicated by Figure 1a, or no protection — then the difference in average mill-delivered timber recovery

[1] Economic wood supply is defined here as a quantity of timber available for harvest at a particular point in time. It details (least cost ordered) quantities of available timber, relative to progressively higher orders of magnitude in average timber recovery costs, typically expressed in terms of $/m³ of roundwood (or roundwood equivalent) delivered at the mill-gate.

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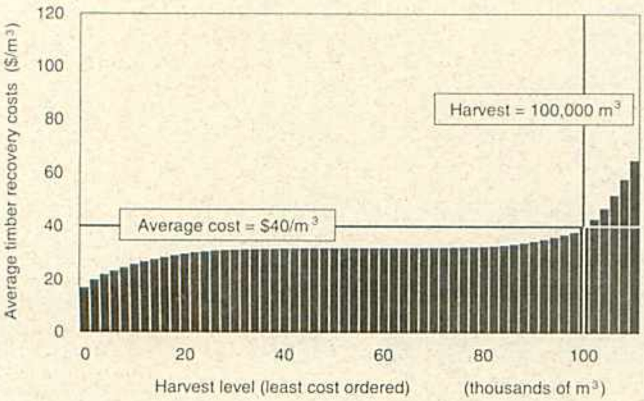

Figure 1a. Economic wood supply (no budworm damage).

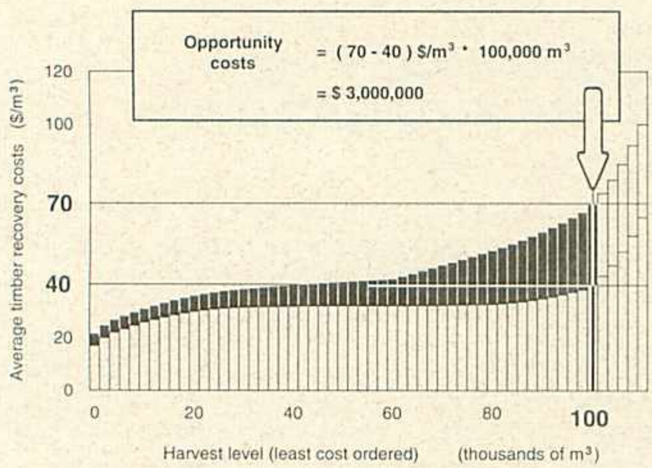

Figure 1b. Opportunity costs of no protection (at 100,000 m³).

costs (at some given harvest level) would indicate the opportunity cost of no protection, as calculated and portrayed in Figure 1b.

As illustrated in Figure 1b, at a targeted harvest of 100,000 m³ per year, the opportunity cost of no protection is $3 million. This result is based upon a comparison of two conceivable outcomes. If, for example, a third scenario was produced that indicated 90% foliage protection at a cost of $2.5 million, would it make economic sense to initiate this particular strategy? What would forest managers make of this third scenario or, for that matter, of any number of possibilities? By determining and comparing opportunity costs, it is possible to gauge the economic impact of spruce budworm defoliation and, given choices among a finite set of alternatives, it should be possible to determine which particular strategy best serves specific timber management and timber procurement objectives (vetted on the basis of opportunity costs, expressed in terms of revealed differences in timber recovery costs).

Commercial enterprise is predicated by perception and expectation — from perceptions of supply and demand in the marketplace, to expectations of market prices and costs of production (in the manufacture of forest products). If extraordinary timber mortality carries a risk of significant distortion of expected production costs, then foreknowledge of such will be of particular value.

The framework represents a practical capability to be used in conjunction with IFPM planning in the event of a spruce budworm epidemic. Coupled with professional judgement, the framework provides insight from relevant and available data — with the intent that such insight will complement and serve to advance the effectiveness of the planning effort. Application of the framework allows for the development of harvest schedules analogous to those portrayed in Figures 1a and 1b, projected in 5-year increments over a specified planning horizon of, for example, 20 to 30 years.

THE ANALYTICAL FRAMEWORK

Assuming that defoliation gives rise to extraordinary timber mortality, what magnitude of economic impact might be expected as a consequence of: (1) increased timber recovery costs as merchantable volume per hectare is reduced, (2) increased timber recovery costs as harvesting systems operability is impeded, and (3) compromised product quality and, hence, lower product prices as disproportionately larger volumes of marginal product (e.g., budworm damaged timber and/or nontargeted tree species) are absorbed as part of the overall mill furnish procurement?

