INSECTS AND DISEASES OF THE MIXEDWOOD FOREST: PROBLEMS OR OPPORTUNITIES?

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Insects and diseases can have a significant effect on forest stand productivity. Although sound estimates of annual volume losses from the combined effects of insects and diseases are difficult to make, there is a perception that for Canada these losses may equal, on average, the annual losses attributed to forest fires. Except for a few instances, insects and diseases have been traditionally ignored in the plans prepared to manage stands in the northern mixedwood forest. In these plans, therefore, the amount of timber required to supply the wood-using industry is obtained by expanding the area from which wood is harvested to offset the losses caused by insects and diseases. As long as the forest resource is not fully allocated to wood-using concerns, and presuming that unlimited opportunities to expand forestry operations exist, the major effects of insect and disease losses are the increased transportation and harvesting costs incurred by operating in an area larger than required had the insect and disease losses not been anticipated.

Naturally, the forest resource is finite, and in some regions of the northern mixedwood forest, most of the resource will soon be allocated to different forestry concerns. The impact of forest insect and disease losses in these forests will depend to a great extent on the objectives of the forest manager. These effects will represent both problems and opportunities for managers and argue strongly for the development of pest management systems for inclusion in future resource management plans. Before pest management systems can be developed, however, some understanding of the manner in which insects and diseases affect forest stand development is necessary.

Recent publications on pollution damage to forest vegetation (Malhotra and Blauel 1980), forest tree diseases (Hiratsuka 1987), and tree and shrub insects (Ives and Wong 1988), coupled with exhaustive reviews by Davidson and Prentice (1967), Hinds (1985), and Jones et al. (1985), obviate the need to review all the biotic and abiotic agents that damage trees in the northern mixedwood forest. Further, the problem of aspen decay was the subject of several papers presented at a recent workshop (Northern Forestry Centre 1987) and a review by Hiratsuka and Loman (1984). My objective in this paper is to forego the traditional recitation of pest species lists and descriptions of life cycles and to concentrate on describing the effects of selected insects and diseases on the development of mixedwood stands.

Graham et al. (1963) described the autecology of aspen (*Populus tremuloides* Michx.) in Michigan and commented on the natural regeneration of pure aspen stands following fire. They also described the succession of species in these stands that produce mixedwood stands. Of particular interest to foresters of the northern mixedwood forest is the invasion, establishment, and growth of white spruce (*Picea glauca* (Moench) Voss) as an understory tree. Because of the importance of spruce, and the increasing importance of aspen to the wood-using industry in this region, it is instructive to understand the agents that influence the development of mixedwood stands so common in western Canada and Alaska.

The forest tent caterpillar (*Malacosoma disstria* Hbn.) may regulate the productivity of aspen stands, according to Mattson and Addy (1975). Although their conclusions were based on simulations of aspen stands, the simulacra they presented on stand productivity with and without defoliation provide us with an opportunity to discuss the significance of forest tent caterpillar defoliation on stand development. They modeled the annual production of stem wood, foliage production, and tent caterpillar biomass production in stands initially 26 years old to age 40. They provided data for a stand that was completely defoliated for 3 consecutive years in one forest tent caterpillar outbreak and contrasted them with data from an unaffected stand.

Mattson and Addy's (1975) simulation suggests that annual stem wood biomass production and foliage production are increasing functions of stand age over the period modeled (Fig. 1). In contrast, when the trees are defoliated by the tent caterpillar the stem wood and foliage production functions are drastically altered (Fig. 2). Stem wood production decreases from its normal value shortly after the onset of the outbreak and shows some degree of recovery in the latter half of the period modeled. At the same time foliage production is initially depressed in response to light feeding, but then climbs to abnormally high values before returning to a normal

