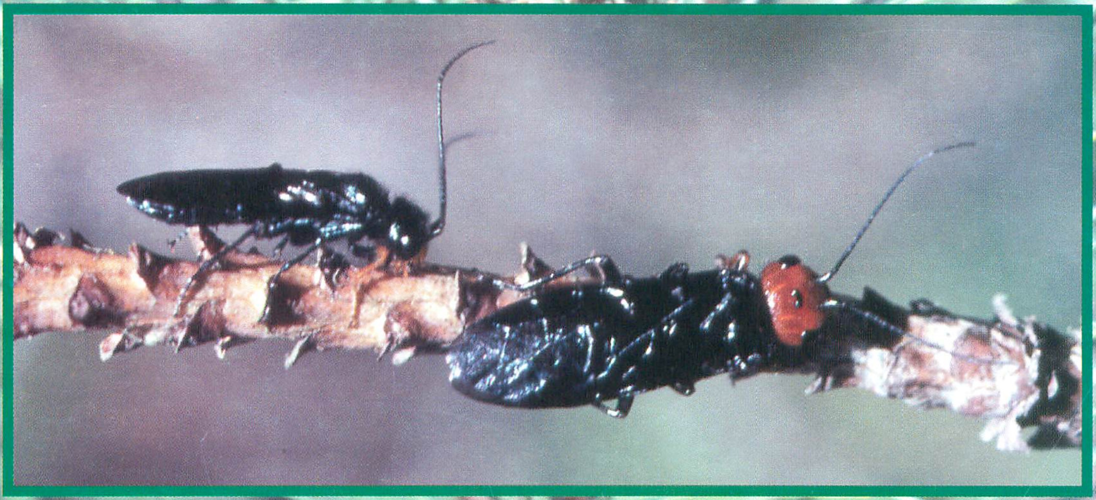
Proceedings of a Workshop on the Pine False Webworm



Natural Resources Canada / Ressources naturelles Canada

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Proceedings of a Workshop on the Pine False Webworm, *Acantholyda erythrocephala* (Hymenoptera: Pamphiliidae)

held
16 February 1998
Faculty of Forestry, University of Toronto
Toronto, Ontario

D. Barry Lyons, Gene C. Jones and Taylor A. Scarr (editors)

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Pine False Webworm in Ontario, Workshop Welcome and Introduction

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When I first heard about pine false webworm, *Acantholyda erythrocephala* (L.), it was during conversations with Barry Lyons when he was doing his graduate research on the insect. At the time, the insect was known as a pest of pine plantations, and it generally disappeared once a stand reached crown closure.

That all changed in Ontario in about 1993, when severe defoliation by this insect was detected on semi-mature red pine by the Forest Insect and Disease Survey unit of the Canadian Forest Service (CFS). Most of the affected area was in Simcoe County and the Ganaraska Forest. We then learned that similar severe defoliation was occurring on white pine in New York.

Three immediate lessons came out of this. The first was that for survey or monitoring programs to be effective, they must not focus only on the big problems, such as spruce budworm or forest tent caterpillar. The long term, comprehensive monitoring by the CFS picked up the new occurrence of severe defoliation, no doubt with information from local foresters and technicians. The historical record for this insect proved invaluable in knowing the current distribution for pine false webworm and its rate of spread (Howse 2000). We could then gauge the potential magnitude of the problem.

Second, basic research (Lyons and Jones 2000) became critical for us to know the biology and ecology of the insect, for us to know the seriousness of this insect and what it could do to the forest resources of south-central Ontario. Furthermore, efficacy trials (Helson and Lyons 2000) gave us a basis for determining what insecticides could be considered for controlling this insect. Had these research projects focussed only on applied research, or not tested chemical insecticides because it's not politically green enough, then we would know very little about the insect and options for controlling it.

The third lesson was that we can learn much from what is happening elsewhere, but only through maintaining networks and sharing expertise and information with other jurisdictions.

This workshop was the culmination of the efforts of several people and agencies. It began as an idea among Barry Lyons, Sandy Smith (our host at the University of Toronto), and myself and Harri Liljalehto of the Ministry of Natural Resources (MNR). But it was the request for just such a workshop, from the landowners, counties, municipalities, and MNR district staff from Midhurst and Peterborough, that arose from the 1997 Forest Health Review that gave the workshop its spark of life.

The workshop brought together MNR specialists and resource managers, researchers from the federal government and university, Conservation Authorities staff, consultants, pesticide suppliers, land managers, representatives of municipalities and counties, Department of National Defence staff, Christmas tree growers, nursery growers, and federal regulators. This wide group of participants reflected both the complexity of the problem and whom it affects, as well as the need to work cooperatively and in partnership towards common goals.

This insect is one of several that must be considered in managing our forests. It is a novel insect, with its cryptic feeding habits, overwintering in the soil as a larva, feeding inside of its web, and not affected by the biological insecticide *B.t.* It thus presents special challenges requiring novel solutions.

Discussed in the Proceedings are the similarities and differences between its behaviour in New York (Allen 2000) and Ontario, and how it is affecting some very high value forest resources. The challenges of dealing with an introduced insect, and about developing new methods of predicting impacts, forecasting populations, and developing management options are described (Lyons and Jones 2000).

We examined the current state of knowledge, from which we scoped out the problem facing us. The insect's history, distribution, and impacts were examined in detail, as were the results of on-going research projects. From this we moved to identifying and examining control options for resource managers.

By the end of the workshop, the researchers took with them a revitalized list of priorities to address the needs of resource managers. The resource managers left with an improved understanding of the insect, how they can apply the results of the research projects, and what control options hold the greatest promise.

The Proceedings of the workshop concludes with a panel discussion, which involved all the presenters, and included a question and answer session. The goals were to foster synergy and partnerships, and to identify what actions need to be taken by whom, when, and with what resources and support.

Introduced insects present the greatest of challenges, but also have the highest potential for success.

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What Do We Know About the Biology of the Pine False Webworm in Ontario?

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Introduction

The goal of this workshop was to bring together key researchers that are working on the pine false webworm, *Acantholyda erythrocephala* (L.) in North America and to find out what we know about the insect. More appropriately, we would like to find out what we do not know, and in doing so, determine the important questions forest managers want to ask about it. The search for answers to these questions will serve to direct our future research activities. Herein, we will discuss some of our research efforts into understanding the biology of this forest insect pest in Ontario, Canada.

Consequently, the objectives of this paper are: 1) introduce the pine false webworm and describe its life history; 2) discuss what we know about the phenology or seasonal development of this insect; 3) describe the work we have been doing on the population dynamics of the insect; 4) outline the impact studies we have conducted; 5) explore potential silvicultural controls; and, 6) discuss preliminary experiments we have undertaken searching for a pheromone for the pine false webworm.

Life History

In the spring (late April to early June), adults (Fig. 1) of the pine false webworm emerge from the soil, in which they overwintered, under the host trees. Adults mate soon after emergence. The sexes of the pine false webworm are easy to distinguish. The female is usually larger than the male and has a bright red head and forelegs. The male has a yellow face or frons, and yellow forelegs. Almost immediately after mating the female begins to oviposit (Fig. 2). The female has a saw-like ovipositor, from which the name sawfly is derived, which she uses to cut a slit into the needles of the host trees. The host trees are species of the genus *Pinus*. The female cuts a slit into the needle, then using her egg-laying apparatus, she inserts a crease of the chorion or shell of the large egg into the slit created in the needle. Eggs are deposited end-to-end along the needle. The eggs are in intimate contact with the vascular system of the plant from which they obtain moisture to swell and continue development. Figure 3 shows eggs that are ready to hatch and eggs containing elongated holes from which larvae have already emerged.

Fig. 1. Male (bottom) and female (top) of the pine false webworm.

Upon emergence from the egg, the larvae crawl down to the base of the needle where they begin to feed. As they develop, they are wasteful feeders. The larvae attach silk strands to the needles and clip them off near the base. Clipped needles drop down on the silk strands and the larvae pull them into the web where they are consumed. Many of the needles that get clipped off are not eaten and dry out. The larvae also construct silken tubes within which they feed. These activities result in a web forming along the branch (Fig. 4). Thus, the web is an accumulation of frass, uneaten needles, and cast skins from the insect, all held together with silken strands. The insects feed primarily on the previous-year's or older foliage. They rarely feed on new foliage on the expanding shoots unless the old foliage has been entirely consumed.

To determine the number of larval instars, widths of head capsules of larvae, collected throughout their development period, were measured using an ocular micrometer mounted on a stereomicroscope. Plotting the frequency of larvae versus the head capsule measurements produced a multimodal distribution corresponding to six larval instars (Fig. 5A). There were six larval instars in the females and only five for the males. This technique was also employed to differentiate the sexes of ultimate-instar larvae (Fig. 5B).

Once the larvae have completed their arboreal development (June to early July), they drop from the trees

Fig. 2. Female of the pine false webworm depositing eggs on a needle of the host plant.

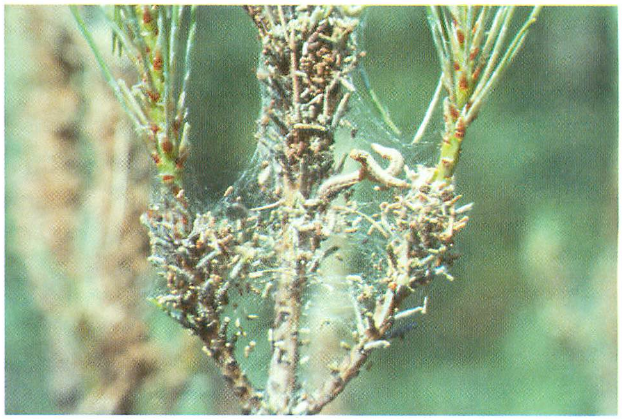

Fig. 4. Web and larvae of the pine false webworm. The larvae have consumed all of the previous-year's foliage.

to the ground and burrow into the soil. When they select suitable sites in the soil, the larvae form cells by undulating their bodies and compacting the sides. This is very different from the cocoon forming behaviour of diprionid and tenthredinid sawflies. A number of years ago, we examined the vertical distribution of larvae in the soil in two different red pine, *P. resinosa* Ait., plantations (Fig. 6). In sandy soil, the larvae all occurred in the top 9 cm of the mineral soil with a median depth of about 5 cm. This distribution is probably variable depending on soil types and the kinds of obstructions encountered in the ground as they burrow. Larvae in this stage of development are known as eonymphs (Fig. 7). A humped-back appearance and a small larva-like eye characterize this stage. Sometime during late summer or early fall these eonymphs transform into pronymphs (Fig. 8). The pronymphs are distinguished from eonymphs by their large pupa-like eyes.

Pine false webworms, collected by the Ontario Ministry of Natural Resources from the soil in the Ganaraska forest in December 1997, were recently examined to determine what proportions of the population were in various stages of development. The majority of the insects, almost 60%, was pronymphs, but a proportion of the population was in the eonymphal stage. The European literature reported that a proportion of the pine false webworm population remains in this eonymphal stage for more than one winter. This delayed development is known as prolonged eonymphal

Fig. 3. Eggs of the pine false webworm on the needles of the host plant. Larvae have emerged from eggs containing slits.

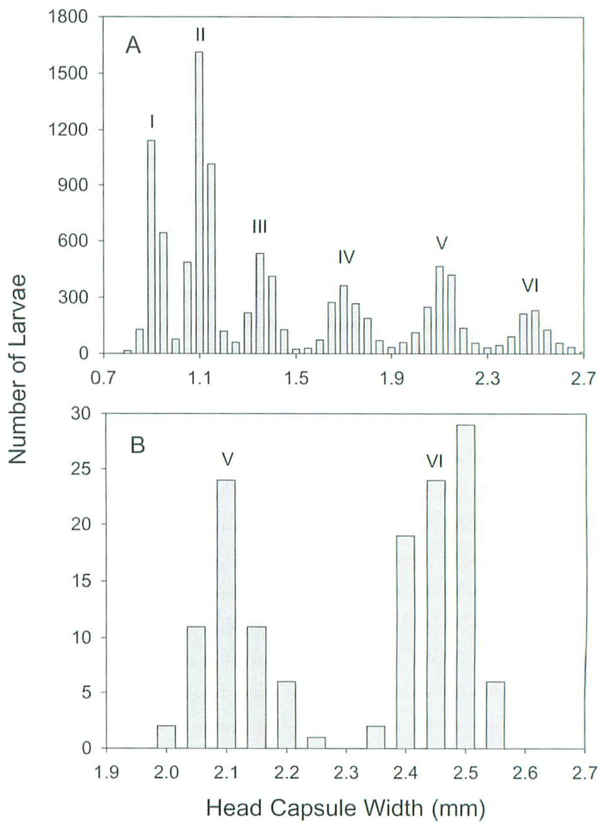

Fig. 5. Frequency distributions of the head capsule measurements of developing larvae (A) and ultimate-instar larvae (B) of the pine false webworm (after Lyons 1995).

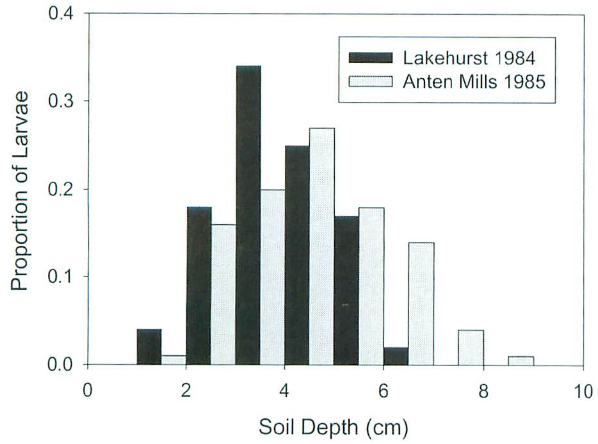

Fig. 6. Vertical distribution of larvae of pine false webworm in the soil at Lakehurst, Ontario in 1984 and Anten Mills, Ontario in 1985.

diapause. In the Ganaraska population, about 20% of the insects were observed in the eonymphal stage. These eonymphs will not complete development the following spring, but will remain in this quiescent state for an additional winter or more. A number of insects were also observed in a transitional stage of eye development (neither eonymphs nor pronymphs). This was unusual because complete development should have occurred by this time. The developmental fate of these insects is unknown at this time. A number of parasitized insects were also observed in these samples. An ichneumonid parasitoid that overwinters in the host is known. Parasitoids of the pine false webworm are discussed by Bourchier *et al.* (2000).

