

PEST MANAGEMENT TOOLS FOR MANAGING THE BOREAL MIXEDWOOD FOREST

W. JAN A. VOLNEY

*Forestry Canada, Northern Forestry Centre
Edmonton, Alberta*

and

G. ALLAN VAN SICKLE

*Forestry Canada, Pacific Forestry Centre
Victoria, British Columbia*

INTRODUCTION

Mixedwood forest pests create problems for the forest manager. Pest management attempts to solve these problems and improve the productivity of the managed forest over its unmanaged counterpart. In the mixedwood forest, however, special constraints are imposed on these solutions because of geographic, demographic and economic considerations peculiar to this region. The vastness of the area to be managed, the length of rotation ages and the values of products derived from these forests to be used in distant markets dictate that only extremely low-intensity management options are economically justifiable at present.

Management is the process by which one controls or directs a system to achieve some goal. This implies that the manager has some knowledge of how the system functions and how it reacts to any treatments prescribed. The management alternative selected in any situation is equally dependent on the management objective and the knowledge base used to arrive at the decision. Mixed wood forest management decisions are likely to present the manager with a large array of options because of the complexity of the stands being managed. Our contribution to this symposium is to provide a sketch of the information available which may be used to manage pests of forest stands of the mixedwood section of the Canadian boreal forest. To the extent possible, examples from northeastern British Columbia will be used.

The trans-continental boreal forest is characterized by the presence of white and black spruces with balsam fir and jack pine of eastern and central forests giving way to lodgepole pine and subalpine fir in the west (Rowe 1972). Mixed with the coniferous species are the birches and trembling aspen. In the Mixedwood section of this forest

(Rowe's B.18a, or boreal white and black spruce in terms of biogeoclimatic terms) the characteristic forest association of upland, well-drained sites is a mixture of trembling aspen, balsam poplar, and white birch. White spruce eventually predominates on these sites as the stands age. The prominence of aspen in this region is due to its remarkable ability to regenerate following disturbance. On drier sites, jack pine or lodgepole pine enter the forest association and is dependent on fire for stand regeneration (Rowe 1972). Most commercial forest operations deal with forests of the well drained and drier sites. Tamarack and black spruce, which are found on the wetter and more northern sites, are also ecologically important in the mixedwood forest section.

Associated with each tree species is a suite of insects and micro-organisms which feed on different tree tissues. Similarly any forest stand is the site in which a variety of plant and animal populations spend all or part of their existence. Whether any one of these organisms is labelled a pest or not depends on the human demand for, and nature of products derived from the stand. There are examples where an organism is considered beneficial in one context and a pest in another. The changing fortunes (from a forestry perspective) of aspen in the mixedwood forest has elevated some insects and diseases previously regarded as benign or not worthy of control to "prime pest status." Indeed, aspen itself is viewed with this ambivalence, even today, depending on whether you are persuaded that softwoods or hardwoods are the *raison d'être* of mixedwood forestry. Before designating a species a pest, it is essential that the ecological characteristics of the species and its significance to the management objective for the stand in which it is found are fully appreciated.

Treatments of pest management concerns at previous symposia provided descriptions of pests, their life cycles

and insecticidal or silvicultural control options (Davidson and Prentice, 1968; Hinds, 1985; and Jones et al. 1985). The major focus of these works was on pests of the hardwood component. Important information regarding the effects of pests on stand development was also presented in these reports. The need to integrate this information for use in the mixedwood forest management prescriptions was commented on by Volney (1988a). The major conclusion repeated in all these papers is that insect and disease losses can be minimized if healthy, fully stocked stands, free of disturbances are maintained. The processes underlying this suggest that natural defenses of trees are lowered during disturbance (from wind, frost, drought, mechanical, sun scald, or pest damage) making the trees susceptible to secondary pest attack, growth loss, and mortality. Presumably the process of opening up the stand further weakens trees and contributes to the demise of aspen stands. These conclusions rely on observational studies which have not been rigorously tested by experiment. Further, many of the relationships described have not been quantified.