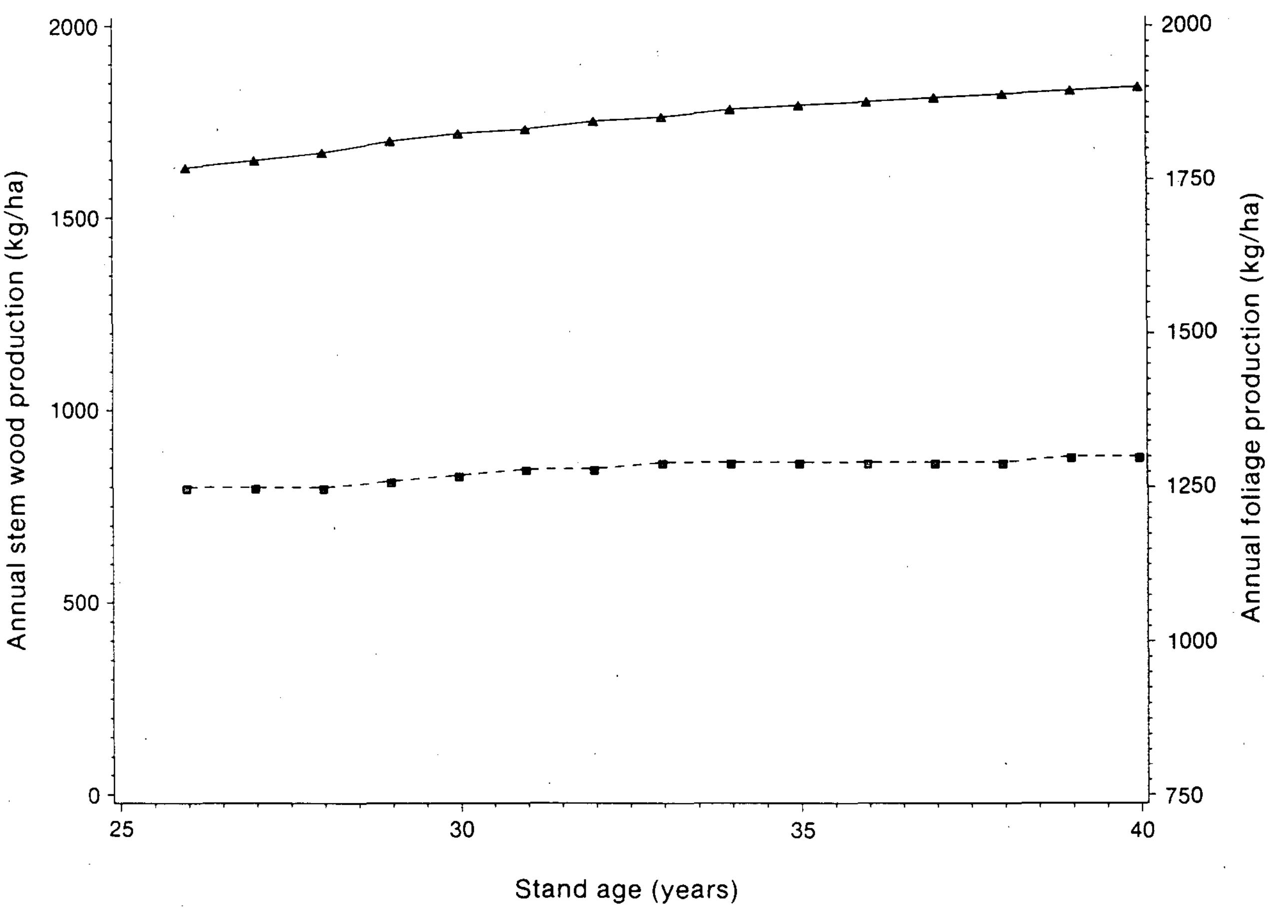

Figure 1. Annual stem wood (solid line) and foliage production (broken line) in a simulated aspen stand without forest tent caterpillar defoliation. (Source: Mattson and Addy 1975.)