Once the soil begins to warm in the spring, the insects transform from pronymphs into exarate pupae (Fig. 9). Exarate pupae have all their appendages, such as antennae and legs, dangling free from their body. Pupae of some other species of insects have appendages fused along their length to the body. Pine false webworm are extremely fragile in this stage. Pupae dug from the soil are easily damaged. Pupation occurs at very low temperatures. Pupae have been observed when ice crystals are still present in the soil.

Fig. 7. Eonymph stage of the pine false webworm.

Fig. 8. Pronymphs of the pine false webworm. The larger pronymph is a female.

Phenology

Figure 10 shows the phenology of the various stages of the pine false webworm in 1986. Individual graphs indicate the dates of occurrence of each stage. Emergence of the adults from the ground began, that year, as early as 27 April and continued until 26 May (Fig. 10A). On average, the males emerged earlier than the females. This is known as protandry. Different defoliation zones in the plantation influenced the time of emergence of the adults. Adults that were in a heavily-defoliated zone, where there was lots of

Fig. 9. Exarate pupae of the pine false webworm. Larger pupa is female.

sun penetration to the floor of the plantation, emerged earlier than insects in a lightly- or moderately-defoliated zone.

Egg deposition began almost as soon as the first adults were observed (Fig. 10B). The period of egg hatch, although not depicted, preceded the larval stages and occurred late in May in that year. The timing of the egg hatch period is variable, as are the phenological periods of all life history stages, and changes from year to year. Insect phenology is influenced by many variables, although the most important is temperature.

The distribution of larval instars indicated that the larval stage occurred until the end of June (Fig. 10C). Fifth-instar larvae were observed as soon as early June. Some of these larvae were males completing development and beginning to drop to the soil. Females or 6th instars were first observed about 12 June. Figure 10D shows the period of larval drop, as they exited the trees to the soil, which occurred over a considerable period of time. The mean drop of males preceded the mean drop of females.

These phenological observations indicated that developmental stages of the pine false webworm have very protracted and overlapping periods. Adults emerged from the soil for almost a month. Larvae were present on the branches for at least a month and larvae were observed dropping from early June to the beginning of July. These extended development periods have considerable implications for applying controls, when specific life history stages are targeted.

Phenology models have been developed to predict the seasonal development of various stages of the pine false webworm. A model that predicts subterranean development, including pupation and adult eclosion has been constructed (Lyons unpublished data). However, this model requires soil temperature input to generate developmental rates. Thus, the temperature of the soil must be known to predict when the adults will emerge from the soil. An oviposition model, where egg deposition is predicted, has been developed which requires adult emergence data to initiate the simulation (Lyons 1996). Models of arboreal development, predicting when egg hatch and larval drop occur, are also available (Lyons 1994). Individual larval instars of the pine false webworm are cryptic and occur within the web. Consequently, it is difficult to observe when there are changes from one larval

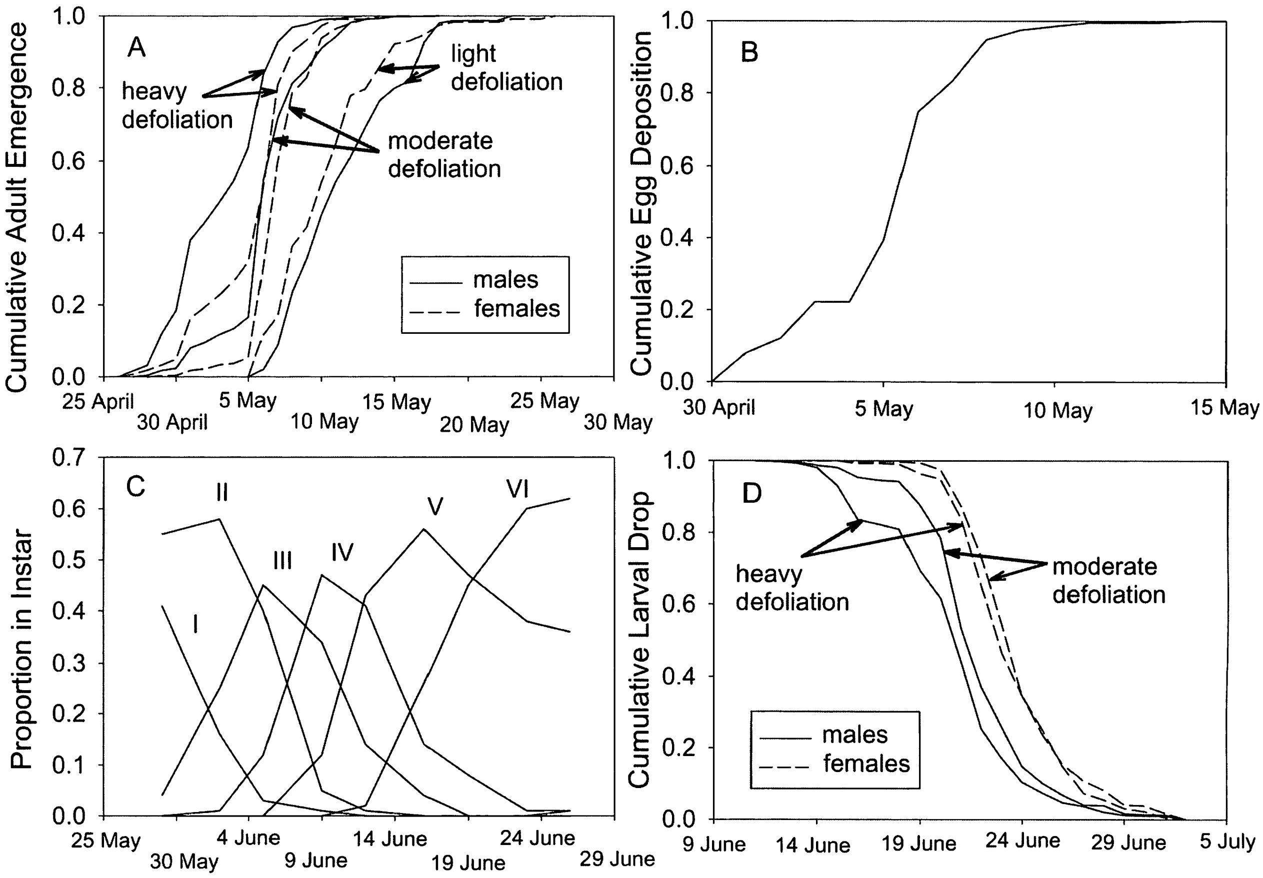

Fig. 10. Phenological periods for adult emergence (A), egg deposition (B), larval instars (C) and larval drop (D) for the pine false webworm at Lakehurst, Ontario in 1986.

instar to the next. Therefore, models to predict development of individual larval instars have not been developed.

Population Estimates and Damage Prediction

We have established 15 plots north of Barrie, Ontario, near the town of Craighurst, in which we have been examining the effects of population densities of pine false webworm on tree damage. The plots were selected to represent a variety of insect densities and defoliation levels. The plots were located within several mature and semi-mature red pine plantations. Each plot contained approximately 100 trees arranged in 10 rows of 10 trees. Individual plots were lettered A through O. Within each plot, each tree was consecutively numbered with aluminum tags and the spatial distribution of each tree was mapped (e.g., Fig. 11). The objective of these investigations was to determine which estimate of population density provided the best predictor of tree defoliation. A suitable estimate must be easy to obtain, reasonably reliable and provide enough lead-time for the forest manager to make management decisions.

Since the work began in 1996, we have estimated a number of population parameters in these plots. Using traps, we have sampled the number of adults emerging from the soil in the springs of 1996 and 1997. Each emergence trap consisted of a cone, constructed from window screen, fixed to a steel hoop wired to the base. A plastic collecting bottle was fixed, via a hole in its side, to a plastic funnel at the apex of the cone. The traps sampled an area of 0.25 m^2 of soil surface. The collecting bottle was partially filled with ethanol to preserve emerging adults. Following completion of their development in the soil, the adults burrowed out of the soil, and crawled or flew up the cones and were captured in the collecting bottles. The numbers of males and females captured in the traps were determined at weekly intervals. Ten traps were placed at 5-m intervals along a transect that ran diagonally across each plot (Fig. 11). The location of the transect was changed each year.

After the adult emergence period was completed in 1996 and 1997, the emergence traps were inverted and suspended on three wooden stakes and became frass- and larval-drop traps. These traps collected the insects' excrement and ultimate-instar larvae as they dropped from the branches. A cork was placed in the funnels at the bottom of the cones to prevent loss of frass or larvae. At weekly intervals, the frass and larvae were collected from the traps and stored in plastic cups. Larvae were picked from the frass and counted. The frass was sieved to remove debris, dried in an oven at 80°C for 72 h, and weighed.

In addition to estimates of adult emergence, and larval- and frass-drop densities, the densities of in-tree populations of larvae were sampled on 3-4 July 1997 and defoliation was estimated on 15 June 1997 (i.e., 1996 defoliation) and 18 August 1997 (i.e., 1997 defoliation). Within each plot, ten trees were randomly selected by number and a 45-cm branch tip was removed from the crown of each tree using a pole-pruner. Defoliation of current and one-year-old foliage was estimated to the nearest 10%. Larval densities were determined by counting the larvae on each branch.

Several relationships between these population estimates and defoliation have been examined. Two of the relationships have shown considerable promise for predicting defoliation from an estimate of population density. When one-year-old foliage which was defoliated in the current year (t_n) was plotted as a function of the number of females captured in emergence traps in the current year, after appropriate transformation of the data, a good fit for the linear regression was obtained (Fig. 12). This suggested that defoliation could be predicted with a high degree of precision from an estimate of the number of females emerging from the soil. However, by the time females have completed emergence, little time is available for forest managers to decide about control options. The second relationship overcame this constraint. The number of larvae collected in drop traps in the previous year (t_{n-1}) was regressed as a function of defoliation of one-year-old foliage in the current year (t_n). A good fit of the regression line was obtained (Fig. 13) suggesting that dropping larvae might be a better predictor of defoliation when lead-time for forest managers is required. This relationship, however, is only based on one year's data. Additional data needs to be collected to determine if this relationship is robust enough to be applicable from year to year.

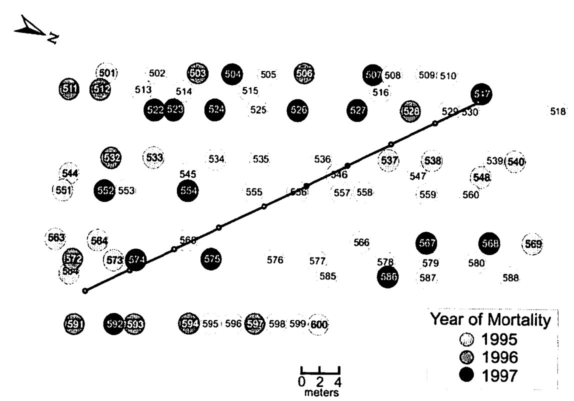

Fig. 11. Map of tree distribution in pine false webworm impact Plot F showing tree mortality in 1995, 1996 and 1997. The horizontal line represents a typical placement of adult emergence/larval drop traps.

Impact

In the same plots in which population estimates were made, the impact of the pine false webworm on tree health and growth was investigated. Two questions were addressed: 1) does pine false webworm affect tree growth? and 2) does the insect kill trees?

To determine the effect of the insect's activity on tree growth, increment cores were extracted from breast height from ten trees within each of the 15 plots and an uninfested plantation, at the end of the growing season in 1996. Annual increments for 1993-1996 were measured for each tree and the mean increment for each plot was calculated. Plotting mean increment by year (Fig. 14), for pooled adjacent plots, revealed that pooled plots that had the highest populations of pine false webworm had the least cumulative growth increment (e.g., pooled plots F, G, H, M), while the pooled plots with the lower densities of pine false webworm had the greatest growth increment (e.g., C, D, E). This evidence strongly suggests that the pine false webworm does affect the growth of red pines.

All trees within the 15 plots were examined yearly in 1995, 1996 and 1997 to determine their state of health. The absence of foliage was not an absolute sign of tree mortality. Confirmation of tree mortality was made using one or more of the following in combination with the lack of green foliage; large pieces of bark easily removed, presence of bark beetle emergence holes, mycelia of *Armillaria*, or wood boring insect damage. Tree mortality was overlain on the maps of tree distribution for each plot to determine if there were spatial patterns to the mortality. No patterns have been detected to date. Most of the 15 plots had little or no mortality that could be attributed to the pine false webworm. However, some plots (e.g., Fig. 11) have sustained severe defoliation and tree mortality over the period of observation. New mortality has been observed every year within plot F and cumulative mortality has reached 50%. The spatial distribution of tree mortality within this plot appeared random.

A preliminary analysis was made to determine the relationship between tree mortality and defoliation. Percent tree mortality in the current year was plotted as a function of defoliation in the previous year and a non-linear regression curve was fitted to the data (Fig. 15). The relationship suggested that levels of defoliation less than about 70% did not result in tree mortality and at defoliation levels greater than 70%, defoliation was positively correlated with mortality. This relationship did not take into consideration the effects of cumulative defoliation, over several years, on mortality. The relationship suggested that the pine false webworm is directly or indirectly responsible for mortality of plantation-grown red pines.

Silvicultural Controls

A salvage clearcutting operation in November 1994 and a selective-thinning operation in May 1997, in red pine plantations in the vicinity of Craighurst, provided opportunities to examine the effects of these practices on pine false webworm. Specifically, we wanted to know if females of the pine false webworm oviposited on foliage in slash piles generated by these logging operations, and if so, did the resulting eggs and larvae survive. Surviving larvae that completed development would add individuals to the existing population. However, branches that received eggs, but the eggs or resultant larvae failed to survive, would act as oviposition traps, mitigating attacks on adjacent trees.