Despite the shortcomings of the information, managers still have to make decisions. Yet there is a large body of information which needs to be analyzed, interpreted, its utility evaluated and the pertinent conclusions used in improving the knowledge on which forest pest management decisions are made. A tool, which will have a major impact on the way pests are managed and one which is in need of development, is a means to make pest related information easily accessible to managers.

INFORMATION ON PEST MANAGEMENT: The long and short of it

Before any attempt is made to manage pests it is important that the identities of the organism capable of causing damage to a stand are known. Considerable effort has been expended to compile this information. Over the past 53 years, the personnel of the Forest Insect and Disease Survey (F.I.D.S.) of Forestry Canada and their co-operators have put together a fairly complete list of the organisms which feed on trees found in mixedwood forests. Beginning in the early 1950's this unit has compiled some 6000 records from the Peace River Area of British Columbia. More than half of these records are of species that are not considered pests. Nevertheless these records are important in permitting specialists to identify recent introductions, and in recognizing the potential for secondary pest problems as new forest management techniques are introduced. These records also include listings of beneficial organisms such as predators and parasites.

Approximately 1/5 of the 6000 records were diseases and the rest dealt with insects. The most common of these were foliar pathogens (10 species), stem or branch rusts (5 species), 1 cone rust, 3 canker fungi, and 4 major decay fungi. Among the insect records there were 21 defoliators (15 on conifers), 4 bark beetles, 2 wood borers, 2 terminal weevils, 5 gall midges or aphids, 5 cone insects and 6 beneficial insects. This list is not long. With a little help any forestry practitioner could become acquainted with the signs and symptoms used in the field-diagnosis of these pests. More importantly, the trained practitioner can then become part of pest detection surveys.

There are a number of field guides and manuals available to help in the identification of pests. A series of these have recently been produced by the Northern Forestry Centre. These deal with the diagnosis of damage to trees in the mixedwood forest including: air pollutants and natural stress agents (Malhotra and Blauel 1980), diseases (Hiratsuka 1987) and insects (Ives and Wong 1988). These manuals treat far more species than would ordinarily be encountered as pests but they serve the purpose of distinguishing pests from benign organisms. These manuals are excellent for use as self-help guides in pest identification. Forest pest leaflets on a wide range of pests are also available from the Pacific Forestry Centre and the Northern Forestry Centre. Both these centres provide an identification service for insect and disease samples originating from forestry concerns in their respective regions. Another set of tools for pest management then, are the collection records for the region and the identification manuals produced largely as a result of this experience.

Besides the identification and determination of pest status of these agents, the F.I.D.S. records serve a second purpose. Because the record spans several years (35-40 years in this area and 53 years in other areas of the mixedwood forest) it is possible to develop spatial and temporal descriptions of outbreak patterns of pests we should be concerned about.

The outbreak patterns for the important insect pests of the aspen component of the mixedwood forest are presented in Figure 1. The most important of these has been the forest tent caterpillar which caused damage during four different intervals in the past 40 years in northeastern British Columbia. Details of the areas affected are presented in the F.I.D.S. annual reports (eg. Wood and Van Sickle 1989) and the Pacific Forestry Centre F.I.D.S. poster presentation at this session. Conditions in other parts of the mixedwood section are reported in the annual reports of the adjacent region (eg. Emond and Cerezke 1989). National summaries are also prepared annually (eg. Moody 1988). Large aspen tortrix outbreaks are more