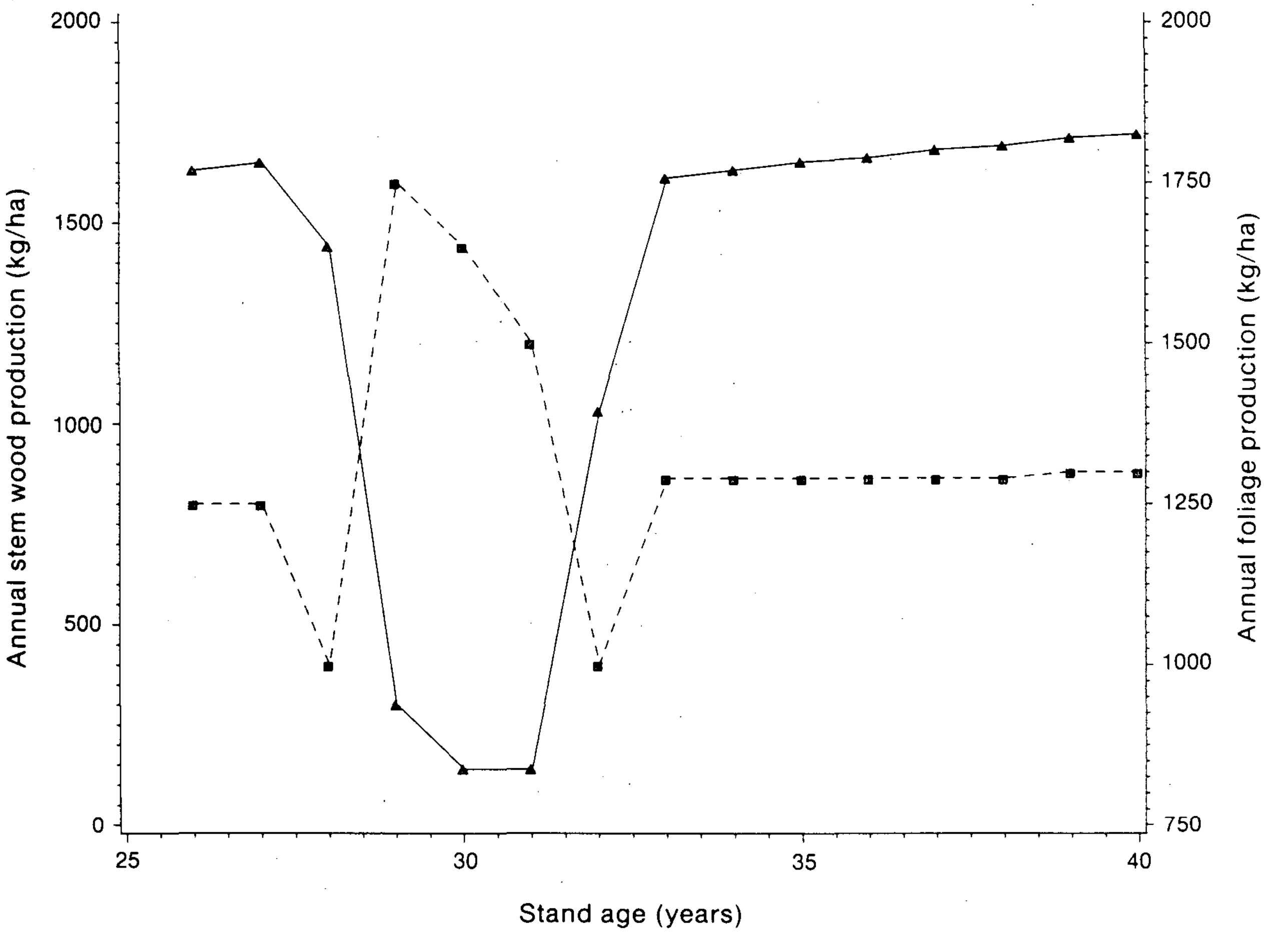

Figure 2. Annual stem wood (solid line) and foliage production (broken line) in a simulated aspen stand defoliated by the forest tent caterpillar. (Source: Mattson and Addy 1975.)

sequence of values. The counter-intuitive behavior of the foliage production function is real and reflects the response of the trees when tent caterpillar population densities are extreme (Fig. 3). The years in which caterpillars completely defoliate aspen stands are the ones in which the trees produce a second crop of foliage, accounting for the extreme foliage production values (Fig. 4). The simulations also suggest that even with light defoliation in response to low populations at the beginning of the outbreak, there is some depression in stem wood production and the recovery to post-outbreak levels of production is not complete for 2 years following the population crash (Fig. 5). More serious, perhaps, is the suggestion that stem wood production never fully recovers when compared to the stand in which no defoliation occurred (Fig. 6). The cumulative effect of the years of lost stem wood productivity in the defoliated stand is an ever-widening gap between the damaged and undamaged stand (Fig. 7). This widening gap is the result of the failure of the post-outbreak stand to recover to stem wood production levels achieved by the undamaged stand.

Mattson and Addy (1975) did not specify the causes of the loss of stem wood production; however, Churchill et al. (1964), in a study of several aspen stands 6 years following defoliation by tent caterpillars in Minnesota, found a general trend toward increasing total stem mortality with increasing severity and duration of the outbreak (Fig. 8A). Only a small portion of the total mortality could be accounted for by other insects (Fig. 8B), but this proportion seemed to become significant only in the most severely defoliated stands. A more significant source of mortality was due to *Hypoxylon* spp. infections. The proportion of trees affected by this disease shows an almost steady increase with increasing outbreak severity (Fig. 8C). Mechanical damage and other biotic and abiotic agents that could be identified showed no relationship between the mortality due to these causes and increasing severity of the outbreak. By far the largest source of mortality was that due to unknown causes. Again, only in the stands most severely defoliated was there an increased level of mortality (Fig. 8D). Churchill et al. (1964) speculated that this mortality might be a direct effect of repeated defoliation by the forest tent caterpillar.

The net result of defoliation by the forest tent caterpillar outbreaks seem to be considerable stem wood volume reduction (as much as 25% by Mattson and Addy's (1975) simulations) largely, it would appear, because of stem mortality from a variety of causes (Churchill et al. 1964). One can only speculate about the effects of these outbreaks in the northern mixedwood forest. Conditions in the northern mixedwood forest are different and the effects on the trees of the understory have not been investigated. Outbreaks of the tent caterpillar seem to be more frequent in this region and occur over larger areas (see annual forest insect and disease reports published by the Canadian Forestry Service). Whether this results in an accelerated decline of the aspen component of stands in the prairie provinces, or the tent caterpillar interacts with aspen differently, is not certain. It would appear, however, that repeated defoliation of aspen would be reflected in compensatory growth in the understory stand.

Graham et al. (1963) mentioned the value of the aspen overstory in protecting developing understory white spruce from attack by what is now regarded as the white pine weevil (*Pissodes strobi* Peck). If the aspen overstory is removed prematurely, then the risk of white pine weevil attack on white spruce terminal shoots increases dramatically. It appears that the spruce understory becomes less susceptible to this attack at about the stage in stand development when the spruce starts to form part of the upper canopy and the aspen component in the stand starts to decline. The stage at which stand productivity can be maximized by harvesting the aspen overstory should be determined for mixedwood stands of this region. The harvesting schedule proposed by Lorne Brace and Imre Bella at this symposium has merit in that the coniferous understory is left to develop largely free from risk of weevil attack.

If aspen production is not the prime objective of stand management, then forest tent caterpillars present an opportunity to thin stands at a rate that might minimize the risk of weevil attack while maximizing yields from the coniferous understory. This assumes that we are able to regulate forest tent caterpillar populations to this end. The use of tent caterpillars in this fashion has the appeal of being species-specific, environmentally safe, and probably fairly inexpensive to manipulate over the vast areas to be managed. Conversely, if aspen production is the prime objective of management, then the tent caterpillar represents a problem for the manager of mixedwood forests who makes plans that ignore this organism.

In conclusion, insects and diseases in the northern mixedwood forest may represent both problems and opportunities. Whether a specific organism is regarded as beneficial or a pest depends on the specific objective of the land manager. In any event, understanding the interaction of the tent caterpillar with aspen stands and secondary organisms, and the interaction among aspen defoliation, white spruce growth, and the risk of attack by the white pine weevil, is required to manage future stands of the mixedwood forest.