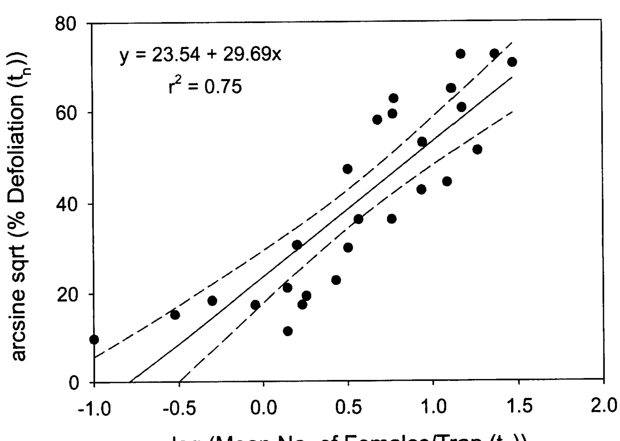

Fig. 12. Defoliation of red pines by pine false webworm in the current year (t_n) as a function of the number of females captured in emergence traps in the current year. Solid line is the regression and dashed lines are 95% confidence intervals.

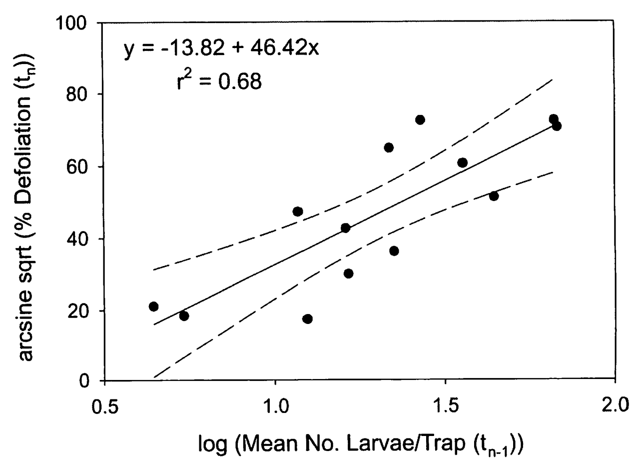

Fig. 13. Defoliation of red pines by pine false webworm in the current year (t_n) as a function of the number of larvae captured in drop traps in the previous year (t_{n-1}). Solid line is the regression and dashed lines are 95% confidence intervals.

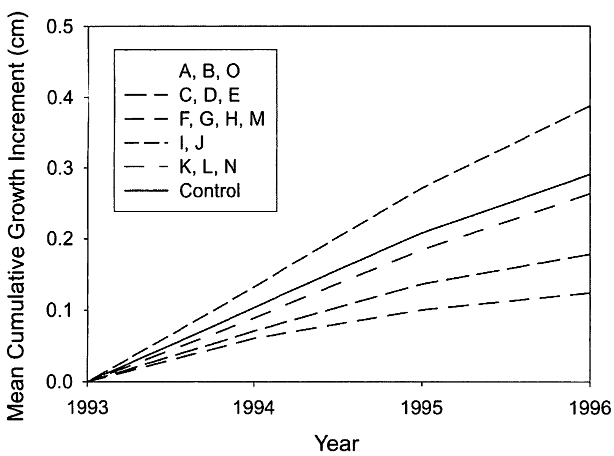

Fig. 14. Cumulative growth increment of plantation-grown red pines in plots infested with pine false webworm. Plots with the greatest increment have the smallest populations of the pest.

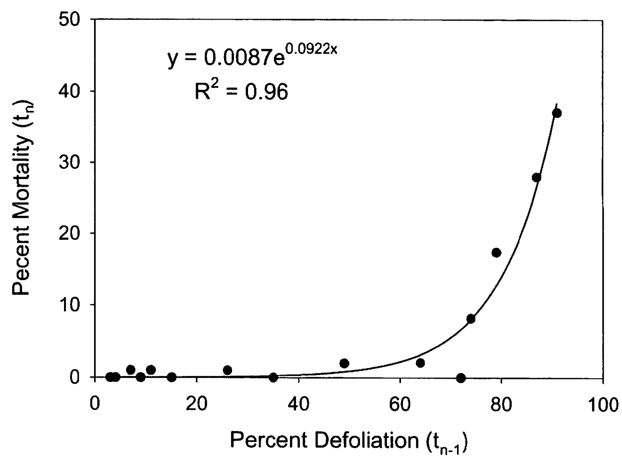

Fig. 15. Percent tree mortality in the current year (t_n) as a function of percent defoliation by the pine false webworm in the previous year (t_{n-1}) in the fifteen plots at Craighurst, Ontario.

To determine if females oviposit on branches in slash piles cut in the previous fall, 45 branch tips in slash piles resulting from the clearcutting in 1994 were marked with flagging tape prior to pine false webworm oviposition in the spring of 1995. The number of eggs deposited on these branches was counted and the number of eggs that hatched was subsequently determined. The fate of emerging larvae on these branches was also noted. A mean (SE) of 45.2 (13.2) eggs was deposited on these branch tips. Only 5% of these eggs hatched. The remaining eggs desiccated as the branches dried out. None of the emerging larvae survived to complete development. From these observations, we concluded that foliage in slash piles, cut in the previous fall, was a suitable oviposition site for the pine false webworm. In addition, the foliage on these branches would probably dry out before the larvae completed development. Thus, these branches served as oviposition traps and reduced the oviposition pressure on adjacent trees. Surviving larvae were not present to augment the subsequent generation.

The thinning operation in 1997 allowed us to explore some additional questions. Does foliage in slash piles, from logging operations in spring, desiccate soon enough to inhibit survival of pine false webworm larvae? Do females exhibit an oviposition preference for certain branch tips (e.g., position above the ground or size of branch)? Do smaller pieces of slash desiccate sooner than larger pieces of slash and does this affect the insects? To answer these questions, branch tips in slash piles were marked and observed as was done in 1995. However, branch tips were categorized as either near the ground (<30 cm from surface) or above the ground (>30 cm from surface), and as tree tops (large biomass) or lateral branches (small biomass). Thirty branch tips were selected in each of the four categories. In addition, the number of eggs per branch tip was also determined for branches collected from the canopy The mean number of eggs on each branch tip type was compared using ANOVA followed by Tukey's multiple range test. Similarly, the mean number of desiccated eggs was statistically compared. Eggs on branches from the canopy were not statistically compared because these estimates were based on the total number of eggs on a branch divided by the number of branch tips. The majority of eggs was deposited on the branch tips on tree tops above the ground (Fig. 16A). Almost all eggs on tips of lateral branches desiccated, while significantly fewer eggs on tree tops dried out (Fig. 16B). Most of the tree-top branches were still green on 27 June when observations were made, while lateral branches were beginning to turn red-brown (Fig. 16C). Additional unmarked branch tips were collected, from other slash piles, at intervals after egg hatch to determine the stage of larval development on them. The head capsules of these larvae were measured to determine larval instar. Ultimate-instar larvae (5^{th} for males; 6^{th} for females) were observed on the branches indicating that larvae were completing development and probably dropping to the soil.

The results from 1997 suggested that slash from logging operations in the spring provide suitable oviposition sites for the pine false webworm the same spring. The females exhibit an oviposition preference for larger pieces of slash (tree tops) lying above the ground. These branches may intercept females as they emerge from the soil and reduce the number of ovipositions in the canopy. However, these larger pieces of slash took longer to desiccate than did smaller lateral branches and some larvae were able to complete development on them. Few eggs hatched on smaller pieces (lateral branches) of slash. Thus, to effectively serve as oviposition traps, branches must be either cut in the fall or be reduced in size to promote desiccation if cut in the spring.

Pheromone Trials

Two experiments were conducted near Craighurst in 1997 to determine if the pine false webworm produces a sex pheromone. In the first experiment, baits were presented in Wing 1C traps (Great Lakes IPM, Vestaberg, MI). Ten replicates of seven bait conditions were deployed. The traps were suspended approximately 1.5 m above the ground from wooden crosses. Each replicate was placed sequentially around the periphery of the immature red pine plantation and the position of treatments was randomized within replicates. Traps were placed at 10-m spacings. At weekly intervals, the trap bottoms were replaced, the insects were counted and the positions of the traps were re-randomized. The seven baits within a replicate were as follows: 1) unbaited control; 2) hexane-soaked rubber septum (control); 3) live virgin female; 4) rubber septum containing extract of hexane-dipped virgin female; 5) rubber septum containing hexane extract of crushed virgin female; 6) live virgin male; and 7) rubber septum containing hexane extract of crushed virgin male. As indicated in Figure 17A, there was no indication that any of the treatments was more attractive than another treatment. All traps captured a large number of males including the unbaited and hexane-baited controls. Median trap catches for each treatment were compared using Kruskal-Wallis One Way Analysis of Variance on Ranks (SigmaStat). There were no statistically significant differences between treatments ($P = 0.965$). Thus, there was no indication of a male- or female-produced sex pheromone. This does not imply that a pheromone does not exist, but it suggests that if there is a pheromone it is not a strong attractant. The traps were positioned at the edge of the plantation where there was considerable male flight activity. Males probably randomly encountered traps.

The second experiment was designed to determine if trap type affected captures and whether or not there was a visual component to attraction. Traps used in this experiment were the sticky bottoms of the wing traps mounted horizontally on flat wooden panels. The 30 cm by 30 cm wooden panels were fixed to the top of wooden posts 0.5-1.0 m above the ground. Five replicates of seven experimental conditions were positioned around a plantation as described previously. The trap baits were as follows: 1) unbaited; 2) hidden (opaque container) live virgin female; 3) rubber septum containing hexane extract of crushed virgin female; 4) hexane-washed dead virgin female; 5) visible (transparent container) live virgin

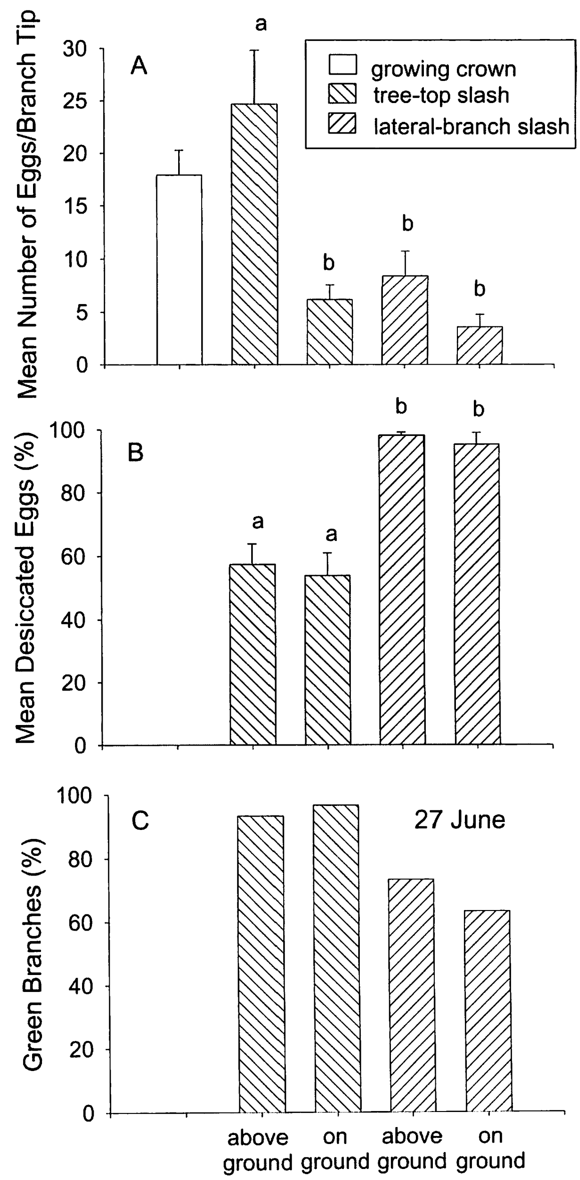

Fig. 16. Mean number of eggs deposited by pine false webworm on branch tips in slash piles and tree crowns (A); mean number of the eggs in slash piles that became desiccated (B) and the percentage of the branch tips in slash piles that had remained green by 27 June (C)

female; 6) visible (transparent container) live virgin male; and 7) virgin female in wing trap. These traps also captured a large number of males (Fig. 17B). The only apparent difference was that the wing traps caught fewer males than did the horizontal traps. This probably reflects the easier access to the latter. Once again the same analysis indicated that there were no statistically significant differences between treatments ($P = 0.263$). Thus, the results of this experiment were also inconclusive and did not suggest the presence of a pheromone or a visual cue for attraction.

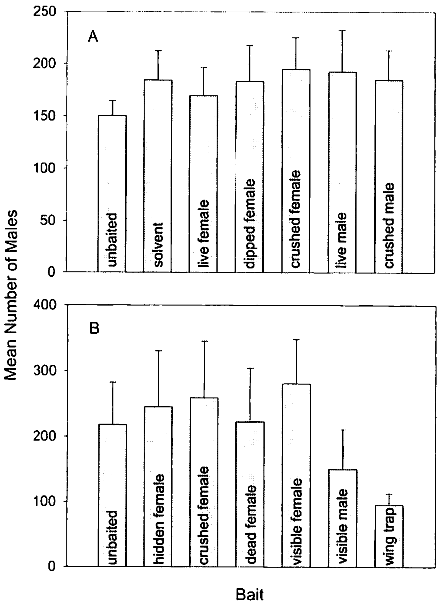

Fig. 17. Number of adult males of pine false webworm caught in pheromone traps using various baits in experiment 1 (A) and experiment 2 (B).

