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by C. A. Miller and I. W. Varty

Current Tactics in Spruce Budworm Management

Constraints on the development of rational tactics

All seven provinces from Manitoba east to Newfoundland as well as the State of Maine are alarmed by current massive outbreaks of spruce budworm. Provincial and state forest authorities are in process of reviewing management options and of developing strategies to cope with the problem. New Brunswick, Quebec, and Ontario have practiced chemical control by aerial sprays for some years, and from time to time have discussed their tactics for a given year¹, but no province has yet produced a definitive public statement of its approaches to long-term budworm management. Such reticence is understandable; the budworm problem is a complex of ecological, economic, and social components, and a provincial policy is difficult to formulate because the future extent, severity, persistence, and impact of an outbreak cannot be predicted. Furthermore the future industrial demand for the resource cannot be precisely estimated, and therefore the need for conservation of the current inventory is hard to gauge.

The development of short-term tactics and long-term strategies is hindered by three major gaps in knowledge: (1) the effect of spraying on the development of an outbreak; (2) the effect of spraying on resource conservation; and (3) the impact of budworm on the resource inventory.

Entomologists have long abandoned any belief that a full-blown budworm outbreak can be terminated by conventional chemical treatments. However Blais's suggestion (1973, 1974) that spray

programs may prolong outbreaks and shorten the interval between them, came as something of a shock to many foresters. New Brunswick's sustained but shifting outbreak is good evidence that conventional spraying of a large infestation may produce an unprecedented situation in which high populations of budworms and millions of acres of mature trees can co-exist in precarious balance. To be sure, spraying does reduce budworm survival rates, but not enough to counter a region-wide trend to irruption under the influence of favorable weather cycles over a period of years. Budworm epidemics appear to differ from outbreak/spray relationships of other forest pests. Spraying of black-headed budworm, hemlock looper, and tussock moths has frequently delivered the coup-de-grace to their outbreaks. In contrast, it is possible that the minimal dosage-minimal acreage convention for insecticide treatment of budworms may so support this pest's food supply that an outbreak potential is maintained indefinitely.

On the other hand, there is a widespread supposition that outbreaks at the early release stage can be suppressed by spraying promptly, broadly, and heavily at the epicentre. Ontario's experience in the Shebandowan Lakes area in 1968 gives credence to this belief. However Quebec's attempt to extinguish the Temiscouata outbreak in 1971 failed to prevent the spread and intensification of that epicentre. Many more replications of this kind of experiment are needed to test the feasibility of the suppression tactic.

It is possible that insecticide treatments can extinguish residual pockets of infestation after a general regional outbreak has collapsed. Quebec's apparent suppression of the persistent infestation in the lower St. Lawrence area in 1960-62 (Blais

¹See the Minutes of Environment Canada's Forest Pest Control Forum, formerly known as the Interdepartmental Advisory Committee on Forest Spraying, in unpublished reports 1958 to 1974.

1963) may be a case in point. Yet New Brunswick's continued treatment of lingering infestations in the Miramichi basin did not bring similar results. Again experiments in heavier dosage would be desirable for development of suppression tactics for collapsing and residual populations.

Thus there is conflicting evidence on the feasibility of using insecticides to influence budworm epidemics. Current research on the nature of moth flights and their relationships to wind fields, having a bearing on the redistribution and aggregation of budworm populations, may lead to greater predictability of such tactics.

The effect of spraying on the conservation of fir-spruce stands is also not well defined. While everyone knows that the object of spraying is to save foliage and protect trees from mortality, there is no quantified statement of what level of foliage protection can be considered as "successful". It is considered that 35% foliage protection is enough to keep a mature balsam fir alive; but in practice, variable foliage protection is achieved in a single year, typically between 15 and 60% when fenitrothion is used at 3 oz/ac (210 mg/ha). However, even when a satisfactory mean level of foliage protection is achieved, inevitably some trees are more defoliated than others, and some tree mortality ensues. The success of a treatment will not be definable until a province can specify an acceptable annual mortality and its willingness to pay for a given level of protection.

Annual increment is a further consideration. Should foliage saving be at a level high enough to ensure a desirable ring growth? If so, how far is it economic to use stronger dosages or wider coverage with insecticides to obtain a desired increment of fibre? Since information on the benefit-cost of treatment options is scanty, it is hard for provincial authorities to optimize their current tactics.

The third gap in knowledge is the impact of the budworm outbreak on the resource inventory, independent of spray treatments. If no insecticide is applied, how much of a stand will die, and what fire hazard will follow? On a provincial scale, what will be the composite effects of stand mortality, fire outbreak and the consequences to game animal conservation, recreation activity, and tourist appeal? There are few guidelines to aid in the prediction of such losses. Current provincial inventories are rarely so complete that current assets can be confidently listed, let alone future losses predicted. However, when inventory statements do show that certain tracts are surplus to current needs and unlikely to be profitable in the future, then it is not logical to provide insecticidal protection. To optimize the benefit-cost of provincial spray programs, it will be necessary to produce a budworm-oriented inventory, recognizing the marginal profitability of some forest tracts with creeping tree mortality, and concentrating protection efforts on tracts most critical to anticipated demand for resources.