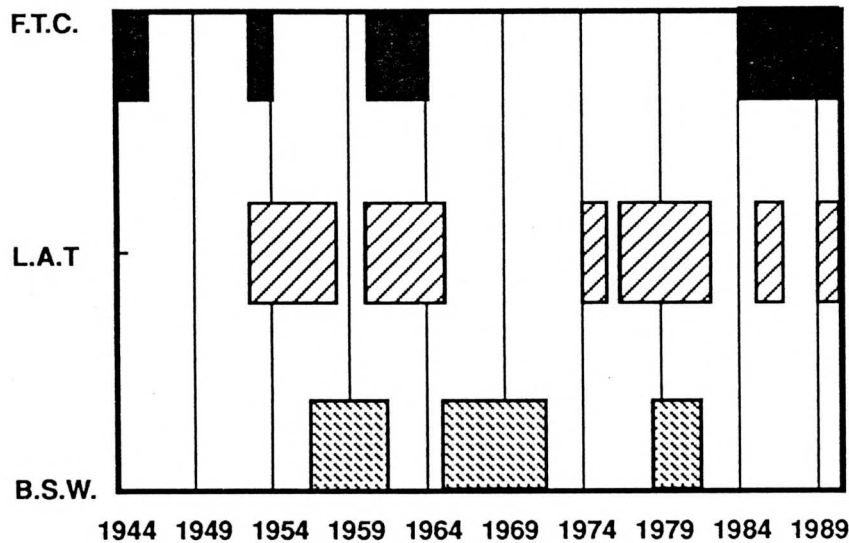


FIGURE 1: Outbreak histories for the major aspen defoliators of northeastern British Columbia.
A) Forest Tent Caterpillar, B) Large Aspen Tortrix, C) Bruce Spanworm

frequent but of shorter duration, occurring 8 times in the past 40 years. Bruce spanworm outbreaks have occurred 3 times in the past. All stands are not affected by every outbreak and no stand is subject to every outbreak. Thus the distribution of outbreaks within an area is very important in evaluating the significance of each of these outbreaks on individual stand development.

Fewer outbreaks have occurred on the conifer component. Outbreaks of the spruce budworm have been reported mostly north of the mixedwood section of British Columbia. Damage caused by the two-year cycle budworm to mature spruce stands in the three outbreak periods of 1950, 1954-57, and 1962-64 was negligible. Similar comments can be made of damage caused by the larch sawfly in the two outbreak periods in 1962-68 and 1975-77. Problems might be anticipated with the spruce beetle. This species has attacked trees where populations have built up in nearby weakened trees, recently killed trees, or decked logs. *Monochamus* wood borers have also caused damage to decked logs and salvaged fire-killed logs.

Diseases are probably under-represented in annual surveys because of their characteristic slow spread in stands. Of major concern are the rots. Trunk rot in aspen, red ring rot, brown cubical rot and tomentosus rot in conifers are common. Damage to older trees, including top-kill and radial growth reduction, has been caused by broom rusts of fir and spruce. Stem and gall rusts, though present, have not been major problems in older lodgepole

pine stands. Other diseases that are local and patchy in occurrence include spruce cone rust, needle casts, needle rusts, ink spots and shoot blights. Animal damage, damage from frost, and snow breakage have also been reported in the Peace River area of British Columbia.

Perhaps the most important value of this historical information to pest management is that it provides a means of developing some understanding of pest epidemiology and making long-term forecasts. For example, the jack pine budworm outbreaks in forests of Saskatchewan and Manitoba were recently analyzed and long-term and short-term predictors of outbreak occurrence developed (Volney 1988b). The outbreak information used in these analyses was largely collected by the Forest Insect and Disease Survey and its forerunners. Similar analyses are possible with the other major defoliators of the mixedwood section to develop forecasts on the occurrence and extent of damage.

These predictors can be used by forestry concerns to formulate policies and plans for the inevitable outbreaks occurring in the region. If the effects of these pests on the forest resource is to be minimized, this policy will most likely include statements on the priority of stands to be harvested. These priorities would be developed from a consideration the probable losses from pests in addition to all the other considerations normally used in developing harvesting schedules.

Knowing the long-term and regional expectations of damage does not provide the manager with the detailed information required to evaluate the hazard for specific stands. Hazard rating stands in the mixedwood forest is in its infancy. However, several components of this tool have been developed for a variety of pests. For example, pheromone trapping techniques are being calibrated to permit the prediction of spruce budworm defoliation in spruce stands (Sanders 1988). The attractants that would permit monitoring all the major aspen defoliators in the mixedwood forest of northeastern British Columbia have been at least partially identified. Synthetic pheromone preparations for the forest tent caterpillar are being tested, for detection purposes, having been identified in 1980 by Chisholm et al. (1980). A pheromone component of the large aspen tortrix has been reported (Weatherston et al. 1976). A sex attractant for the Bruce spanworm moth has been characterized (Underhill et al. 1987). Attractants for the jack pine budworm, a pest of eastern forests of the mixedwood section, have also been field tested (Butterworth and Silk 1989). These tools could be developed in concert with the traditional detection surveys to provide improved site-specific and short-term forecasts of population increases and potential for damage to the stand.