Conclusions

The title of this paper asks the question "What do we know about the biology of the pine false webworm in Ontario?". The preceding discussion is an outline of some of the aspects of the biology of the insect that are known for populations in Ontario. This outline, however, has generated as many questions as it has answered. How important is the prolonged eonymphal diapause to a population and does the trait vary geographically? In European populations of this species and similar sawflies, there tends to be a very close relationship between prolonged diapause and climatic temperatures. The lower the temperature the greater the incidence of eonymphal diapause. We do not know if this occurs in Ontario populations of pine false webworm. Can predictive models for defoliation be developed? Progress has been made in this area, but we require additional data to strengthen and validate the models. Can damage thresholds be developed? How much damage can we tolerate before we have to do some sort of control intervention? Do we have a good handle on what kind of defoliation levels result in tree mortality? What are some of the effects of forest practices on population dynamics? Does thinning of stands or plantations of red pines have an impact on the population dynamics of pine false webworm. Does opening up the canopy ameliorate pine false webworm populations? Does the pine false webworm produce a sex pheromone? How would a pheromone be used in the management of this insect?

Investigations into the use of control products against pine false webworm have suggested that feeding damage differs considerably between red and white pines, *P. strobus* L. (Helson and Lyons 2000). Most of the investigations that we have conducted on pine false webworm have been on populations feeding on red pine. The biology, ecology and impact of the insect on white pine in Ontario are largely unknown. The increased occurrence of this insect on white pine, in places like Ganaraska forest, suggests that a better understanding of these host relationships is warranted. The insect has also been reported on Jack pine, *P. banksiana* Lamb., in Ontario and on lodgepole pine, *P. contorta* Dougl., elsewhere in Canada (Howse 2000). Nothing is known about the biology or impact of this insect on these hosts. These and other questions need to be answered to effectively manage this insect. The process for answering some of these questions was addressed in the Panel Discussion.

Acknowledgements

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The History, Distribution and Damage Levels of the Pine False Webworm in Canada

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The pine false webworm, *Acantholyda erythrocephala* (L.), is a forest insect pest that was introduced (probably accidentally) to North America. Its origin is listed as Eurasia (Haack 1993). It was first found in North America in 1925 at Chestnut Hill, Pennsylvania (Griswold 1939). Since then, it has been found in New Jersey, New York, Connecticut, Pennsylvania, the "Lake States" (presumably Michigan, Wisconsin and Minnesota) (Wilson 1977) and Canada, primarily Ontario. It probably occurs in many more states than those listed above.

Acantholyda erythrocephala was first reported in Canada by Eidt and McPhee (1963). McPhee collected several larvae in 1961 from a mugho pine, *Pinus mugo* Turra var. *mughus* Zenari, in Scarborough Township, York County (east Toronto) that were reared in Fredericton, N.B. From these, a single male was obtained that enabled identification to species.

The preferred hosts are reported to be red, *P. resinosa* Aiton, and white pine, *P. strobus* L., but it also attacks other pines, including Scots, *P. sylvestris* L.; Austrian, *P. nigra* Arnold; mugho; Swiss mountain, *P. mugo* Turra; and Japanese red, *P. densiflora* Sieb. and Zucc. (Drooz 1985). In Ontario, there have been 500 collections of this insect made between 1961 and 1994. *Acantholyda erythrocephala* was collected on red pine; white pine; Scots pine; jack pine, *P. banksiana* Lambert; and mugho pine a total of 369, 82, 25, 17 and four times, respectively, and once each on shagbark hickory, *Carya ovata* (Miller) K. Koch; red oak, *Quercus rubra* L. and an unidentified conifer. The latter trees are probably not hosts.

Following the first report in Ontario in 1961, the insect was collected and identified to species once in 1964 and once in 1975 (Fig. 1). From 1978 to 1994, *A. erythrocephala* was collected frequently each year. By 1979, the insect was found in two main concentrations: central part of southern Ontario and eastern Ontario. In 1978, the insect was detected on red pine regeneration at Stevens Bay, Lake of the Woods, Kenora District for the first record for northwestern Ontario. Between 1980 and 1984, the distribution did not change much but intensified considerably. In 1981, the insect was found on red pine in Bastedo Township, North Bay District, which was the furthest north in northeastern Ontario that the insect had been found to that point. Again, between 1985 and 1989, the insect was collected most frequently in the central and eastern parts of Ontario but was also found in southwestern Ontario, the "north shore" on red pine near Espanola and on white pine near Blind River in 1989, at Thunder Bay for the first time in 1986 on ornamental trees including white pine and in Arnott Township, Hearst District in a jack pine plantation. The latter was a new distribution record (furthest north to date). Between 1990 and 1994, there was little change in southern Ontario but the insect was found more frequently between Sault Ste. Marie and Sudbury on young red pine primarily but also on jack pine and mugho pine. Several collections were made in or near the City of Thunder Bay and it was found in a jack pine plantation in Stoddart Township, Hearst District in 1990. The latter was a new distribution record being the furthest north in Ontario to this point in time.

In 1978, the Forest Insect and Disease Survey (FIDS) Unit initiated a systematic survey of conifer plantations. White spruce, *Picea glauca* (Moench) Voss, was the target in 1978. In 1979, the species examined were red pine in southern Ontario and jack pine in northern Ontario. The red pine surveys were repeated in 1982, 1985 and 1988. From this, it was learned that pine false webworm was virtually absent in the southwestern part of Ontario, which is still the situation today.

Elsewhere in Canada, there are only two records in FIDS Infobase for Quebec (Fig. 2) both for 1987, one on red pine, the other on jack pine. However, the reality is that the insect must be distributed in southern Quebec, at least where there is young red pine. Pine false webworm was found defoliating Scots pine in Edmonton in 1989 and has become well established throughout the city since. It may have been present a few years prior to 1989. In Edmonton, it also fed on western white pine, *P. monticola* Douglas, ornamental trees that were approximately a metre tall. There are four records for St. John's, Newfoundland, two for 1993 and two for 1994. Austrian pine seems to be the preferred host, followed by mugho pine, Scots pine, jack pine and red pine.

The foregoing information about this insect in Canada is the "official record" gleaned from FIDS Infobase and FIDS reports.

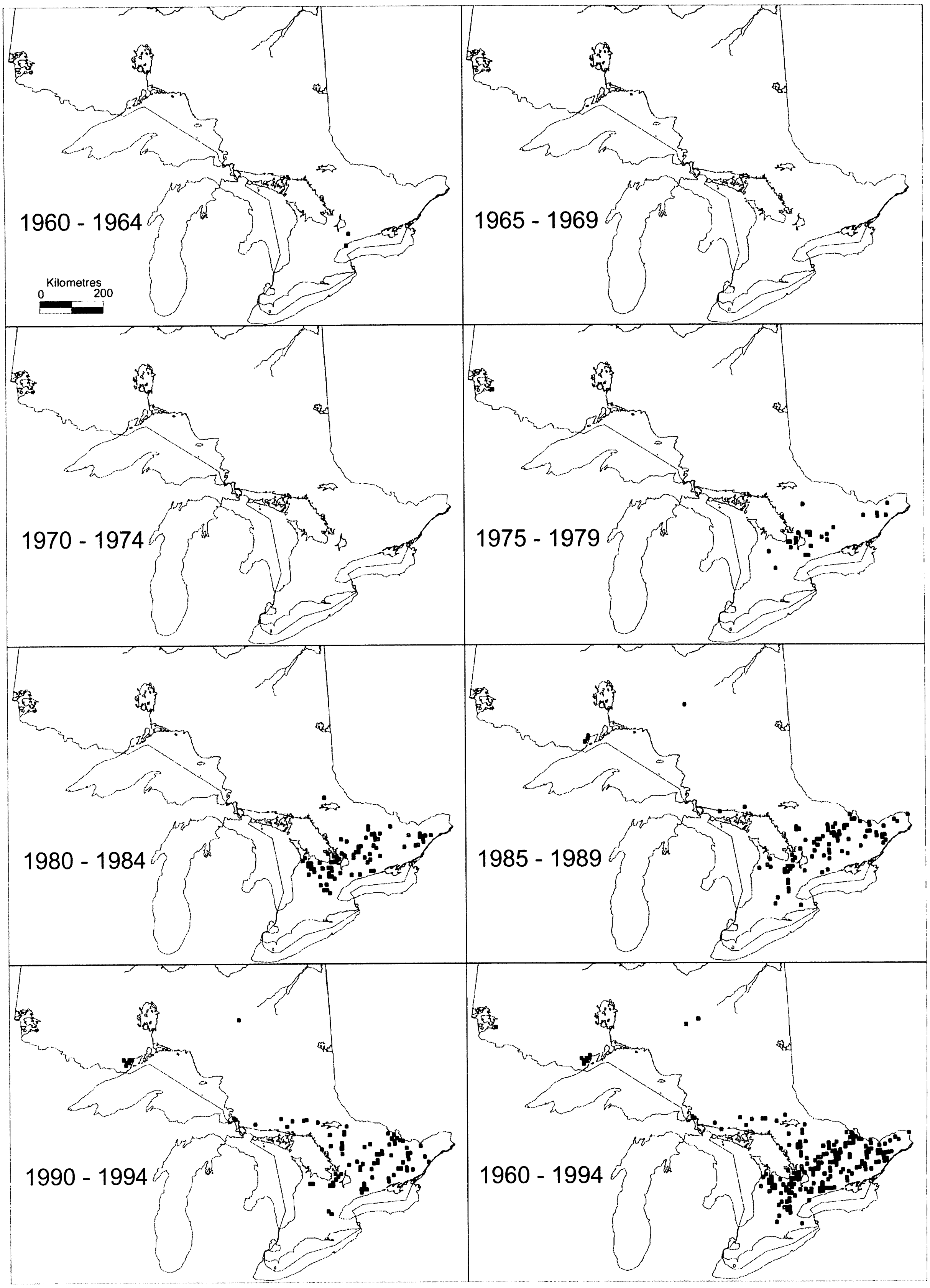

Fig. 1. Distribution of pine false webworm in Ontario 1960-1994.

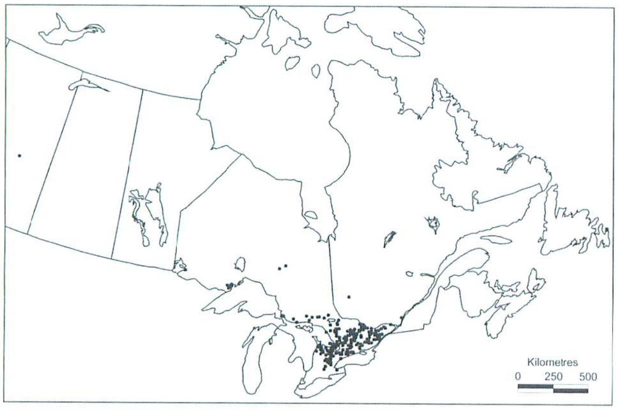

Fig. 2. Distribution of pine false webworm in Canada between 1961-1994.

Throughout the 1980s in Ontario, pine false webworm was considered to be a chronic type of problem primarily in young red pine plantations (Fig. 3). It was not considered to be a significant tree killer although it could ruin trees destined for Christmas tree production (Fig. 4). The red pine plantation surveys of 1979, 1982, 1985 and 1988 informed us, in addition to distribution of the pest, that red pine trees up to six meters in height were most likely to be infested, whereas trees over six meters were only rarely infested.

In 1993, however, an unusual situation was discovered in Oro Township, Midhurst District, where 287 ha of red and white pine 15 to 20 meters tall and 45 to 55 years of age were heavily infested (Howse and Applejohn 1993). This defoliation, which averaged 75%, was aerially mapped (Fig. 5). A second area of infestation in this older age class totalling 73 ha of red pine plantations 20 and 30 years of age was aerially mapped in the Ganaraska County Forest, west of Rice Lake in Hope Township, Tweed District (now Peterborough District) (Sajan *et al.* 1994). It was noted that one of the currently infested (1993) stands may have been severely defoliated in 1992 but neither the damage nor the pest was confirmed until 1993.

The problem has persisted at both locations since 1993. Populations of this insect expanded in 1997, particularly in the Ganaraska Forest area where 1,368 ha of red pine and white pine including plantations up to 12 meters in height and large overstory white pine were severely defoliated in Hope - Cavan townships in Peterborough District and Clark Township in Aurora District. A total of 167 ha of defoliation was mapped near Craighurst in Oro, Medonte, Flos and Vespra townships in Midhurst District. Large mature white pine, old Scots pine and red pine plantations of all heights were severely defoliated. Up to 60% tree mortality has occurred to older, near pole size red pine in the older infested plantations (Fig. 6). In 1994, in an attempt to control the spread of this pest in Oro Township, Ontario Ministry of Natural Resources (OMNR) clear cut approximately 25 ha in the most heavily damaged area in October and early November. These trees were still alive but the concern was that they would start to deteriorate and die.

Fig. 3. Young red pine defoliated by pine false webworm (photograph by B. Lyons).

Based on the report "The Timber Resources of Ontario - 1993" published by OMNR (1993) there are approximately 36,200 ha of red pine and 31,700 ha of white pine in the 0 - 60 year age class potentially at risk in the Southern Region. If we include the next age class 60 - 80 years then there would be another 600 ha of red pine and 11,560 ha of white pine that may be susceptible to this insect.

Fig. 4. Young Scots pine Christmas trees severely defoliated by pine false webworm (photograph by B. Biggs).

Fig. 5. Semimature red pine severely defoliated by pine false webworm (photograph by J. McFarlane).

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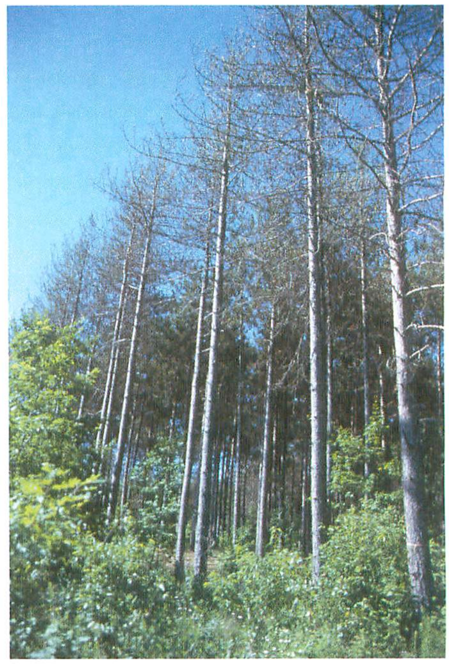

Fig. 6. Dead or dying semimature red pine - the result of defoliation by pine false webworm (photograph by B. Lyons).