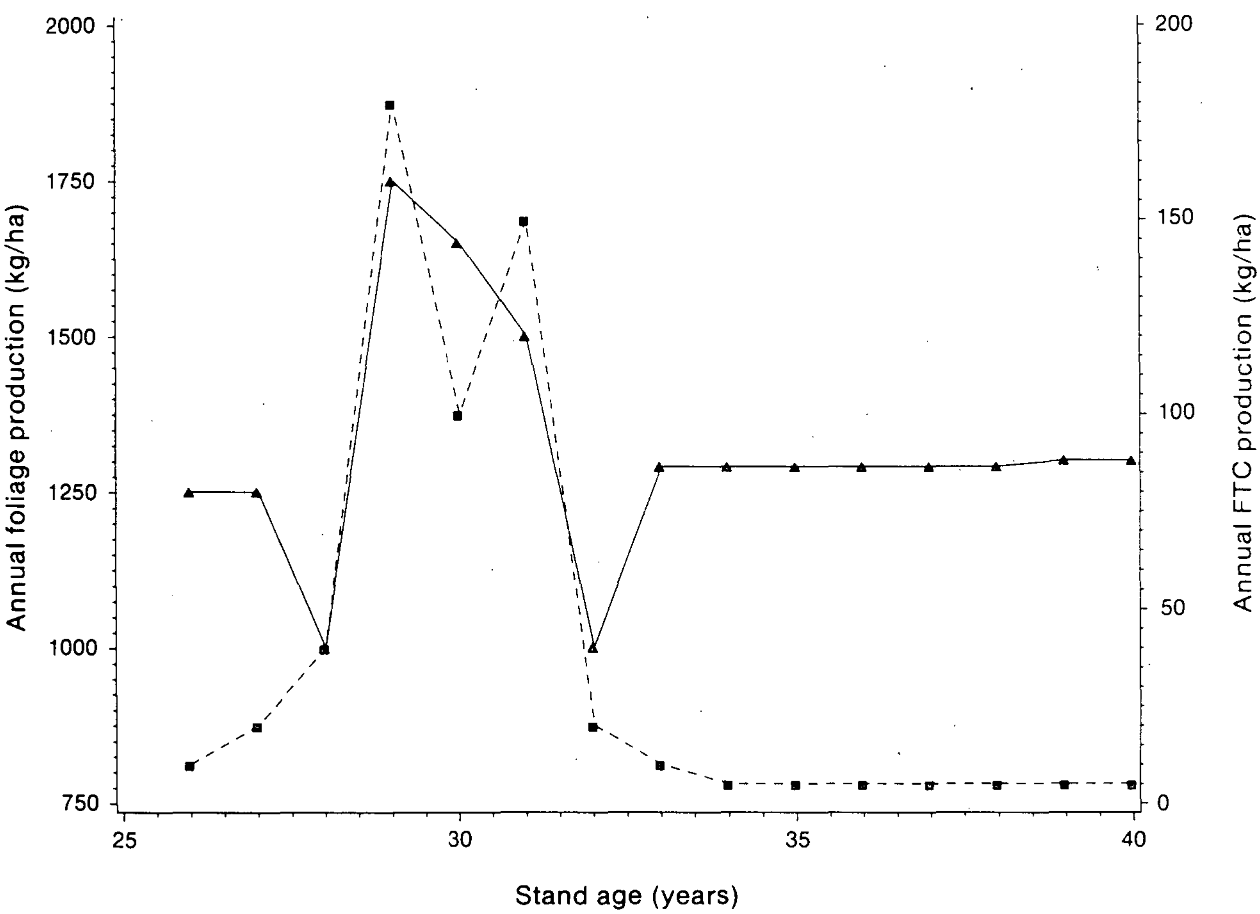

Figure 3. Annual foliage production (solid line) and forest tent caterpillar biomass production (broken line) in simulated stands with forest tent caterpillar damage. (Source: Mattson and Addy 1975.)