Less information is available on the effects of pests in reducing stand yields. Nevertheless, there are means of predicting the impact of pests on stand productivity from present and future outbreaks. An example of the effect of a forest tent caterpillar outbreak on the development of young aspen stands was presented at the last mixedwood symposium (Volney 1988a). Based on the modeling efforts of Mattson and Addy (1975) the net effect of one outbreak was a 25% reduction in the accumulated stem wood biomass and a permanent reduction of the capacity of the stand to realize its maximum yield. Predictions of pest impacts can be adjusted for local conditions. The impact information now being acquired by F.I.D.S. personnel in this region together with other forest inventory data would ultimately permit predictions of this sort to be made. The important point is that repeated outbreaks have considerable impact on the productivity of stands.

What can be done about forecasts of unacceptably high pest populations? Perhaps the single most effective treatment tool available to the forest manager is modification of harvest schedules to harvest high-risk stands before they sustain unacceptable levels of pest damage. This technique has the appeal that there is no, or very little, increased cost in its application and there is little increased environmental risk in its implementation. The disadvantage is if the proportion of stands in the high-risk category is large, it will be impossible to harvest all stands requiring treatment without seriously affecting future timber sup-

plies. When this occurs, other techniques have to be resorted to. Direct control of defoliators has been practiced in Canada for several years. Presently, the favored control technique for the forest tent caterpillar on large areas is to aerially apply a biological insecticide, *Bacillus thuringiensis* (or B.t.). Although not specifically registered for the large aspen tortrix, this insecticide is known to be effective in reducing damage from the large aspen tortrix (Holsten and Hard 1985). (As the registration status of individual preparations change it is best to determine which materials are registered for specific pests on each host for a particular use by checking with the Pesticides Directorate of Agriculture Canada and the provincial agencies which regulate pesticide use in the jurisdiction concerned.)

In some situations a do-nothing option may be valid. More than a dozen parasites of large aspen tortrix along with disease and weather usually cause collapse within three years. Because the larvae feed early in the spring, the trees refoliate in the same year usually with little tree mortality. The impact on growth and risk of attack from secondary pests may be sufficiently low to be acceptable at current levels of management. Impacts on aesthetics or public concerns may be greater.

Silvicultural treatments to mitigate pest conditions in mixedwood stands have not been developed. Some silvicultural treatments may exacerbate pest effects. There is considerable experience to suggest that heavy thinning of aspen stands to release spruce may not achieve the desired result. Young white spruce trees are extremely susceptible to attack by the white pine weevil, so much so that it is called the spruce weevil in this western province. The result of opening up stands prematurely can, therefore, be quite devastating on understory white spruce. This could be a potential problem in the Peace River region as forest management intensifies. Diseases which are now benign in the region, such as septoria canker, may become a problem with the introduction of hybrid and exotic poplars (Davidson and Prentice 1968).

PEST MANAGEMENT AND EXPERT SYSTEMS

A self-improving solution?

Pests create a bewildering array of concerns for the forest manager who often feels ill-equipped to make decisions regarding pest management. Further, there is often a sense that the information available is incomplete or unavailable, despite the enormous amount of effort expended by specialists in the past. To further exacerbate the manager's predicament, pest management specialists may not be available to provide the individual attention required to

satisfactorily design and implement pest management protocols for the land base being managed. One tool developed to assist resource managers is the pest management system.