Current tactics in the provinces

Not surprisingly, different policies have developed in different provinces. In the absence of published policy statements, the actions of the various provincial authorities may be examined to speculate on their goals.

New Brunswick's aim has been to keep intact its entire fir-spruce estate; from time to time provincial authorities have expressed the need to protect "every acre" or "every stick". This policy arises from the fact that almost all of the province's 15 million acres (6 million ha) of forest land is productive and accessible, and the fir-spruce portion is merchantable now or in the future. The spray programs carried out since 1952 were conducted on the assumption that industry needs or will need all of the 100 million cunits (280 million m³) of fir-spruce growing stock. Marshall's (1975) benefit-cost analysis suggests a clear economic advantage from investment in protection in this province, where industries using fir and spruce constitute about 20% of the total economy. Moreover there are social benefits from spraying; much of New Brunswick's forest land is owned by smallholders depending in part on pulp sales for their livelihoods. Loss of such woodlands would be a social disaster, but not necessarily an industrial one. The fire-hazard in budworm-killed woods is also a social problem, since many people live in small settlements surrounded by forest. Therefore the protection of farm woodlands is important to rural income, property, and personal security, independent of the economists' industrial quota.

Quebec's policy dilemma began in the late 1960's when a large budworm outbreak began in the western part of the province, and a few incipient infestations were evident in central and eastern forests. The first impulse was to protect everything; that is, to prevent large-scale mortality in the western outbreak, and to attempt local suppression of the St. Maurice and Temiscouata epicentres in central and eastern Quebec. The attempts at epicentre suppression, launched before tree mortality threatened, were unsuccessful, and the outbreaks continued to expand. By 1972 it was evident that the province's fir-spruce regions were under blanket infestation.

Quebec moved quickly to review the benefit-costs of various long-term protection options (Nadeau 1973), and in 1972 established an interdisciplinary committee of managers, economists, and entomologists to advise its Lands and Forests Department on current tactics. A policy of large-scale foliage protection was adopted, and in 1973 the province accomplished the largest single year's spray operation, 9.9 million acres (4.0 million ha), ever undertaken in Canada. In spite of these efforts, the infestation spread and intensified, reportedly around 85 million acres (34 million ha) in 1974. Provincial authorities recognized their inability to cope with so large a hazard area, especially in view of the shortage of

insecticides. The province, in 1975, was preparing a management plan to establish areas of priority for protection (Gaspé, lower St. Lawrence, St. Maurice, and Anticosti), and to make provision for salvage cuts in threatened and dying stands². It is probable that large areas will be abandoned to the spruce budworm. However, Quebec has a standing volume of 800 million cunits (2 300 million m³) of fir-spruce trees, ordinarily producing an annual increment around 16 million cunits (45 million m³). Since current fibre consumption (the latest estimate was 9.6 million cunits of *all* species in 1969) is probably well below the normal growth increment, the loss of some standing volume of fir-spruce in less accessible areas might not be viewed as a disaster.

Whereas New Brunswick is intent on total protection, and Quebec is aiming at partial protection, Ontario sees little need for protection of its 25 million acres at high infestation in 1975. Policy decision in Ontario is extremely difficult because the recognition of benefit-cost advantage is not clear-cut. Moreover, Ontario has various regional differences in the characteristics of its fir-spruce growing stock, so that not one, but two or more policies are needed.

There are two main territorial situations. In northwestern Ontario at large, little mature fir and spruce survived the outbreak of the 1940's and the fires that followed; most of the current growing stock is immature and non-merchantable. The surviving areas of merchantable fir-spruce are scattered, except for a block of about 5 million acres just west of the Lakehead. This block has been under careful surveillance, and when signs of budworm resurgence appeared in the late 1960's, a policy of local suppression of epicentres was adopted. Successive small-scale spray operations up to 1974 (the largest being 275,000 acres in 1968) have apparently been successful in preventing an outbreak³.

In northeastern and southern Ontario, where millions of acres of fir-spruce stands are now at high hazard from blanket infestations, only a few thousand acres of scenic woodlands in provincial parks have been protected by aerial sprays in the 1970's. In this huge untreated area, balsam fir and white spruce are of minor importance, being characterized by low stocking, poor quality, and immaturity. Woods companies neither depend on balsam fir nor esteem its resource value; it provides only around 1% of the volume of the trees cut. The province's main concern is that budworm kill of fir may increase fire incidence, with prospective damage to the esteemed black spruce and jack pine stands in matrix with the fir stands. Even then, in areas remote from habitation, fire is not necessarily disastrous, since it may lead to succession by jack pine and black spruce regeneration in place of the fir.

