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IMPACT OF WILDLIFE PREDATION ON THE WHITE PINE WEEVIL ASSOCIATED WITH STAND CONDITIONS IN JACK PINE PLANTATIONS

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INTRODUCTION

Throughout North America, several species of pine (*Pinus* spp.) and spruce (*Picea* spp.) are infested by the white pine weevil (*Pissodes strobi* Peck). Although jack pine (*Pinus banksiana* Lamb) is a common tree species in the boreal forest and one of the most important in lumber and pulp production, most studies have focused on white pine weevil infestation in eastern white pine (*Pinus strobus* L.) and sitka spruce (*Picea sitchensis* Carr.). In jack pine plantations in northern Ontario, reports have revealed attack rates of 30 percent (Canadian Forestry Service 1987) and a reduction of 13 percent in the commercial value of mature stands (Davidson 1991).

White pine weevil damage often causes a loss of the terminal shoot (leader); this rarely results in tree mortality but reduces timber volume and quality. Traditional management options to control the white pine weevil include the provision of shade with nurse crops, underplanting, shelterwood harvesting, or the establishment of high density plantations; the removal of infested leaders; and the destruction of adult overwintering sites through controlled burns or raking (Dixon et al. 1979, Hodge et al. 1989). Recently, a significant advance has been made in the use of Integrated Pest Management (IPM) for control of the white pine weevil in sitka spruce plantations. This measure is based on a combination of genetic resistance, chemical control, and silvicultural strategies (Alfaro et al. 1994).

The white pine weevil has one generation per year. In jack pine plantations in northern Ontario, weevils overwinter as adults in the duff layer under host trees. In early spring they emerge from overwintering sites, feed, mate, and oviposit in the host terminals. While feeding, the larvae make their way down the vascular tissue and eventually kill the leader. Pupation occurs at the base of the leader and adults emerge by the end of the summer. Immature weevils (larvae and pupae) are vulnerable to bird and insect predation during the summer; overwintering adult weevils are vulnerable to mammalian predation during the winter. (Fig. 1).

Stand conditions may influence survival of the white pine weevil. Environmental conditions created by the type of reforestation, woody debris, competing vegetation, or depth of the duff layer may affect different stages of weevil

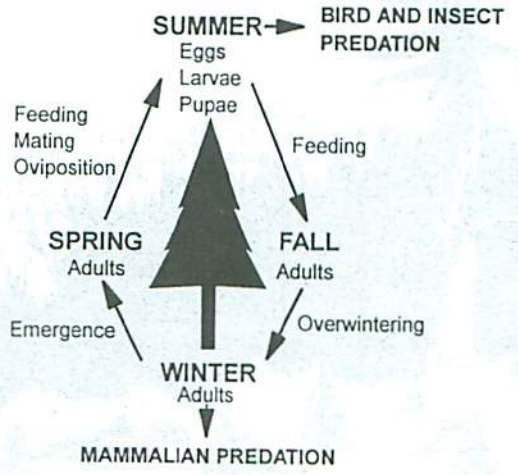

Figure 1. Life cycle of the white pine weevil, Pissodes strobi Peck., *showing the stages of highest vulnerability to bird and mammal predation in jack pine plantations in northern Ontario.*

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development (Sullivan 1960, Archambault et al. 1993). In addition, stand conditions influence the diversity and abundance of the weevils' vertebrate predators. This document reports on the impacts of wildlife predation on the white pine weevil under different stand conditions in jack pine plantations in northern Ontario.

SMALL MAMMAL PREDATION

To assess mammalian predation on overwintering weevils, both control (open) and screened cages were used. The screened cages prevent access by small mammals to the weevils placed into the cages. Predation by insects or birds was not expected because most insects are inactive during the winter and most insectivorous birds emigrate to their wintering ranges. Total overwintering mortality (based on the control cages) ranged from 76–92 percent over a 3-year period. Despite precautions, this may slightly overestimate mortality because some weevils may have escaped from the cages or died if their overwintering sites were located very close to the aluminum ring. Mammalian predation accounted for 5–13 percent mortality of the adult weevil population (Bellocq and Smith 1995a). Most species of shrews (*Sorex* spp.) and some species of mice (Family Cricetidae) are able to forage in the first few centimeters of the duff layer during the winter and, thus, are potential predators of adult weevils.

The study examined the influence of reforestation techniques, distance from woody debris, presence of competing vegetation, and depth of the duff layer on the overwintering mortality of weevils and on mammalian predation of weevils (*see* Table 1). Overwintering mortality of weevils can be influenced by the type of reforestation (e.g., mortality was higher in the planted stands than in the seeded stands). Distance from woody debris had no significant effect on total overwintering mortality or on mammalian predation. Although total overwintering mortality of weevils was not affected by the presence of competing vegetation, mammalian predation was higher in the weed patch than in the weed-free patch, where a higher abundance of small mammals was recorded. Weevil mortality during the winter decreased with an increasing depth of the duff layer.