Forest pest management should be an integral part of integrated resource management. As such, the decisions to acquire information about pest conditions, to treat stands and to evaluate treatments have to be compared to the competing opportunities for the funds required to perform all activities of the management agency. A crucial concern in this regard is how the information required to manage pests is to be acquired and utilized. Pest management systems perform these functions. A typical system might consist of procedures to: monitor pest conditions in individual stands, forecast the likelihood of damage from the pest conditions reports, decide on a course of action, and to monitor and evaluate the results of the prescribed action. These procedures are based on an understanding of the reciprocal interactions among pest populations dynamics, stand dynamics, and treatment effects. The response of the pest populations and stand productivity to the various treatment options are evaluated using econometric tools to obtain benefit/cost ratios which can be used to select among the options available to the manager. Depending on the complexity of the situation involved, this system may be automated to varying degrees using computer-based models in addition to other decision support systems used to collect, process, and display information required to make decisions in forest management.

Despite the development of decision support systems and pest management systems for several major forest pests in other regions of North America, several of the tools were not applied (Coulson et al. 1989). One of the major causes for this was the difficulty of handling incomplete information. This difficulty is compounded by the scarcity of specialists to assess the utility of opinions and evaluate the consequences of using "best guesses" which experts often are forced to use when faced with inadequate information. Systems are now being developed to overcome these deficiencies (Coulson et al. 1989).

Known as knowledge-based systems, or more commonly, "expert systems", these tools attempt to simulate the reasoning used by experts in dealing with the management of complex enterprises. An expert system contains a "knowledge base" in which all knowledge available on a

subject is coded in a fashion that makes it accessible to an "inference engine." This inference engine processes the information, updates the knowledge base with current information and produces a recommendation for the manager's scrutiny. The manager has the option of obtaining statements on how the system arrived at a particular recommendation. A characteristic of expert systems is that the information fed back to the system as a result of action can be used to modify the knowledge base. Thus the experience gained from implementing any action on the forest is immediately incorporated to improve the knowledge-base. This is analogous to learning from experience, and is critical to improving our understanding of the system being managed.

Expert systems designed for forest pest management will probably have several peripheral systems to assist in automating the decision making process as well as managing and acquiring the data sets. In situations where many individual stands are being managed, a geographic information system would become an important component of the expert system. Other utilities would include connection management systems for managing information flow among several distributed work sites, data base management systems for data management, and various output devices to display results.

A final feature of these systems is that they can be configured to address the questions asked by managers at several levels of the management hierarchy. Thus the district forester, the regional resource management officer, and the chief forester of an agency can utilize the same information to make decisions at different administrative levels.

The costs, constraints, and benefits involved in expert system development for forest pest management in conditions such as those of the northern mixedwood forest were discussed recently (Volney 1989). Expert systems of this sort are expected to take six to eight person years to develop provided that the necessary experts can be assembled and persuaded to participate. In addition to the fuller utilization of available information in making decisions, expert systems offer an opportunity to overcome some of the training and technology transfer problems the older systems encountered in their implementation. Of equal importance, they will not replace human experts but will serve to assist them in focusing on the more difficult pest management problems.

CONCLUSIONS

The tools required to manage pests of the mixedwood forests are the ability to: identify pests, predict the threat pests present to achieving forest management goals, evaluate the need for treatment, select the best treatment warranted; and evaluate the results of treatments. How good these tools are depends on the skill of the manager in applying what is available. All tools (be they pest identi-

fication, pest conditions assessment, predictors of spatial and temporal characteristics of outbreaks, hazard rating methods, or impact models) need improvement. The real challenge is to improve them in a manner which will result in the greatest improvement of management results for the effort expended. A means of improving our skills of managing pests, the information about managing pests, and of improving our understanding of the deficiencies of the knowledge-base may be provided by expert systems.