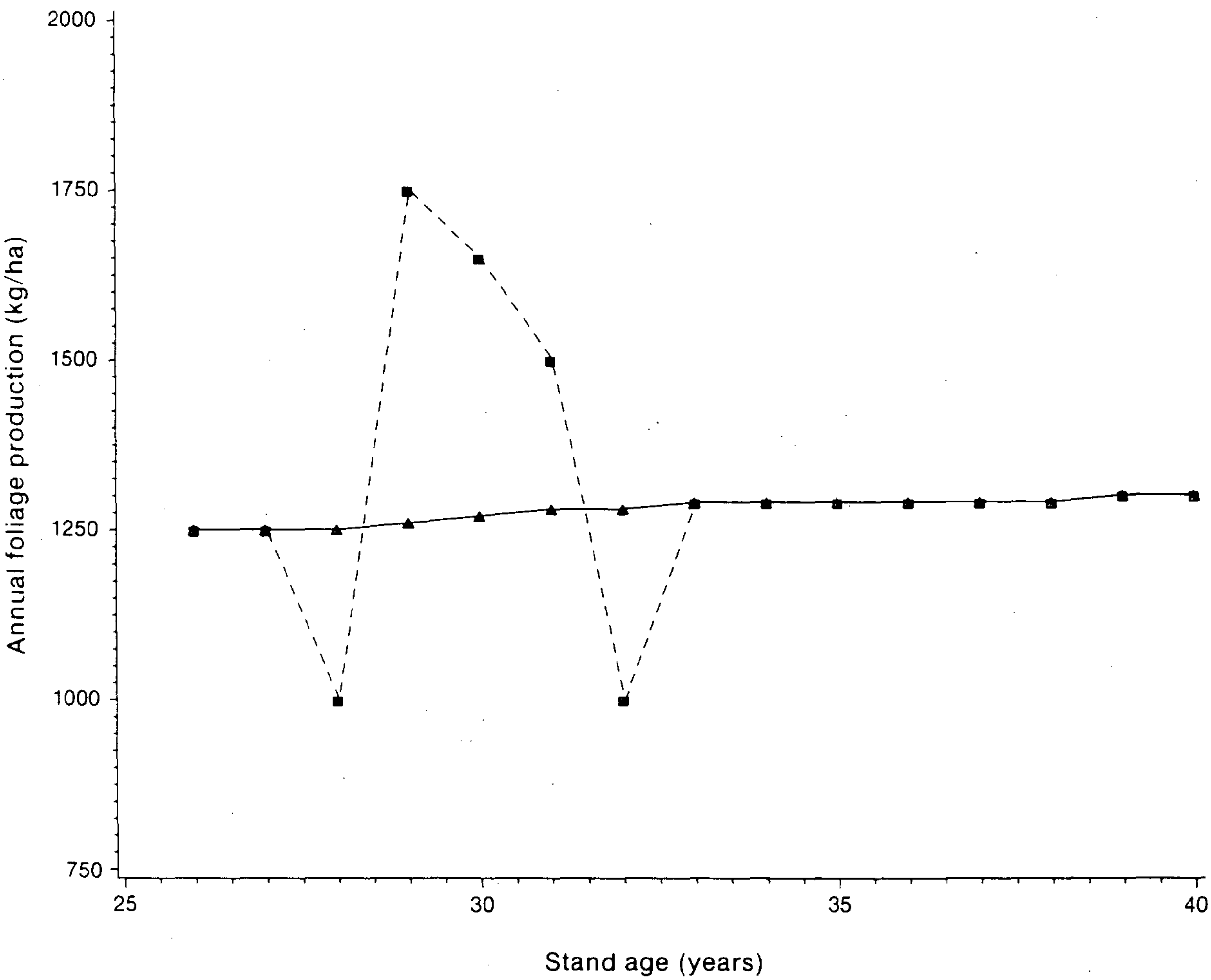

Figure 4. Simulated foliage production in stands with (solid line) and without (broken line) forest tent caterpillar. (Source: Mattson and Addy 1975.)