²Personal Communication. 1974. G. Paquet, Service de la Protection, Ministère des Terres et Forêts, Gouvernement du Québec.

³Personal communication. 1975. K. B. Turner, Ontario Ministry of Natural Resources.

Ontario, which innovated aerial spraying as a forest protection technique, currently makes meagre use of insecticides primarily because of economic considerations. Balsam fir and white spruce are not important components of the forest inventory as a whole, probably together not much more than 12% of the volume, and their quality is marginal to profitable exploitation. The budworm is not considered an immediate threat to the province's fibre needs, and indeed, forestry is not a dominant factor in the larger provincial economy.

Newfoundland, where the budworm outbreak is newly developing, has issued a public statement (May 1975) to the effect that spraying would be avoided as long as possible, and that cutting and salvage operations would be carried out in heavily damaged stands.

The attitudes that have shaped these divergent policies bear some examination. There was and continues to be a strong tendency to view the budworm problem as an "insect" problem; this attitude has had important implications in budworm research and in budworm control decisions. Control decisions, in particular, have been influenced, even oriented, by the notion that millions of budworms are threatening the fir stands of a region, and most must be killed to prevent tree mortality. On the basis of this attitude, hopes have focused on an entomological solution, and the early success of chemical control in the western United States and eastern Canada in the 1950's encouraged this belief. By 1960, DDT was seen as the victor. But in New Brunswick, the insect refused to be extirpated; infestations persisted in the 1960's and exploded in the early 1970's to their present massive outbreak levels.

Provincial foresters are now beginning to look on the budworm, not as an insect problem but as a "tree" problem. Viewed in this manner, the basic decision in management is not how to control the insect but how to identify and protect a resource. The resource is defined as X acres of forest required for fibre-production, Y acres for recreation and game, and Z acres for esthetics. The first need is an inventory of resource assets (fir-spruce fibres, recreation land), then a detailed analysis of public and private requirements of these assets, and finally well-defined policies of maximal utilization (including protection) of the assets. This would not be a simple task. For example, the current New Brunswick forest inventory was set up to measure volume of fibre on forested land, and not to define the "risk" to budworm attack and damage. Therefore, one would be immediately faced with a new provincial forest survey. The second need is to define social demands on resources and to manage output. This is very difficult when the resources are under multiple-ownership. However, if all these problems could be solved, then a rational plan for budworm management could be formulated.

Finally, allow us to peek at the future trend in budworm management through our crystal ball.

Budworm-free forests are not expected in the future. On the contrary, we expect the budworm to be persistently common because its food supply has been protected and maintained over large areas. Thus there will be a continuing need for budworm management, and whatever form it takes, it will be most effective if applied over large areas. For example, budworm management in New Brunswick could not be wholly independent of the budworm situation in Quebec, Maine, Nova Scotia, and Prince Edward Island.

Hopefully, budworm-management zones will eventually be designated, and within these zones the "axe" will be a prominent tool in stand manipulation. At the same time, there will be a need to minimize budworm abundance to levels that trees can tolerate without major losses in growth. Blais (1973) has reviewed the optional strategies in some detail. In our view, chemical sprays against larvae and adults will continue to be the most effective treatment while the biological alternative, *Bacillus thuringiensis*, could be used in ecologically sensitive areas. Research should continue on other biological alternatives but it is doubtful if parasite manipulation, viruses, or other pathogens will be used in operational programs in the next few years, and the prospects for the sex attractant, Soolure, have yet to be defined in the field.

However, further improvements and innovations in chemical control technology are probable: new potent chemicals, better formulations, improved delivery systems, more sensitive pest detection methods, and a broader attack on the budworm in its non-larval stages. Substantial changes in technology will lead to more effective tactics.

One of the new approaches to budworm management is the current development of a bud-

worm simulation model. This is a joint project of the Canadian Forestry Service, the University of British Columbia and the International Institute for Applied Systems Analysis based in Austria. This model integrates biological, climatic, and inventory factors, and simulates the budworm-forest interaction over time. Since it is continuously refined by new research information, the model will facilitate the testing of various policy options to obtain a given management goal. Benefit-cost studies will eventually become more realistic by application of the model. The next problem will be to put the model to work in provincial planning agencies. We do not wish to imply that the model will be a panacea. It is only a powerful tool to check current tactics and devise long-term strategies.

Certainly the outlook in 1975 is gloomy, as reports of widespread mortality and defoliation stream in from the eastern provinces. We believe that realistic expectations of better management planning, more powerful spray technology and the chance of a return to a weather cycle unfavorable to the budworm, make the further outlook somewhat brighter.

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