REFERENCES

- Butterworth, E.W. and Silk, P.J. 1989. Personal communication.
- Chisholm, M.D.; Underhill, E.W.; Steck, W.; Slessor, K.N.; Grant, G.G. 1980. (Z)-5, (E)-7-Dodecadienal and (Z)-5, (E)-7-Dodecadien-1-ol, Sex pheromone components of the forest tent caterpillar, *Malacosoma disstria*. *Environ. Entomol.* 9: 278-282.
- Coulson, R.N.; Saunders, M.C.; Loh, D.K.; Olivera, F.L.; Drummond, D.; Barry, P.J.; Swian, K.M. 1989. Knowledge system environment for integrated pest management in forest landscapes: the southern pine beetle (Coleoptera: Scolytidae). *Bull. Entomol. Soc. Am. Summer*: 1989 26-32.
- Davidson, A.G., and R.M. Prentice. 1968. Insects and Diseases. In Maini, J.S. and J.H. Cayford. Eds. *Growth and Utilization of Poplars in Canada*. Can. Dept. For. & Rural Develop., Ottawa, Ontario. p. 116-144.
- Emond, F.J.; Cerezke, H.F. 1989. Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1988 and predictions for 1989. *For. Can., North For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-303*.
- Hinds, T.E. 1985. Diseases. In DeByle, N.V., and R.P. Winokur. Eds. *Aspen: Ecology and Management in the Western United States*. U.S.D.A. For. Serv. Rocky Mount. For. & Range Expt. Stn. Fort Collins, Colorado. *Gen. Tech. Rep. RM-119* p. 87-107.
- Hiratsuka, Y., 1987. Forest tree diseases of the prairie provinces. *Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-286*.
- Holsten, E.H.; Hard, J. 1985. Efficacy of *Bacillus thuringiensis* Berliner for suppressing populations of large aspen tortrix in Alaska. *Can. Ent.* 117: 587-591.
- Ives, W.G.H., and H.R. Wong. 1988. Tree and shrub insects of the prairie provinces. *Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-292*.
- Jones, J.R., N.V. DeByle, and D.M. Bowers. 1985. Insects and other invertebrates. In DeByle, N.V., and R.P. Winokur. Eds. *Aspen: Ecology and Management in the Western United States*. U.S.D.A. For. Serv. Rocky Mount. For. & Range Expt. Stn. Fort Collins, Colorado. *Gen. Tech. Rep. RM-119* p. 107-114.
- Malhotra, S.S., and R.A. Blauel. 1980. Diagnosis of air pollutant and natural stress symptoms of forest vegetation in western Canada. *Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-228*.
- Mattson, W.J., and N.D. Addy. 1975. Phytophagous insects as regulators of forest primary production. *Science*. 190: 515-522.
- Moody, B.H. (Compiler) 1988. Forest insect and disease conditions in Canada 1987. Forestry Canada. Ottawa, Ontario
- Rowe, J.S. 1972. Forest Regions of Canada. *Can. Dept. Environ., Can. For. Serv., Publ. No. 1300*.
- Sanders, C.J. 1988. Monitoring spruce budworm population density with sex pheromone traps. *Can. Ent.* 120: 175-183.
- Underhill, E.W.; Millar, J.G.; Ring, R.A.; Wong, J.W.; Barton, D.; Giblin, M. 1987. Use of a sex attractant and inhibitor for monitoring winter moth and Bruce spanworm populations. *J. Chem. Ecol.* 13: 1319-1330.

- Volney, W.J.A. 1988a. Insects and diseases of the mixedwood forest: Problems or opportunities? In Samoil, J.K. (ed.) Management and utilization of northern mixedwoods. Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-296. pp 99-109.
- _____. 1988b. Analysis of historic jack pine budworm outbreaks in the prairie provinces of Canada. Can. J. For. Res. 18: 1152-1158.
- _____. 1989. Artificial Intelligence for Forest Pest Management. In prep.
- Weatherston, I.; Percy, J.E.; MacDonald, L.M. 1976. Field testing of cis-11-tetradecenal as attractant or synergist in Torticinae. Experientia. 32: 178-179.
- Wood, C.S.; Van Sickle, G.A. 1989. Forest insect and disease conditions, British Columbia & Yukon. For. Can. Pacific For. Cent. Victoria, B.C. Inf. Rep. BC-X-306.

Northern Mixedwood '89

**Proceedings of a symposium held at
Fort St. John, B.C.**

September 12-14, 1989

Edited by

**Art Shortreid
Forestry Canada
Pacific and Yukon Region**

Symposium Planning and Management by

**Northern Lights College
Fort St. John**

**Forestry Canada
Pacific and Yukon Region
Pacific Forestry Centre**

FRDA Report 164

1991