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Chemical and Biorational Control of the Pine False Webworm

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About ten years ago, we initiated a research project to find effective insecticides for controlling pine false webworm. At that time pine false webworm was causing severe damage in some young red pine plantations in central Ontario. District offices of the Ministry of Natural Resources, who wanted to carry out control measures, needed to know what insecticides were effective against this species. There was no North American information available on the control of pine false webworm and only a few reports from Europe, which were mostly outdated, because the insecticides were no longer being used here. First, we evaluated two conventional insecticides, permethrin and carbaryl by mistblower applications in a representative young red pine plantation. An insect growth regulator, Dimilin, was also tested in these trials. Most recently, two natural products, neem and spinosad have been evaluated in the laboratory and field. Neem has been tested extensively for several years now and has proven effective by both foliar and systemic applications. The new natural product, spinosad from Dow AgroSciences is also showing promise.

Foliage Applications

Conventional Insecticides. The first step was to screen candidate insecticides in the laboratory to determine their relative activity to pine false webworm larvae. However, our standard bioassay method of spraying the foliage with an insecticide, putting larvae on the sprayed foliage and determining mortality could not be used with this species. Being a web-spinning sawfly, the larvae do not survive well when removed from the webs and placed on new foliage. A novel bioassay method was designed for doing these tests (Lyons *et al.* 1993). A male and female were placed in a lantern globe containing a red pine branch with the cut end in water. After mating, the female laid her eggs on the needles of the branch. The adults were removed after 24 h and the branches with eggs were held for 6 days until the eggs were about to hatch. The branches were then sprayed with insecticides in a spray tower. Afterwards, the larvae were left undisturbed to establish themselves, build webs, feed and develop on the branches. Twelve days after treatment, the survival of larvae on sprayed branches was assessed in comparison to survival on untreated branches.

Using this bioassay technique, ten different insecticides belonging to four different classes were screened including the synthetic pyrethroids represented by permethrin; the carbamate insecticides, carbaryl and propoxur; several organophosphate insecticides and the organochlorine insecticide, methoxychlor (Lyons *et al.* 1993). First, we evaluated if any of these insecticides resulted in egg mortality by determining the percentage of eggs hatching after treatments with dosages of 50 or 200 grams per hectare (g/ha). None of these insecticides had any substantial effect on egg hatch (Table 1). Only one insecticide, dimethoate at 200 g/ha, resulted in a significant small increase in egg mortality.

However, most of these insecticides did kill larvae (Table 2). Permethrin and carbaryl were the two most active insecticides. At 50 g/ha, permethrin gave 99% mortality and carbaryl, 94% mortality, while the other insecticides

Table 1. Effects of insecticide treatments on egg hatch of the pine false webworm after laboratory application.

Insecticide	Dosage (g/ha)	Egg mortality (%)
Permethrin	25	0
	50	0
Carbaryl	25	0
	50	6.7
	200	7.4
Propoxur	50	4.5
	200	0
Dimethoate	50	7.0
	200	15.4
Diazinon	50	0
	200	4.6
Chlorpyrifos	50	3.5
	200	1.2
Malathion	50	2.0
	200	0
Acephate	50	0
	200	0
Fenitrothion	50	0
	200	0
Methoxychlor	500	0

were less effective. Both permethrin and carbaryl also provided high mortality of the larvae at 25 g/ha. These two insecticides were the most promising candidates for further evaluation and mistblower trials were then conducted with them.

Between 1990 and 1995, mistblower trials were conducted in a young red pine plantation near Sprucedale, Ontario (Lyons *et al.* 1993, Lyons *et al.* 1998). In 1996 and 1997, a white pine plantation near Chatsworth, Ontario, south of Owen Sound was used. The tree height in these plantations was generally 2 to 4 m. The planting density was approximately 2500 trees per hectare. Typically damage levels to the one-year-old foliage on untreated trees in these plantations ranged from 60 to 90%. The damage on current-year foliage on untreated trees was typically 10 to 20%. Dosages are expressed as grams per hectare based on a tree density of 2500 trees per hectare. For example, at 50 g/ha, each tree was sprayed with 0.02 g of insecticide. Two application times were used: an early application (the first application in a double application) or a late application (the second application in a double application). For the early applications, most of the eggs had been laid, and between 3 and 53% of the eggs had hatched at the time of treatment. The larvae were still small at this time. On average about 25% of the eggs had hatched at the time of these early applications. All of these early applications were done between 1 June and 16 June each year. Although insect development does vary from year to year and needs to be monitored for proper treatment timing, all the applications were done typically during the second week of June. Late applications were done on 11 June and 20 June in two different years when most of the eggs had hatched and some third and fourth instar larvae were present on the trees.

Table 2. Effects of insecticide treatments on survival of larvae of the pine false webworm after laboratory application.

Insecticide	Dosage (g/ha)	Larval mortality (%)
Permethrin	25	92
	50	99
Carbaryl	25	97
	50	94
	200	100
Propoxur	50	17
	200	1
Dimethoate	50	28
	200	100
Diazinon	50	3
	200	42
Chlorpyrifos	50	0
	200	57
Malathion	50	0
	200	92
Acephate	50	5
	200	100
Fenitrothion	50	5
	200	55
Methoxychlor	500	20

A Solo Port 423 motorized backpack mistblower with a standard nozzle was used for all trials. The application rate was 525 ml per minute. Single rows of trees were treated at a walking speed of 0.5 meters per second. The same technician (Fig. 1) performed all applications.

The first two insecticides to be tested were carbaryl and permethrin (Lyons *et al.* 1993). Carbaryl is a carbamate insecticide. The formulation used in these trials was Sevin XLR+ which is a 48% liquid suspension. Carbaryl has a relatively low toxicity to mammals, birds and fish. However, it is considered hazardous to aquatic invertebrates and bees.

Permethrin is a synthetic pyrethroid. The formulation used in these trials was Ambush 500 EC, which is an emulsifiable concentrate containing 50% permethrin. It has low mammalian and bird toxicity, but it is very toxic to fish. Buffer zones are required near water. Permethrin has very high contact toxicity to insects and good residual activity.

In 1990, permethrin was tested at 35 g/ha and 70 g/ha as an early treatment as well as double applications of 35 g/ha (Fig. 2). The 35 g/ha treatment did not reduce populations of larvae compared to untreated trees. The double application of 35 g/ha resulted in population reductions of about 90% and was better than one application of 70 g/ha which resulted in a reduction of 60%.

Fig. 1. Insecticide being applied to small red pines in a plantation using a backpack mistblower.

Carbaryl was tested at 125, 250 and 500 g/ha in early applications as well as a double application of 125 g/ha (Fig. 2). The early applications of 250 and 500 g/ha and the double application of 125 g/ha provided more than 80% population reductions. Defoliation of treated and untreated trees was measured in 1990, but the results were not reliable because of large variations in defoliation throughout the plantation. Thereafter, the defoliation in each treated row was compared with the defoliation in the adjacent upwind untreated row. This technique provided consistent and reliable results. The same technician performed all defoliation estimates.

In 1991, permethrin was tested at 35 g/ha in an early, a late and a double application (Fig. 3). The single applications of permethrin provided about 40% protection of one-year-old foliage and the double application provided close to 50%. Early and late treatments of carbaryl at 125 g/ha gave 30-40% protection, while a double application provided 60% protection. Carbaryl, in an early application of 500 g/ha, provided very good foliage protection of 90%. All treatments, except the early application of carbaryl at 125 g/ha, provided over 80% foliage protection of current-year-foliage. The foliage protection of current-year foliage is typically higher than the one-year-old foliage because pine false webworm larvae normally do not feed on the new foliage until they have consumed most of the old foliage.

Dimilin. Dimilin or diflubenzuron has been reported to be active on pine false webworm larvae in Europe (Tsankov 1989). It is an insect growth regulator with a unique mode of action. It inhibits chitin synthesis in insects and crustaceans, which disrupts molting. It is not toxic to mammals, bird and fish; diflubenzuron is also not hazardous to most non-target organisms except some other immature insects and aquatic crustaceans. Regarding its insecticidal properties, Dimilin is a slow acting insecticide.

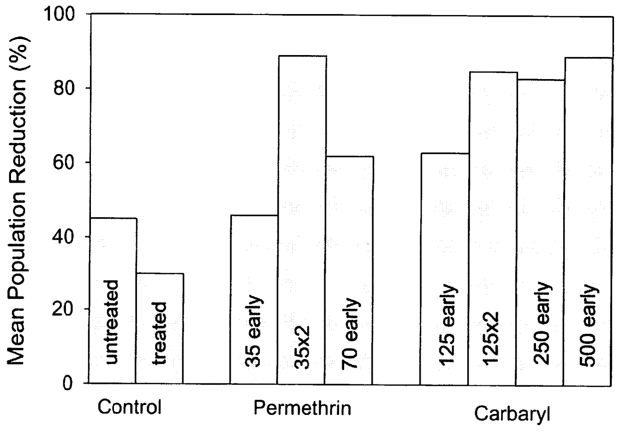

Fig. 2. Mean population reductions of pine false webworm following mistblower applications to red pine in 1990.

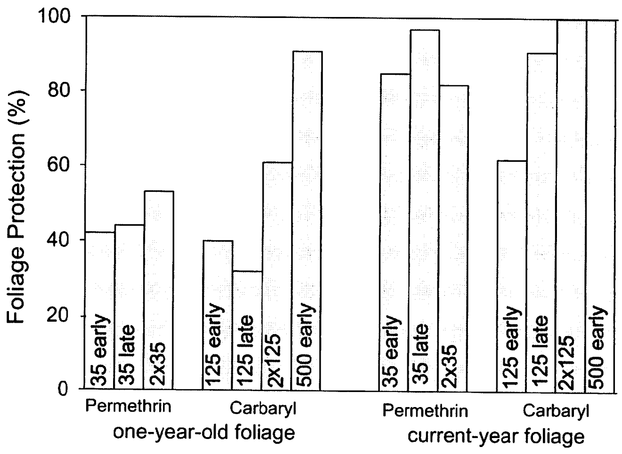

Fig. 3. Foliage protection of red pine trees following mistblower applications of conventional insecticides in 1991.

After larvae ingest it, they are not affected until they molt to the next instar, which often occurs several days later. It is important to target young larvae with Dimilin so little feeding damage occurs before they are affected. It is toxic to insects by ingestion and has little contact toxicity. Dimilin is also very persistent on foliage. We tested a 25% wettable powder formulation (Lyons *et al.* 1998). Dimilin was very active on pine false webworm larvae in the laboratory. It resulted in 100% mortality at a dosage of 5 g/ha compared to 92% mortality with permethrin at 25 g/ha. It is more active than either carbaryl or permethrin in the laboratory. It also provided excellent control in the field (Fig. 4). In 1991 at 70 g/ha, Dimilin resulted in 100% foliage protection. In 1993 at 35 g/ha, it provided very good foliage protection of about 85% on old foliage and 97% on new foliage. Dimilin is an excellent insecticide against pine false webworm.

Neem Seed Extracts. We have evaluated neem seed extracts extensively for managing pine false webworm (Lyons *et al.* 1998, Helson *et al.* 1999). This natural product comes from the neem tree, *Azadirachta indica* A. Juss., a tropical tree that is very common in India. The active insecticidal ingredient in the seed kernel extracts is a compound called azadirachtin. Neem has both antifeedant and growth inhibiting effects on insects. It is safe to humans, other mammals and birds. It is not harmful to most other non-target organisms including bees, fish and aquatic insects at effective dosages. It degrades readily in the environment. There is much world-wide interest in developing neem as a safe and effective botanical insecticide. It is registered in the United States as an biochemical insecticide. The products, Neemix and Neemix 4.5 are registered by Thermo Trilogy in the USA. (Recently, three more neem formulations were registered in the USA by AmVac Corp. and Fortune Biotech Limited). Neem is not yet registered in Canada.

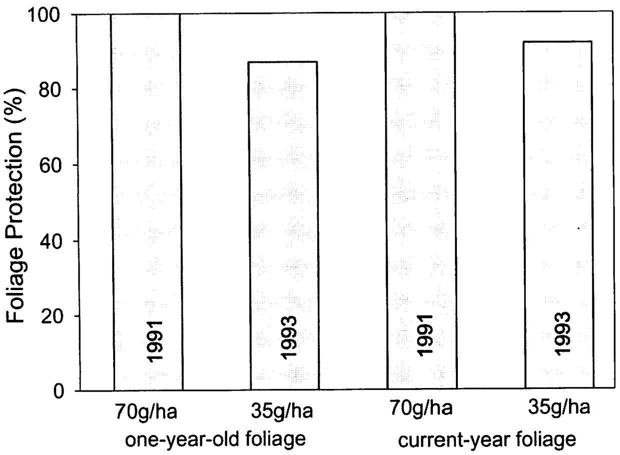

Fig. 4. Protection of red pine foliage from pine false webworm damage after mistblower applications of Dimilin.

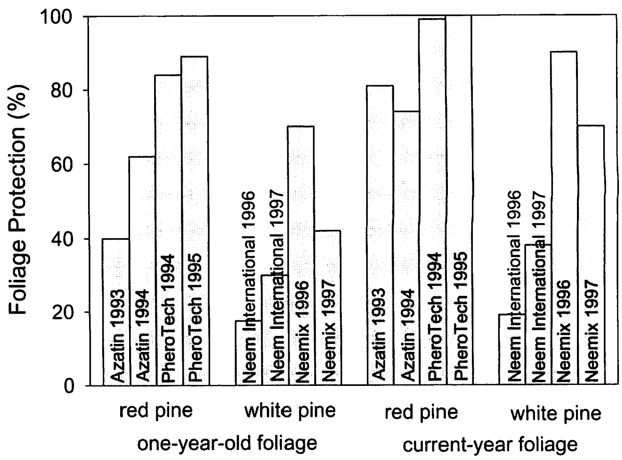

Fig. 5. Foliage protection from pine false webworm damage after mistblower application of neem-based insecticides at 50 g AI/ha to red and white pines.