If the intent is to undertake a comprehensive determination of the economic impact of spruce budworm defoliation, the preceding questions fail to accommodate all relevant influences.[2] However, they do represent the dominant effects and, as such, serve to define the context and the relevant parameters of the analytical framework. The framework is a system composed of the following parts:

1. a forest resource inventory;
2. a growth and yield model;
3. an inventory projection model;
4. a spruce budworm defoliation susceptibility rating system; and
5. a timber harvesting and transportation costs model.

A variant of Plonski's Normal Volume Tables (Bell 1978) provided the basis for development of the growth and yield model. FORMAN+1,[3] an inventory projection model, was adopted as the simulation platform. A spruce budworm hazard rating system developed in Quebec provided the basis for development of a localized defoliation susceptibility rating system (Gagnon and Chabot 1990). Harvesting costs were derived from earlier research results (Lougheed 1988).

[2] From a perspective of commercial interests, the economic impact of defoliation-induced mortality was perceived to be most evident in terms of its effect upon stump-to-roadside harvesting costs (in the short-term). Other effects, by no means insignificant, range from conceivable reductions in annual allowable cut allocations, to compromised aesthetic values.

[3] FORMAN+1 is a proprietary product of Timberline Forest Inventory Consultants Limited. Further information on FORMAN+1 may be obtained from the company at: #315 10357-109 St., Edmonton, AB. T5J 1N3. Tel. 403-425-8826. The use of FORMAN+1 does not constitute endorsement, implied or otherwise, by Natural Resources Canada or Avenor Inc.

If opportunity cost estimates are to provide the basis for economic impact assessment, they must follow from determinations of economic wood supply (as illustrated in Figure 1a). Divergence in outcomes, as described by comparative differences in economic wood supply projections, are derived from paired FORMAN+1 simulation results.

In applying the framework, FORMAN+1 simulations are generated in a two-stage process: first, at a highly aggregated level to determine timber production targets and second, at a more detailed level to determine the impact of defoliation-induced mortality on harvesting costs. On the assumption that timber production targets remain relatively fixed in the short term, successive simulations are used to test the possible mitigative effects of alternative IFPM strategies.

A data generator was developed to facilitate the task requirements of running multiple FORMAN+1 simulations. Using a process of interactive query, the data generator assimilates both empirical and judgmental information to build the necessary FORMAN+1 input data files.

Susceptibility to spruce budworm defoliation is influenced (in decreasing order) by factors of: proportional areal coverage to balsam fir (*Abies balsamea* [L.] Mill.) and white spruce (*Picea glauca* [Moench] Voss), age of the standing timber, stocking, proportional black spruce (*Picea mariana* [Mill.] B.S.P.) coverage, and determinants of site quality. Utilizing stand-level forest resource inventory (FRI) data, area-weighted means are compiled and processed to generate susceptibility rankings. Determinants of vulnerability (i.e., estimates of likely mortality) are provided by the user based upon intuitive assessment of forest class characteristics, the system-generated susceptibility rankings, and an acquired knowledge of local conditions.

APPLICATION

The framework was tested using FRI data from two northwestern Ontario forest management units. In one case, two scenarios were evaluated at a targeted harvest level of 150,000 m^3 per year. The scenarios contrasted forest development within the protected and the budworm damaged (i.e., unprotected) forest. With reduced yields per unit area, stump-to-roadside timber extraction costs were perceived to increase. This perceived increase is analogous to a measure of the opportunity costs of choice (i.e., of choice, given two alternative IFPM strategies).

Figure 2 is indicative of the nominal value opportunity costs of forgoing protection, projected in 5-year increments over a 30-year period. To expand the opportunity cost estimates to measures of impact upon mill-delivered timber recovery costs, additional costs must also come into play.

For example, Figure 3 indicates a substantive increase in the area of the harvest, over time. With harvests extending over an expanded land base, administration and road construction costs must also increase. Therefore, to account for these increases, a number of supplemental steps may be required to bring the stump-to-roadside estimates, as indicated by Figure 2, up to a full measure of the potential impact upon mill-gate delivered timber recovery costs.