Overwintering mortality has been described as a key mortality factor of white pine weevil populations in white pine (Dixon and Houseweart 1982), and the authors have further shown that it is also very high in jack pine. Adult mortality appeared inversely related to the depth of the duff layer, and lower adult mortality was observed in the seeded stands (which also had a deeper duff layer) than in the planted stands. It should be noted that abiotic conditions may also influence biotic mortality factors, e.g., mammalian predation also declines with an increasing duff layer depth (Semel and Andersen 1988).

The presence of competing vegetation may influence weevil survival directly by affecting their success in leaders, and indirectly by affecting the density of small mammals. Overstory vegetation has been shown to affect weevil attack and damage to stands depending on the tree species involved. In white pine (Wallace and Sullivan 1985) and sitka spruce (Alfaro and Omule 1990), denser plantations seem to sustain lower attack rates than do more open plantations. In contrast, in Norway spruce (Archambault et al. 1993) and jack pine (Bellocq and Smith 1994), the level of weevil attack seems to be independent of the plantation density. This study showed that for jack pine the mortality of overwintering weevils was higher in planted stands than in seeded stands. Presumably, the low density of trees resulted in a shallow layer of duff, and this favored higher weevil mortality in the planted stands. Furthermore, mammalian predation was higher in the planted stands than in the seeded stands, where more shrews were trapped.

Table 1. Total overwintering mortality of adult weevils and mortality due to mammalian predation under different conditions given by the type of reforestation, distance from woody debris, presence of competing vegetation, and depth of the duff layer in jack pine plantations in northern Ontario.

	Treatment	Total overwintering mortality (percent)	Mammalian predation (percent)
Type of reforestation	Planted	92	13
	Seeded	76	11
Distance from slash	Beside slash	87	7
	100 m from slash	89	5
Presence of competing vegetation	Weed patch	85	0
	Weed-free patch	81	5
Depth of the duff layer (cm)	0	92	—
	2.5	88	—
	5.0	85	—
	7.5	80	—
	10.0	75	—

BIRD PREDATION

The authors also assessed total mortality of pupae and mortality due to bird predation in five planted stands and five seeded stands of jack pine (Table 2). Birds consumed up to 8 percent of the weevil pupae available in weevil-killed terminals of a stand, ranging from 0.1–13.2 percent in the planted stands and from 1.3–20.2 percent in the seeded stands. The type of reforestation did not seem to influence bird predation on weevils. In the planted stands, 1.9–43.5 percent of the weevil-killed leaders showed signs of bird predation on the bark; 9.4–34.8 percent of the leaders were stripped by birds in the

Table 2. Total mortality of pupae weevils and percentage pupae eaten by birds in five planted stands and five seeded stands of jack pine in northern Ontario.

Type of reforestation	Stand	Total mortality of pupae (percent)	Pupae eaten by birds (percent)
Planted	1	54.3	7.0
	2	61.2	11.9
	3	61.9	13.2
	4	52.5	0.1
	5	47.9	0.1
Seeded	1	55.9	9.1
	2	48.3	1.3
	3	65.6	20.2
	4	63.6	7.6
	5	55.9	7.9

seeded stands. Birds removed 27 percent of the pupae available on explored leaders. The percentage of pupae eaten by birds in a stand may be predicted from the percentage of leaders in the stand showing signs of bird predation (Bellocq and Smith 1994). According to the current study, birds must exploit at least 35 percent of the weevil-killed leaders in a jack pine stand to kill 10 percent of the weevil pupae.

Insects are the main source of food for most of the bird species observed in young jack pine plantations. Some of these species forage on the ground or in the foliage and could potentially feed on adult weevils during the spring and fall. Other species remove the bark to feed on the insects beneath it. These would have a more significant impact on weevils during the larval and pupal stages in the summer months.

MANAGEMENT IMPLICATIONS

Factors other than predation were more important in the successful overwintering of adult weevils, although the exact processes are unclear. A large proportion of the adult weevil population died while overwintering in young jack pine plantations. Weevils in the adult stage have the highest reproductive value, especially after they successfully survive the winter. Consequently, management options that target the adult stage (especially in the spring after overwintering mortality occurred) would be more effective for weevil control. Although mammalian predation represents a small fraction of the total overwintering mortality of weevils, it should be considered as part of IPM strategies in jack pine. A small increase in the already high mortality of overwintering weevils will theoretically result in a significant reduction in the abundance of weevils in the subsequent generation (Bellocq and Smith 1995b). Mammalian predation can be manipulated by favoring microhabitat features associated with a high abundance of small mammals, especially shrews. Such features would include fallen logs, and overstory and understory cover (Bellocq and Smith 1995b).

By foraging on late larvae and pupae, birds do not prevent damage in leaders that are already infested but help to decrease the subsequent adult population. Predation by birds was variable among stands that could be linked to the type of surrounding habitat. Appropriate management to increase the abundance of some insectivorous birds will result in an increase of bird predation on weevils. Leaving mature stands around young plantations and retaining snags when harvesting, for instance, will encourage cavity nesters such as woodpeckers (*Dryocopus* spp.).

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