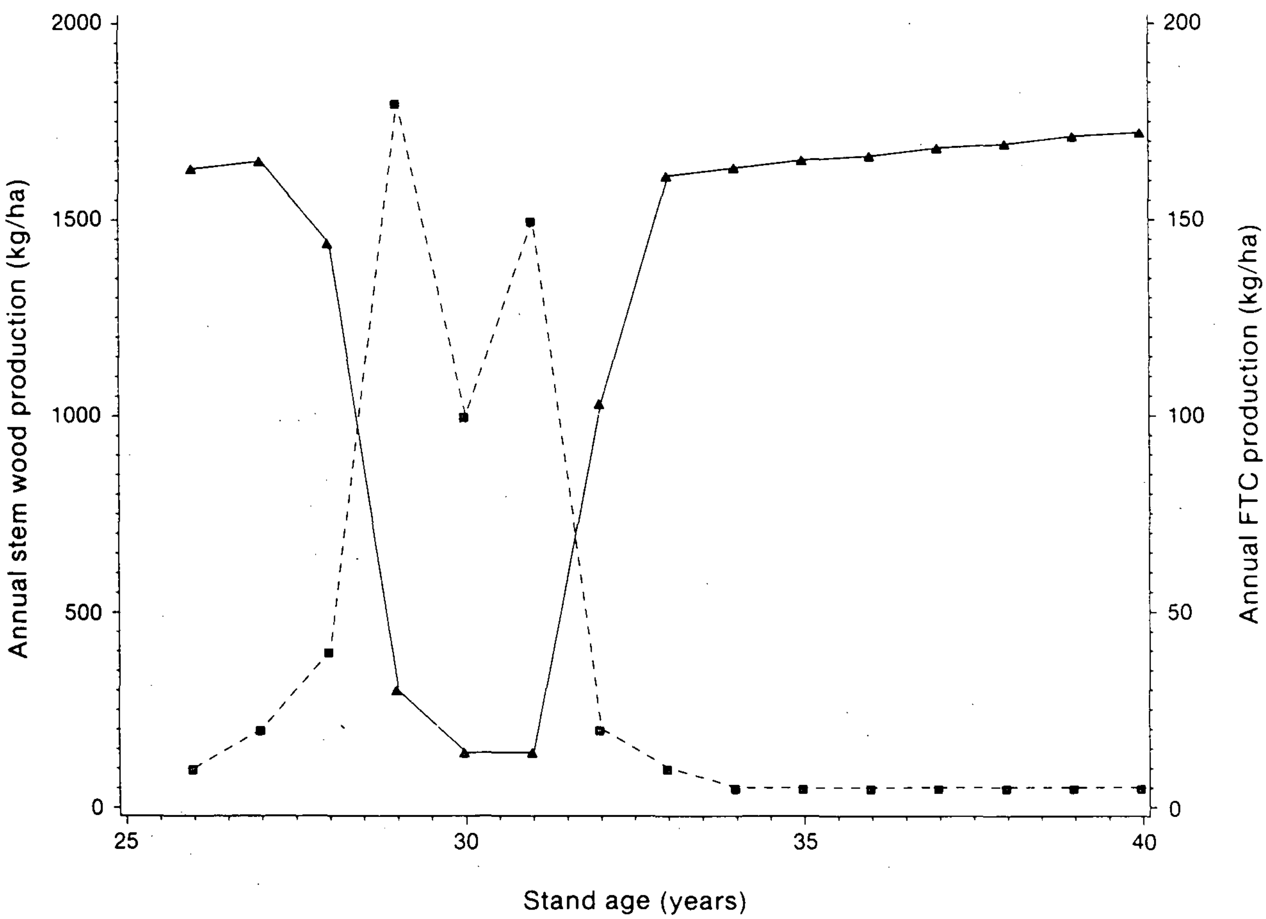

Figure 5. Simulated stem wood (solid line) and forest tent caterpillar biomass production (broken line) in the damaged stand. (Source: Mattson and Addy 1975.)

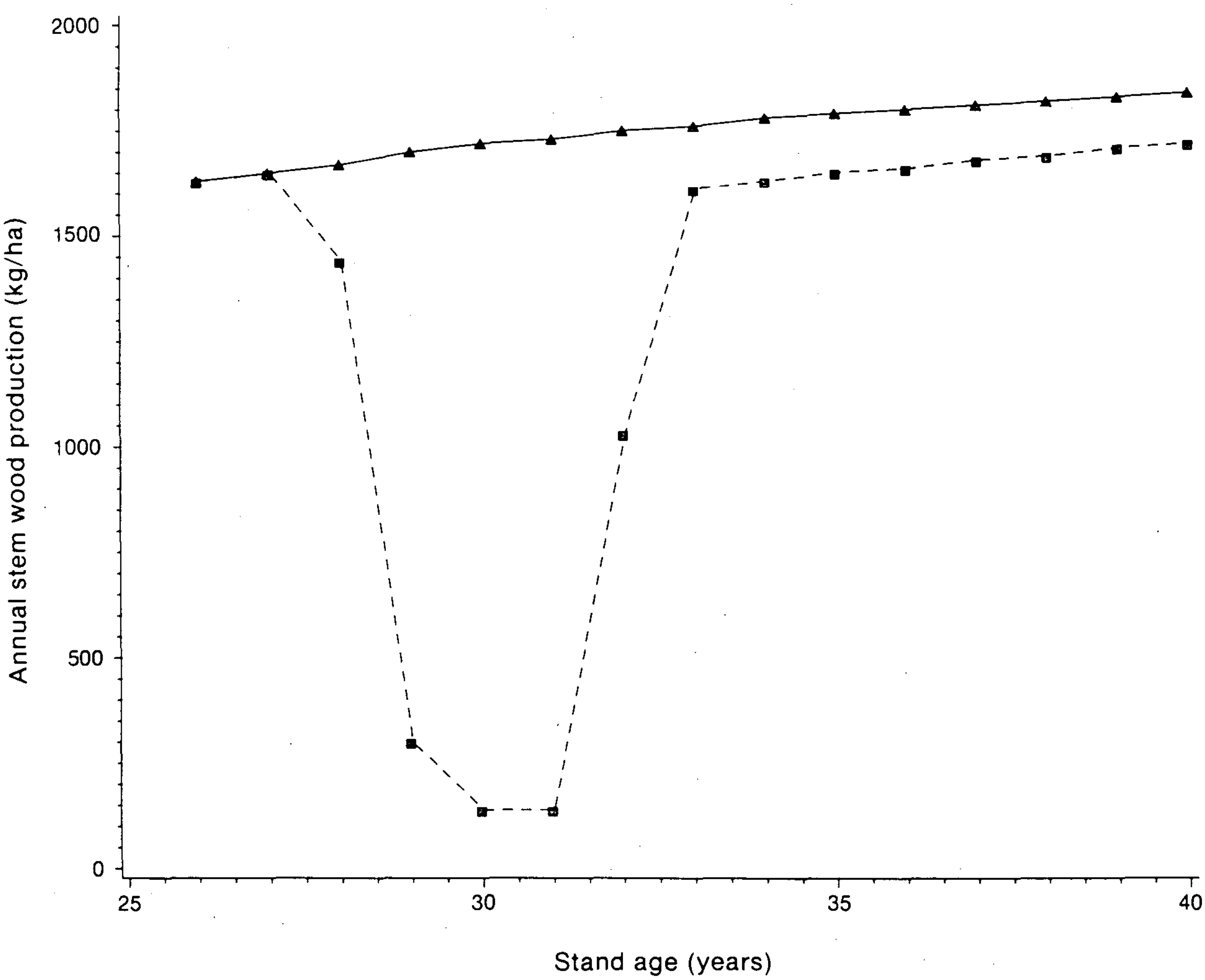

Figure 6. Simulated annual stem wood production in an undamaged (solid line) and damaged (broken line) stands. (Source: Mattson and Addy 1975).