In the laboratory, these neem seed extracts were highly active on pine false webworm larvae. Larval mortality was 96% at 5 g/ha compared to 92% with permethrin at 25 g/ha. The activity of neem and Dimilin are very similar in the laboratory. We have conducted mistblower applications with four different neem EC formulations at 50 g/ha on both red pine and white pine over a period of four years from 1993 to 1997 (Fig. 5). Initially, we tested Azatin EC (AgriDyne Technologies Inc., Salt Lake City, UT) followed by an experimental formulation from Phero Tech Inc. a Canadian company located in British Columbia. Then we tested another experimental formulation from Neem International Enterprises in British Columbia as well as the Neemix 4.5 formulation from Thermo Trilogy. Foliage protection with these different formulations in different years on the two pine species was generally acceptable except with the Neem International formulation. Typically, between 40 to 90% foliage protection of the old foliage and 70 to >95% of the new foliage was obtained with the other three neem formulations. Although the Phero Tech formulation seemed to provide the best protection, this may not only be due to differences in the formulations. Each year, tree condition, the timing of the applications and weather conditions were also different.

Two other types of equipment have been used to apply neem in ground applications. One, a backpack compressed air sprayer, delivers a high volume of about 400 ml of a neem-in-water mixture per tree compared to 35 ml/tree with the mistblower. Compressed air sprayers would typically be used for ornamental tree treatments. We also applied neem to trees with a Micron mini ULVA sprayer. This ultra-low-volume spraying device produces very small drops and applies very low volumes (about 1 ml of material) per tree. This device could spray neem emulsifiable concentrate formulations without any dilution with water. At 50 g azadirachtin per ha the backpack compressed air sprayer and the mistblower provided very similar protection (Fig. 6). Both provided very good foliage protection. The ultra-low-volume sprayer provided less protection at 50 g/ha; but at 200 g/ha it provided comparable protection to the backpack and mistblower sprays at 50 g/ha. This application method may have been less effective because of greater inter-tree variability in deposits of neem. This Micron mini ULVA sprayer simulates an ultra-low-volume aerial application. The results indicate that neem could be effective when applied by aircraft as an ultra low volume spray using small droplets.

Spinosad. A new natural product known as spinosad, under commercial development by Dow AgroSciences, is currently being evaluated by us for forest insect pest management. Spinosad is a mixture of a group of insect control molecules, called spinosyns, which are produced by a new species of Actinomycetes, *Saccharopolyspora spinosa,* which was discovered in a sugar mill rum still. It has very low toxicity to mammals, fish and birds. It is extremely active against many larval insect pests. In the laboratory, it is the most active compound we have tested to date against the pine false webworm. Spinosad resulted in 95% mortality at 0.25 g/ha. Neem and Dimilin provide comparable effects at 5 g/ha. We are conducting mistblower applications with spinosad against pine false webworm larvae. The results in 1998 were promising and further trials are underway in 1999.

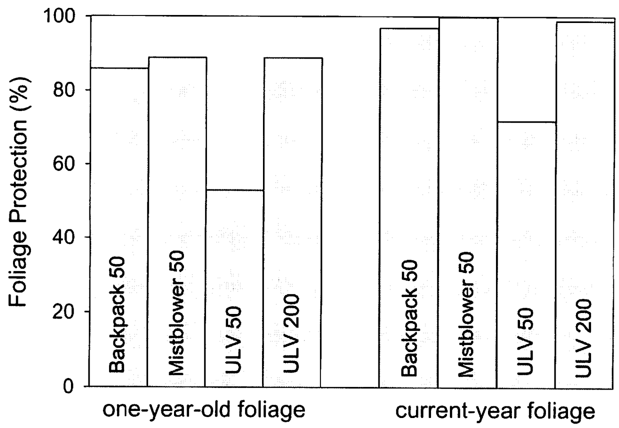

Fig. 6. Foliage protection of red pine after application of neem using different ground-spray equipment.

Systemic Applications

Neem. Neem has systemic properties. If neem is injected into the trunk of a tree, it will translocate up into the foliage and can potentially provide protection against insect defoliation. Systemic applications of neem have been shown to control birch leaf miner in small birch trees. We have conducted laboratory and field experiments to determine if neem has systemic properties against pine false webworm larvae (Lyons *et al.* 1996). First we prepared several concentrations of neem in water and immersed the cut ends of red pine branches, which had pine false webworm eggs oviposited on them, into the different concentrations. Neem could potentially move up the branches and into the foliage. After 18 days, larval mortality was determined at the different concentrations. Very high mortality of pine false webworm was observed at very low concentrations of neem in water, which indicated that neem does have systemic properties against pine false webworm. Neem was also active as a soil drench against larvae on potted white pine seedlings.

We then evaluated the systemic activity of neem in the field against pine false webworm on small, 3-4 m, red pine trees. Two holes were drilled on opposite sides of the bole at the base of each tree about 2 cm in depth and 1 cm in diameter. Undiluted neem EC formulation was pipetted into each hole to give a dosage of 0.05 g azadirachtin per tree requiring approximately one ml per hole (Fig. 7). In 1995, Azatin was applied when 47% of the eggs had hatched. Damage was significantly reduced on the treated trees. In 1996, we treated the trees about two and four weeks before egg hatch with two different neem formulations. Excellent protection was achieved with these treatments indicating that early timing of systemic applications was necessary to allow for translocation of the neem up to the foliage (Table 3).

Table 3. Percent egg hatch and foliage protection after systemic application of neem-based insecticides to small red pines.

Product	Date	Egg hatch (%)	Foliage protection (%)
Azatin	15 June	47	53
Neem International	16 May	0	95
Neem International	31 May	0	100
Neemix	31 May	0	96

Large red pine trees under heavy attack by pine false webworm were treated systemically with neem by inoculating Neemix 4.5 into the trunks using a funnel attached by a tube to a maple sap spile hammered into each hole. Applications were made in 1997, about two weeks before egg hatch at two different dosages, 0.05 and 0.1 g azadirachtin per cm dbh (diameter at breast height) into one or two holes (Table 4). Before treatment, all the trees had between 14 and 26% defoliation of 1996 foliage from feeding in the previous year. Whereas 91% of the 1996 foliage was consumed on the untreated control trees in 1997, there was no significant defoliation of this foliage in any of the treatments. The new 1997 foliage was also completely protected. Larval populations were greatly

Table 4. Neem systemic treatments of large (25-30 cm dbh) red pine, Strachan Tract, Simcoe Co., 1997.

Treatment dose (g/cm dbh)	Number of holes	Defoliation of one-year-old foliage (%)		Defoliation of new foliage (%)	Number of larvae/branch
		pre-treatment	post-treatment	post-treatment	
control	2	16	91	26	31.0
0.10	2	14	23	0	0
0.05	2	23	9	0	0.5
0.05	1	15	23	0	9.0
0.10†	2	26	29	0	0.8

† only partly taken up

reduced on the treated trees although reductions were not as great on the trees treated at 0.05g/cm dbh in one hole. Systemic applications of neem to large pines for pine false webworm control is a promising approach for selective tree treatments including seed orchards, small pockets of infestation, and ornamental trees.

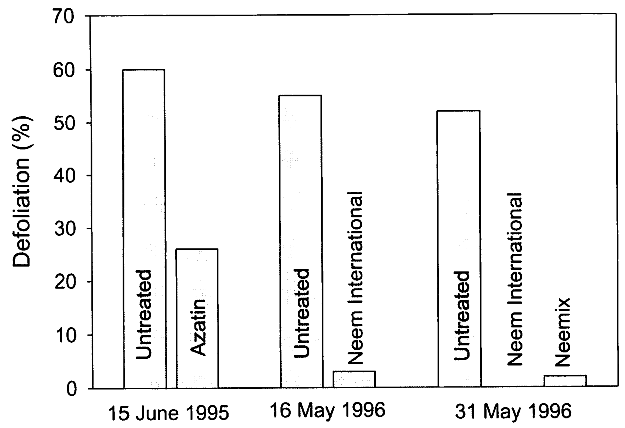

Fig. 7. Defoliation of small red pines after systemic applications of neem-based insecticides at 0.05g/tree.

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The Potential for Biological Control of the Pine False Webworm using Entomophagous Parasitoids

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Introduction

Biological control programs can be divided into seven stages of activity (Fig. 1). The biological control program for pine false webworm, *Acantholyda erythrocephala* (L.) (Hymenoptera: Pamphiliidae) in Ontario is between stages 4 and 5, with current studies addressing propagation methods and field releases of a number of agents. In this paper we describe the current status of biological control studies of the pine false webworm and how we have reached our current stage. This report includes details on the initial studies to assess the role of native parasitoids in Ontario (Stage 1) and subsequent work on the development of classical and inundative biological control strategies (Stages 2-4) for this insect. The classical biological control program has involved exploration for natural enemies in Europe, where the insect is believed to have originated. The inundative biological control program has been focussed in the mass propagation and release of two egg parasitoids of the genus *Trichogramma.*

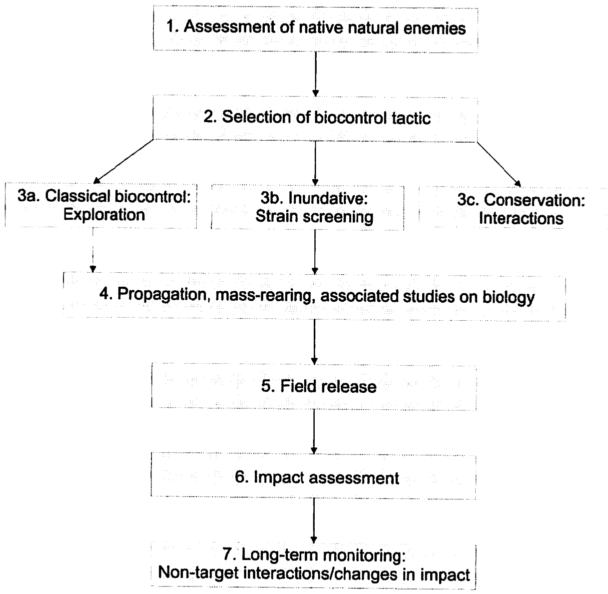

Fig. 1. Stages in a biological control program.

Assessment of Native Parasitoids

Studies on native parasitoids in Ontario were designed to assess the impact of existing natural enemies on the target insect, to assess the potential for displacement of these insects by introduced biological control agents and to check for empty niches not currently filled by natural enemies (Fig. 1: Stage 1).

A few species of parasitoids have been reared from pine false webworm in North America. Barron (1981) described a new species, *Ctenopelma erythrocephalae* (Hymenoptera: Ichneumonidae), collected as adults, ovipositing in eggs of the pine false webworm. *Homaspis interruptus* (Provancher) (Hymenoptera: Ichneumonidae) was reported from *Acantholyda* sp. in Ontario (Barron 1990) and was subsequently reared from *A. erythrocephala* in New York state (Asaro 1996). Two species of ichneumonids, *Sinophorus megalodontis* Sanborne (Fig. 2) and a new species of *Olesicampe* sp. (Fig. 3) (H. Townes, personal communication), and *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae) have been reared from the pine false webworm in Ontario (Lyons 1995).

The biologies of the latter two ichneumonids were investigated in Anten Mills and Lakehurst, Ontario in 1983 and 1986, respectively. In 1986, cone traps placed on the soil surface were used to determine the period of adult emergence and Malaise traps were used to observe the flight periods of the two ichneumonids (Fig. 4). Traps were examined daily during the parasitoid emergence and flight periods. The total proportion of females of *S. megalodontis* collected from emergence traps was not significantly different from 50% (n = 42, % female = 52.4, $\chi^2 = 0.10$, $P > 0.05$), while collections of *Olesicampe* sp. contained significantly more males (n = 56, % female = 35.7, $\chi^2 = 4.57$, $P < 0.05$). Adults of both species were captured in emergence traps beginning 23 May (day of year 143). Emergence periods of *S. megalodontis* and *Olesicampe* sp. lasted for 17 and 16 days, respectively. Peak adult emergence coincided with average instar 1.5 of the host

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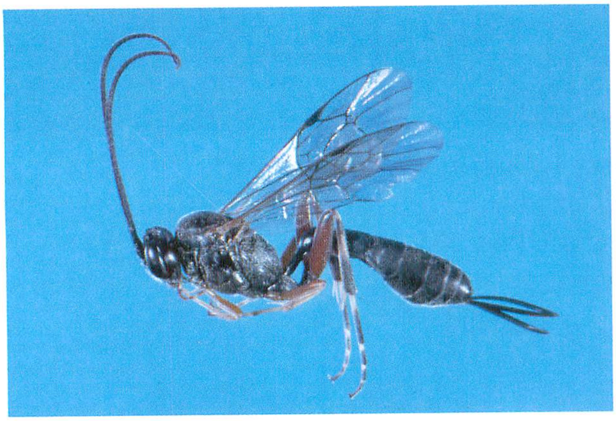

Fig. 2. Adult female of *Sinophorus megalodontis*.