From contrasting two IFPM options (as indicated by Figures 2 and 3), the evaluation was subsequently expanded to encompass a variety of feasible strategies. The preferred strategy was largely determined by the magnitude, over time, of the anticipated industrial timber requirements. Under perceived circumstances of a tight wood supply, results of the analyses suggested that some form of limited protection, coupled with earlier harvesting of more susceptible forest cover types, was warranted. Otherwise, where available supply exceeded industrial requirements, the case for protection was largely muted.

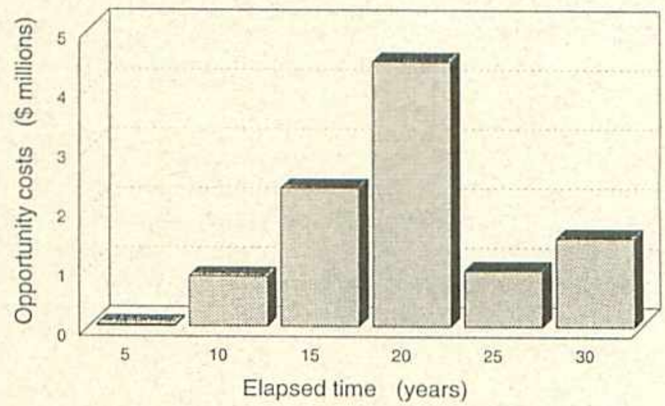

Figure 2. Stump-to-roadside (nominal value) opportunity costs of no protection.

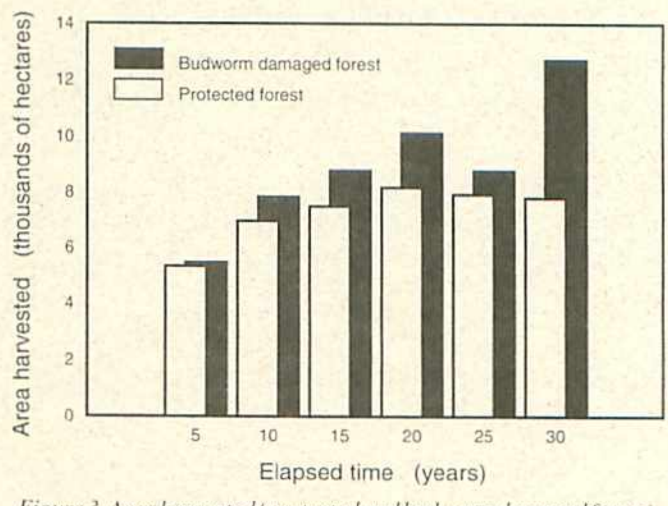

Figure 3. Area harvested (protected and budworm damaged forest).

CONCLUSIONS

As noted, the framework was used to test selected IFPM strategies incorporating different combinations of protection, coupled with alternative road access and harvesting options.[4]

[4] Documentation detailing the analytical framework and supple-mental information summarizing the results of selected analyses are available, upon request, from Stig Andersen, Canadian Forest Service–Ontario.

The generated opportunity cost estimates, predicated by determinations of economic wood supply, lend themselves well to cost-benefit analyses and to operational applications where decisions are to be vetted on the basis of economic efficiency criteria.

Interpretation of analyses conducted as part of the CFS–Avenor initiative produced results consistent with expectations. For example, opportunity costs of a no protection option, as illustrated by Figure 1b, were substantially higher under circumstances of a tight wood supply. Also, if harvesting is allowed to migrate across management units to locations of least-cost timber recovery, the possible adverse economic impact of defoliation-induced mortality may be circumvented — if only to shift the consequences from the short-term to some future point in time. However, the implications of such temporal shifts are particularly significant if, for example, circumstances of industrial restructuring, technological innovation, or evolving consumer preferences or societal values might be expected to demonstrably alter prevailing fundamentals of supply and demand in the forest products marketplace.

The framework was developed to be consistent with common approaches to timber production planning, to be easily implemented, and to provide a functional capability allowing for the ready integration of both subjective and empirical data and information at a level of detail consistent with strategic, forest-level management planning over a 20- to 30-year horizon.

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