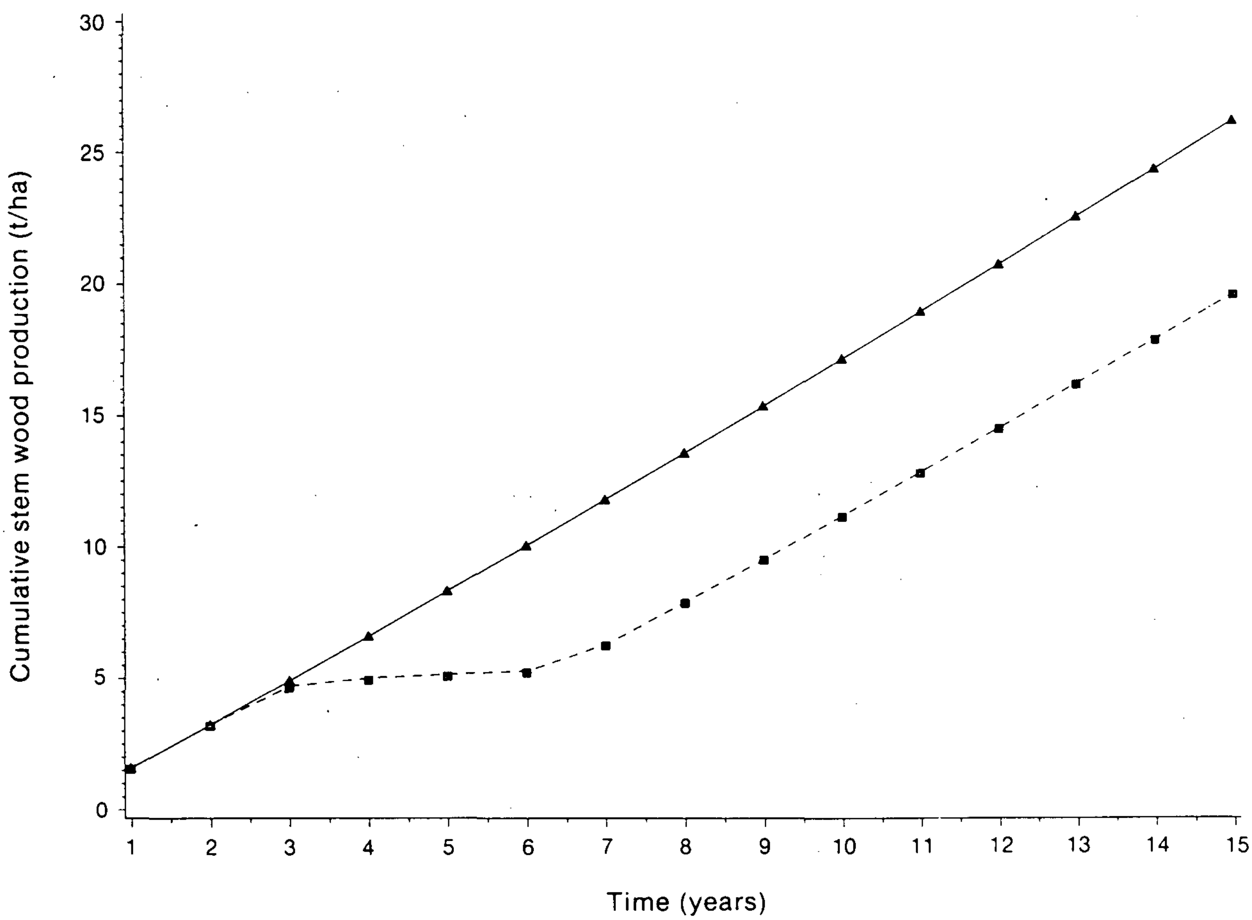

Figure 7. Cumulative stem wood production in simulated aspen stands that are undamaged (solid line) or defoliated (broken line) by forest tent caterpillar. (Source: Mattson and Addy 1975.)