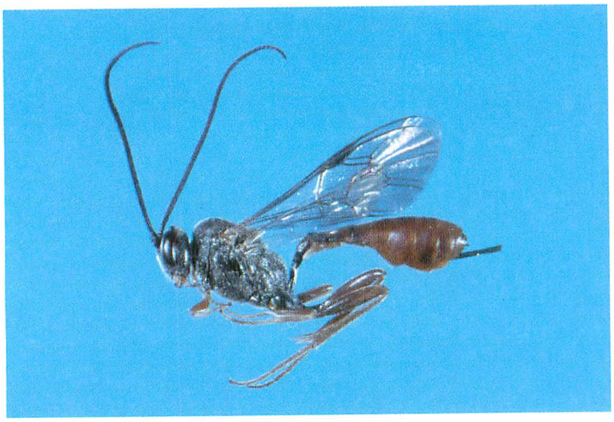

Fig. 3. Adult female of *Olesicampe* sp.

and lasted until average instar 3.8. Both species emerged protandrously, that is males preceded females, from the soil.

The onset of the observed flight period (Fig. 4) coincided with the beginning of emergence from the soil. Malaise trap captures were biased towards males. This probably resulted from differences in the flight behaviour of the sexes. Females spent more time searching for hosts in the tree canopy, while males searched for newly emerged females. The observed flight period of both species lasted 28 days until 18 June (day of year 169). The depression in trap catch in the middle of the flight period occurred during a period of low temperature and rainfall.

Females of both species were dissected and eggs were examined (Fig. 5). Host larvae collected from throughout the season, by branch sampling and larval drop trapping, were also dissected and parasitoid eggs encountered were compared with eggs from the parasitoid females. Parasitoid larvae were identified by association with empty chorions (egg shells) (Fig. 5). Eggs of *S. megalodontis* were brown and were readily observed through the integument of the host (Fig. 5A). Eggs of *Olesicampe* sp. were white and empty chorions were transparent and not readily detected (Fig 5B). First-instar larvae of both parasitoid species were of the ichneumonid mandibulate-caudate type. The head capsule of *S. megalodontis* (Fig. 5A) was darker and longer diagonally than the head capsule of *Olesicampe* sp. (Fig. 5C). The length of the tail was also consistently longer in the former species. Unhatched eggs *of S. megalodontis* were found in all instars of the host in 1983 and 1986, although the majority was found in the fourth instar in 1983 and the first instar in 1986. Similarly, the eggs of *Olesicampe* sp. were distributed among all instars in 1983, but were limited to instars one to three in 1986. These differences suggested that there were year-to-year variations in synchronization with the phenology of the host. Parasitoid larvae were found in all instars of the host indicating that the eggs hatched soon after oviposition. Parasitoid larvae remained as first instars until sometime after the host larvae dropped to the ground to overwinter.

Encapsulation of parasitoid larvae by host haemocytes, an immune response of the host to foreign bodies, was extremely common. There were encapsulated larvae of *S. megalodontis* in all host instars, but they occurred mainly in host instars four to six. Encapsulated larvae of *Olesicampe* sp. were only found in the last three host instars. Eggs were rarely encapsulated. Encapsulated

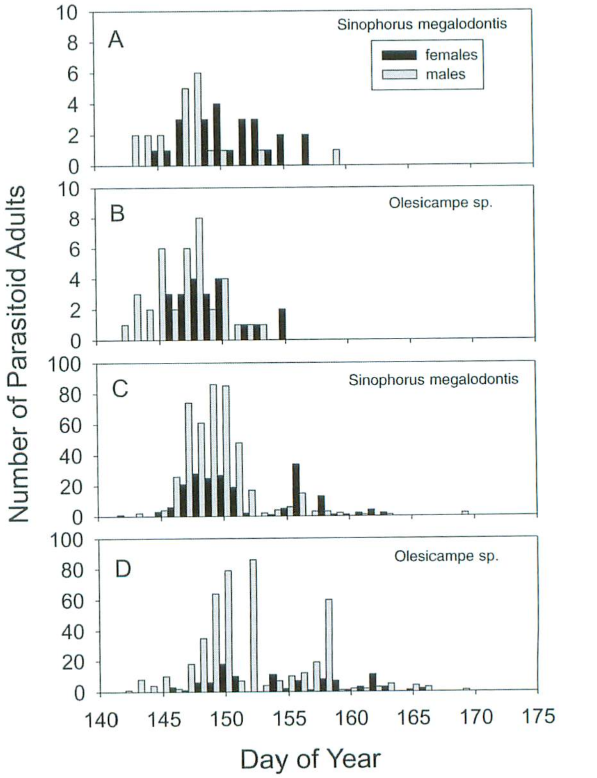

Fig. 4. Adult flight periods (A, B) and emergence (C, D) of two ichneumonid parasitoids, *Sinophorus megalodontis* and *Olesicampe* sp., of the pine false webworm in a red pine plantation at Lakehurst, Ontario in 1986.

larvae do not survive, thus severely limiting the effectiveness of the parasitoids at reducing the host population.

The effectiveness of both parasitoids was also limited by superparasitism (parasitism of a single host larva by more than one individual of the same parasitoid species) and multiparasitism (parasitism of a single host larvae by both parasitoid species). Host larvae contained as many as nine immatures of *S. megalodontis* and three immatures of *Olesicampe* sp.

To determine the spatial distribution of parasitism, host larvae were pooled for all sample days from three vertical strata of the plantation canopy sampled in 1983 and the two strata sampled in 1986 (Fig. 6), or by cardinal direction (Fig. 7) in 1983. The greatest incidence of parasitism for both parasitoids was in the low canopy stratum in 1983. In 1986, parasitism was equally distributed in the two canopy strata that were sampled. In 1983, eastern sides of the trees had significantly lower parasitism by *S. megalodontis* than all other directions, whereas only parasitism on the eastern side of the tree was significantly different from parasitism on the west side of the tree for *Olesicampe* sp. Consequently, sampling for parasitism must take vertical distribution and aspect into consideration to be effective.

To determine the effect of the time of pine false webworm larval drop on the incidence of parasitism, samples of dropping larvae were dissected and pooled for three-day intervals for the first 12 days of the drop period, while the last eight days made up the final sample (Fig. 8). Eggs of *S. megalodontis* were found in ultimate instars. This suggests that even late-instar larvae were being attacked by the parasitoids. Parasitism rates by the two parasitoids, of both sexes of hosts, increased throughout the drop period. This may have resulted from a reduction in development rates of parasitized host larvae or increased parasitoid activity at the end of the larval period. For the entire drop period, the proportion of parasitized larvae was not significantly different between the sexes of the host. Thus, parasitism by these species had little impact on sex ratios in pine false webworm populations.

Larval drop of pine false webworm was the most effective time for estimating absolute parasitism rates because no larval parasitoid recruitment occurred after this stage. Total parasitism of the pine false webworm by *S. megalodontis* and *Olesicampe* sp., for the period of larval drop, was

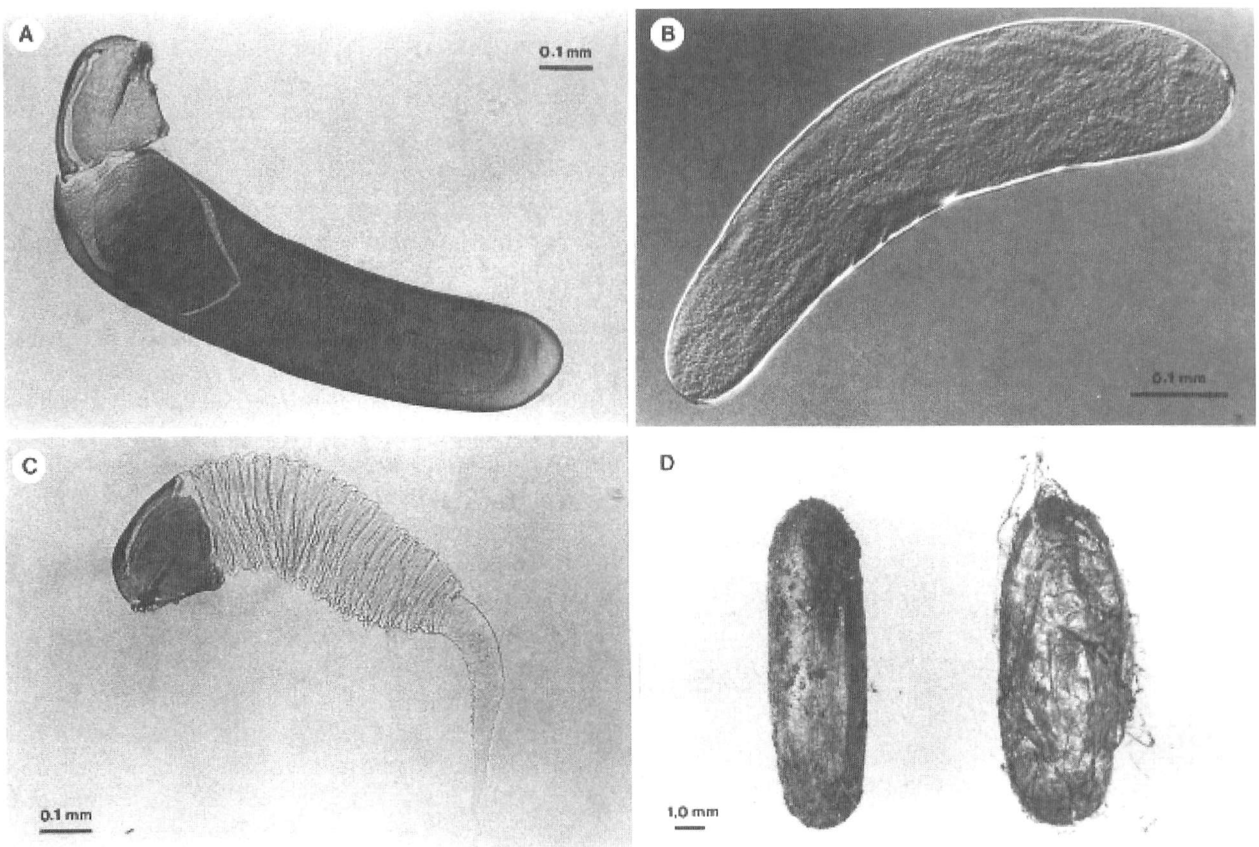

Fig. 5. Larva of *Sinophorus megalodontis* emerging from its egg (A), egg (B) and larva (C) of *Olesicampe* sp. and cocoons (D) of *Sinophorus megalodontis* (left) and *Olesicampe* sp. (right).

17.7% and 6.2% (n = 1,261), respectively. Approximately 10.9% of host larvae, at the time of larval drop, were superparasitized by *S. megalodontis*, while 0.2% of the larvae were superparasitized by *Olesicampe* sp. Many of these host larvae also contained encapsulated parasitoids or were multiparasitized. Approximately 3.6% of host larvae, captured in drop traps, were parasitized by both species. Thus, parasitoids were unable to distinguish between larvae already attacked by their own species and larvae attacked by the other species. The percentage of larvae that contained at least one non-encapsulated parasitoid of either species was 11.3%. This was the effective parasitism rate for these two species, unless additional encapsulation occurs after the host larvae exit the trees.

Cocoons (Fig. 5D) of *S. megalodontis* were collected from the soil cells, formed by the host, in fall indicating that this species emerges from the host prior to overwintering. Cocoons (Fig. 4D) of *Olesicampe* sp. were only collected in spring. The larvae of this parasitoid emerged from

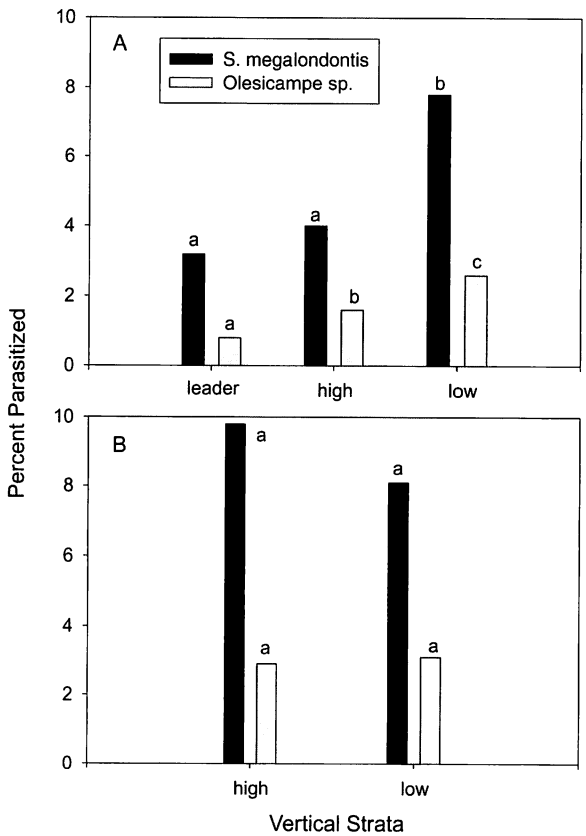

Fig. 6. Parasitism of pine false webworm larvae by *Sinophorus megalodontis* and *Olesicampe* sp. in different vertical strata of plantation-grown red pines at Anten Mills, Ontario in 1983 (A) and Lakehurst, Ontario in 1986 (B). For each species, bars with the same letters are not significantly different (G-test, $P>0.5$).

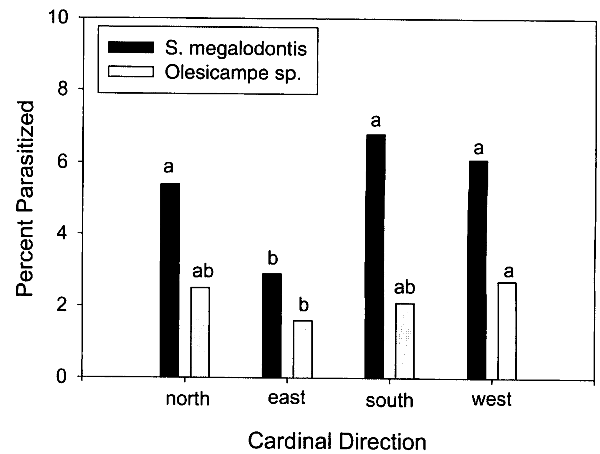

Fig. 7. Parasitism of pine false webworm larvae by *Sinophorus megalodontis* and *Olesicampe* sp. in different cardinal directions of plantation-grown red pines at Lakehurst, Ontario in 1986. For each species, bars with the same letters are not significantly different (G-test, $P>0.5$).

yellow-coloured host larvae that retained small eonymphal eyes indicating that they had not transformed to pronymphs the previous fall. This suggests that *Olesicampe* sp. overwinters in the host integument as a fully-formed larva.