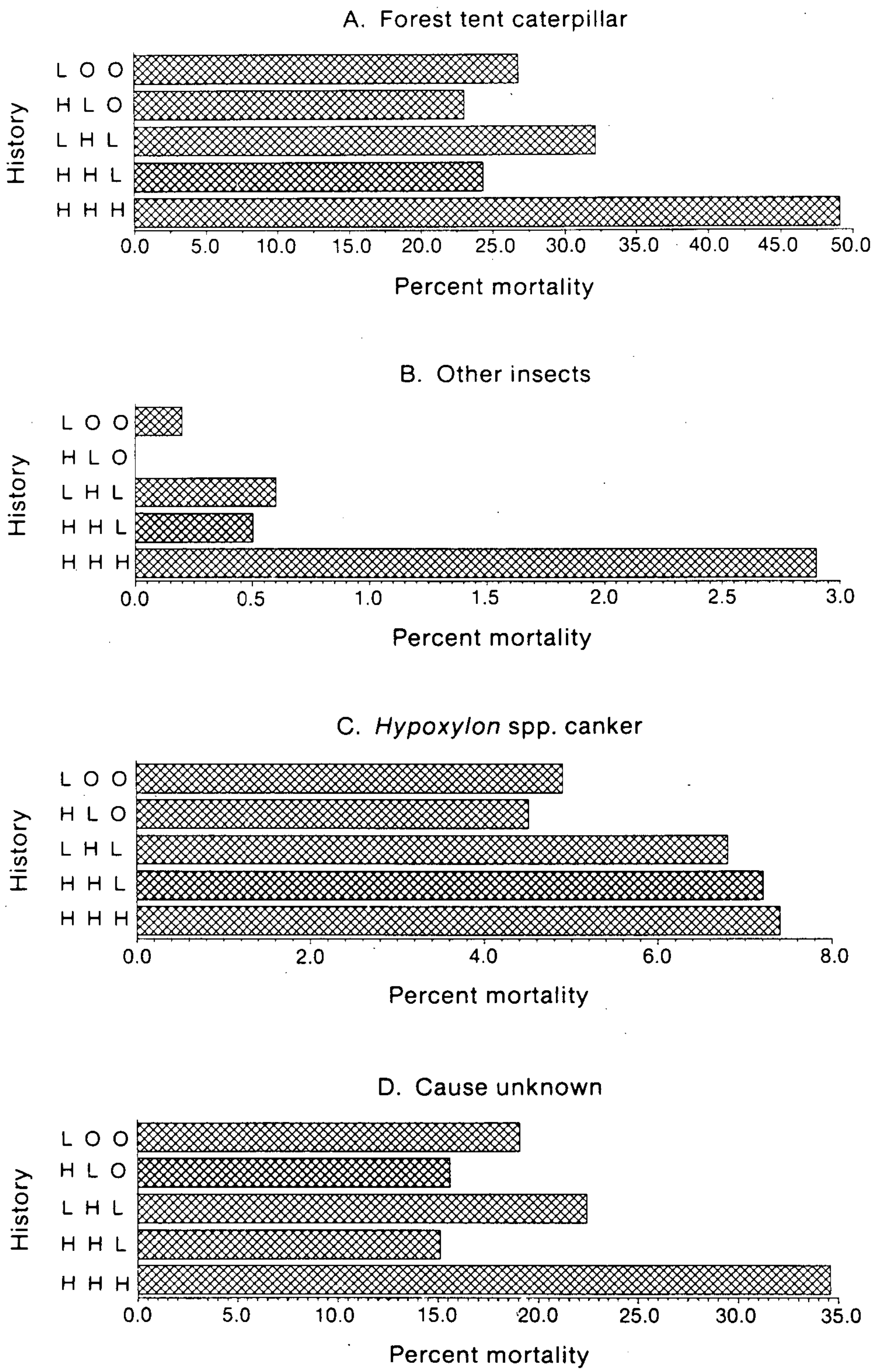

Figure 8. Tree mortality attributed to attack by various damaging agents over a 3-year period: A) forest tent caterpillar; B) insects other than forest tent caterpillar; C) *Hypoxylon* spp. canker; and D) no known cause (H = high, L = low, and O = no defoliation. (Source: Churchill et al. 1984.)

ACKNOWLEDGMENTS

I thank my colleagues H. Cerezke, Y. Hiratsuka, and K. Mallett of the Northern Forestry Centre for discussions that contributed to the genesis of this paper.

REFERENCES

Churchill, G.B.; John, H.H.; Duncan, D.P.; Hodson, A.C. 1964. Long-term effects of defoliation of aspen by the forest tent caterpillar. Ecology 45:630-633.

Davidson, A.G.; Prentice, R.M. 1967. Insects and diseases. Pages 116-144 *in* J.S. Maini and J.H. Cayford, editors. Growth and utilization of poplars in canada. Can. Dep. For. Rural Dev., Ottawa, Ontario.

Graham, S.A.; Harrison, R.P., Jr.; Westell, C.E., Jr. 1963. Aspens: Phoenix trees of the Great Lakes region. University of Michigan Press, Ann Arbor, Michigan.

Hinds, T.E. 1985. Diseases. Pages 87-107 *in* N.V. DeByle and R.P. Winokur, editors. Aspen: ecology and management in the western United States. U.S. For. Serv., Rocky Mt. For. Range Exp. Stn., Fort Collins, Colorado. Gen. Tech. Rep. RM-119.

Hiratsuka, Y. 1987. Forest tree diseases of the prairie provinces. Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-286.

Hiratsuka, Y.; Loman, A.A. 1984. Decay of aspen and balsam poplar in Alberta. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-262.

Ives, W.G.H.; Wong, H.R. 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.; DeByle, N.V.; Bowers, D.M. 1985. Insects and other invertebrates. Pages 107-114 *in* N.V. DeByle and R.P. Winokur, editors. Aspen: ecology and management in the western United States. U.S. For. Serv., Rocky Mt. For. Range Exp. Stn., Fort Collins, Colorado. Gen. Tech. Rep. RM-119.

Malhotra, S.S.; Blauel, R.A. 1980. Diagnosis of air pollutant and natural stress symptoms of forest vegetation in western Canada. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-228.

Mattson, W.J.; Addy, N.D. 1975. Phytophagous insects as regulators of forest primary production. Science 190:515-522.

Unpublished report:

Northern Forestry Centre. 1987. Aspen quality workshop. Proceedings of a workshop held February 12, 1987, Edmonton, Alberta. Prepared under the Canada-Alberta Forest Resource Development Agreement.

MANAGEMENT AND UTILIZATION OF NORTHERN MIXEDWOODS

Proceedings of a symposium
held April 11-14, 1988, in Edmonton, Alberta

J.K. Samoil, editor

INFORMATION REPORT NOR-X-296

NORTHERN FORESTRY CENTRE
CANADIAN FORESTRY SERVICE
1988

Sponsored by the Canadian Forestry Service
in cooperation with the provinces of
Alberta, Saskatchewan, and Manitoba
under the auspices of the
Canada-Alberta Forest Resource Development Agreement,
Canada-Saskatchewan Forest Resource Development Agreement, and
Canada-Manitoba Forest Renewal Agreement.