The transcontinental distribution of *S. megalodontis* (Sanborne 1984) and the reports of unidentified species of *Sinophorus* and *Olesicampe* attacking *Cephalcia* spp. in Canada (Eidt 1969) suggested that these species are endemic to North America. *Sinophorus megalodontis* and *Olesicampe* sp. are apparently native larval endoparasitoids that have adapted to attacking the introduced pine false webworm. Both species are univoltine. Their impact on the pine false webworm is limited because of variable host synchronization, multiparasitism, superparasitism and encapsulation. Investigations of classical and inundative biocontrol strategies were initiated to increase pine false webworm mortality from natural enemies.

Classical Biocontrol (Importation of Natural Enemies from Europe)

Literature and field surveys were made to assess the natural enemy complex of the pine false webworm in Europe and its importance for natural control of webworm populations. As expected, natural enemies, especially parasitoids, are more numerous and more important in the native region of their host than in the region of introduction. Outbreaks of pine false webworm in Europe are usually of lower density and of shorter duration than in North America indicating that North America could benefit from the introduction of European parasitoids. In Europe, eggs of the pine false webworm are attacked by *Trichogramma*

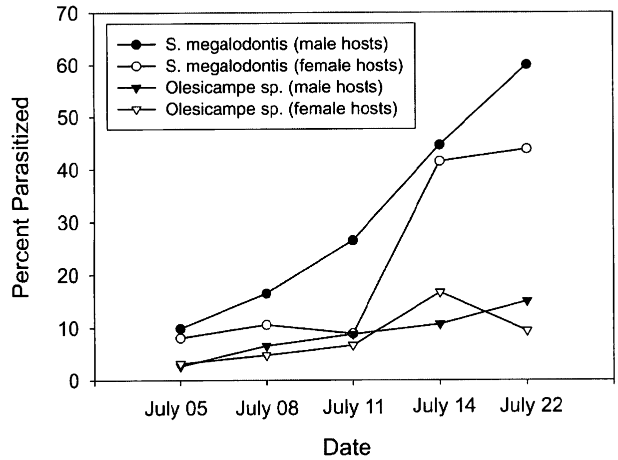

Fig. 8. Parasitism of ultimate-instar larvae of the pine false webworm by *Sinophorus megalodontis* and *Olesicampe* sp. as a function of the date they drop from the trees.

spp. The main larval parasitoids are a tachinid, *Myxexoristops hertingi* Mesnil, and several ichneumonids, among which the most common are *Xenochesis fulvipes* Gravenhorst and *Sinophorus crassifemur* (Thomson). Investigations in Europe have been focussed on the tachinid, *M. hertingi,* and a *Trichogramma* sp. Parasitoid collections were made in Poland and Italy.

Myxexoristops hertingi is considered the most promising candidate for introduction into North America because: (1) it is the most frequently cited parasitoid *of A. erythrocephala* in Europe and the most important species in outbreak populations in Poland; (2) it has a broad climatic distribution; (3) *M. hertingi* is apparently specific to *A. erythrocephala,* while closely related *Acantholyda* spp. and *Cephalcia* spp. are attacked by other *Myxexoristops* spp.; (4) there are no tachinids reported from the pine false webworm in North America and thus *M. hertingi* would fill in an empty ecological niche in the region of introduction. Work in Europe is now at stage 4 targeting the development of rearing methods, which are difficult, because of problems getting the flies to mate. A method has been developed for prolonged storage of the parasitoid that would synchronize emergence of adults with Canadian populations of the pine false webworm.

The life cycle of *M. hertingi* can be summarized as follows: *M. hertingi* overwinters as a mature maggot within the dead host larval skin in the soil. In spring the maggot climbs to the soil surface and builds its puparium. Adults emerge about a month later and mate soon after. In the laboratory, mated females start to lay eggs less than ten days after emergence. Females deposit microtype eggs on the foliage of the host plant where they are consumed by the host larvae. Fecundity is very high. On average, 1,500 eggs were found in gravid females (SD = 436; n = 8). The majority of the parasitoid larval development occurs after the host larva leaves the foliage to enter the soil; development is rapid and the maggot consumes most of the host within a few weeks.

A second possible classical biological-control agent for the pine false webworm is an undescribed *Trichogramma* sp. of the group *fasciatum*. This parasitoid was collected from outbreak populations of *Acantholyda posticalis* Matsumura, and low-density populations of *A. erythrocephala*, in northern Italy. This species is apparently univoltine; mature larvae enter into an obligatory diapause in pine false webworm eggs and three to 12 individuals emerge per host egg in spring. This species appears to be quite host specific, as it is not known from any other host outside the genus *Acantholyda*. To further assess the host specificity of this parasitoid, adults were screened against eggs of the Mediterranean flour moth, *Anagasta kuehniella* (Zeller); black army cutworm, *Actebia fennica* (Tauscher); spruce budworm, *Choristoneura fumiferana* (Clemens); hemlock looper, *Lambdina fiscellaria fiscellaria* (Guenée) and pine false webworm. No oviposition or successful parasitism were observed on eggs of Mediterranean flour moth, black army cutworm or spruce budworm. Ovipositions were observed in eggs of hemlock looper but no parasitoids emerged. Successful parasitism of pine false webworm eggs was observed. These results confirm that this European species of *Trichogramma* is more specific to the pine false webworm than the *Trichogramma* spp. found attacking pine false webworm in North America. The latter species will attack other hosts and requires alternate host eggs later in the season. With its single generation per year and confined host specificity, the European species of *Trichogramma* is a promising biological control agent for pine false webworm in North America.

Inundative Release (Mass Release of Egg Parasitoids)

Experimental releases of two *Trichogramma* spp. were made in a white pine, *Pinus strobus* L., plantation infested with pine false webworm, near Owen Sound, Ontario in 1996. Trees in the plantation were three to five m tall. *Trichogramma minutum* used in the release had been collected near Barrie, Ontario in May 1995 from pine false webworm eggs and reared on flour moth eggs until the release in June 1996. The parasitoid was selected from a number of *T. minutum* lines that were tested on pine false webworm eggs in the summer of 1995. *Trichogramma minutum* were mass-reared at Sault Ste. Marie in the spring of 1996 prior to the release and were timed so that no storage of parasitized material was required.

Table 1. Parasitism of pine false webworm (PFW) eggs by *Trichogramma minutum* (*T.m.*) and *T. platneri* (*T.p.*) released in a white pine plantation near Owen Sound, Ontario in 1996.

Nominal release rates (no. of females)	Actual release rate (no. of females)	Mean number of PFW eggs	Maximum parasitism per tree (%)	Mean parasitism per tree (%)	Mean PFW emergence (%)	Mean % dead PFW
64,000 *T.m.*	22,600	198.3	8.6	3.3	73.0	13.8
16,000 *T.m.*	11,300	151.8	1.8	0.6	71.9	14.5
8,000 *T.m.*	2,800	172.4	2.9	1.3	76.1	12.2
64,000 *T.p.*	28,000	187.0	36.2	10.9	61.9	19.6
control	-	143.7	0.5	0.1	83.8	7.5

Trichogramma platneri Nagarkatti was provided by Beneficial Insectary, Guelph, Ontario. This species is normally used in apple orchards for codling moth control. This species was included in the field test because it is an arboreal species and there is a potential commercial supplier. Released material had been stored in diapause prior to release.

Nominal release rates of *T. minutum* were 64,000, 16,000, and 8,000 females per ten trees while *T. platneri* was released at a rate of 64,000 females per ten trees. There were also ten trees monitored as controls. Treatments were randomized to release trees; the release was conducted on 3 June 1996.

Parasitoid emergence, sex ratio, parasitism of sentinel egg masses and parasitism of pine false webworm were measured. Following the release, a sub-sample of the emergence cards containing release material was frozen daily and the cumulative emergence and sex ratio were determined. Eggs of the Mediterranean flour moths, pasted on cards, were used as sentinels to determine parasitoid activity. The cards, which were deployed in the tree canopies, were changed every three days from 3 June to 15 June. To assess parasitism of pine false webworm eggs, 25 white pine shoots containing host eggs were collected on 12 June and the eggs were allowed to complete development in the laboratory. The numbers of melanized eggs (successful parasitism), emerging pine false webworm larvae and non-viable eggs were recorded

Emergence of *T. minutum* was 65% of the available parasitized eggs by 15 June whereas the percent emergence by *T. platneri* was almost 95% by 15 June (Fig. 9). On 12 June when the pine false webworm eggs were sampled *T. minutum* emergence was 33% and emergence of *T. platneri* was 55% (Fig. 9). Actual release rates of female wasps (Table 1) estimated using the observed sex ratio, emergence rates and the number of black eggs on the release cards, were significantly lower than planned.

Parasitism of sentinel egg masses followed a similar pattern for both species; peaking on 9 June (day of year 161) and declining by the time the last sentinel egg masses were brought in on 15 June (day of year 168). The temporal pattern of parasitism of sentinel egg masses was similar for all *T. minutum* release rates (Fig. 10). Parasitism of sentinel egg masses was positively correlated with *T. minutum* release rates (Fig. 10).

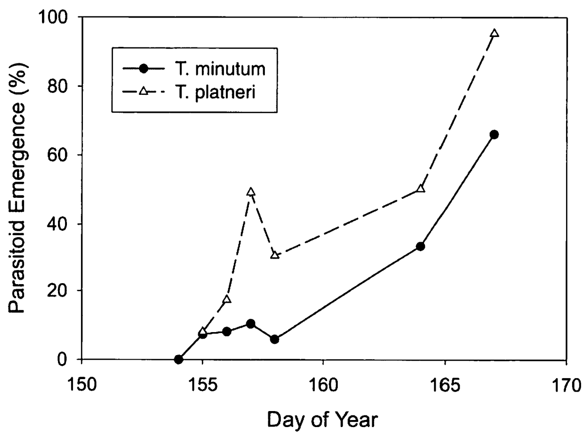

Fig. 9. Cumulative emergence of adults of *Trichogramma* spp. from field released eggs of the factitious host at Owen Sound, Ontario, 3-15 June 1996.

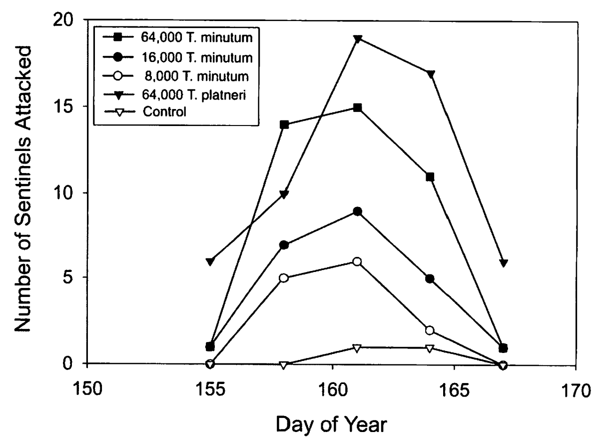

Fig. 10. Parasitism of sentinel egg masses on cards after point release of *Trichogramma* spp. at different release rates.

The mean apparent parasitism by *T. platneri* of pine false webworm eggs was 10.9% with a maximum at one tree of 36.2%. This rate of parasitism was significantly higher than the control trees. The higher rate of parasitism by *T. platneri* was matched with a lower rate of pine false webworm emergence (Table 1). There was a trend towards increased pine false webworm mortality at all treated trees compared to controls, but this was not statistically significant. Parasitism by *T. minutum* was not significantly higher than at control trees and there were no effects of release rate on rates of parasitism.

The release results are promising in that for one species (*T. platneri)* we were able to demonstrate a significant increase in parasitism of pine false webworm eggs. A key issue for both species was the timing of the release. We observed significant activity of pine false webworm adults on 31 May indicating that an earlier release date might have better targeted the availability of host eggs. In addition the emergence of both parasitoid species was slow and peaked after both our sampling of pine false webworm eggs and the start of pine false webworm emergence from the host eggs. The impact of both species will be improved by synchronizing parasitoid emergence with the initiation of pine false webworm egg laying.

The cumulative emergence of 66% for *T. minutum* (Fig. 9) was lower than we have observed in previous *T. minutum* releases (Bourchier and Smith 1998). Actual release rates of *T. minutum* females, on the date that pine false webworm eggs were sampled (12 June), were very low (900, 3,600, 7,200 for 8,000, 16,000 and 64,000, respectively) because of the delay in parasitoid emergence. Given the number of females available to attack the host on our sampling date it is encouraging that there was any observable parasitism at all at the *T. minutum* trees (Table 1). There is potential to make *T. minutum* more effective by better timing of emergence and improving the cumulative level of emergence to historical levels (approximately 85%).

In the future there is considerable potential for both classical and inundative biological control of the pine false webworm. Classical biological control studies will target development of mating and propagation techniques for *M. hertingi* and inundative release studies with *Trichogramma* should be repeated with an effort to improve the synchronization of parasitoid emergence with host oviposition. Improved monitoring of adult pine false webworm emergence will insure better release timing. The European species of *Trichogramma* shows promise, however, additional studies are required to assess the potential interactions between the introduced species and native *Trichogramma* used for inundative release.

Acknowledgements

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The Pine False Webworm in New York

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Introduction

To the best of our knowledge, only four incidents of pine false webworm have been observed in New York's natural pine forests and pine plantations (Fig. 1). However, this sawfly has been associated with ornamental pines in this state for some time (Johnson and Lyon 1988). In the early 1980s, approximately 8 ha of red pine in Schoharie County (southeastern NY) were heavily and repeatedly defoliated. The Department of Environmental Conservation, Bureau of Lands and Forests eliminated this outbreak by clear cutting the affected stand along with an additional 8 ha buffer of sparsely infested pine. Even though webworm continued its presence in stands adjacent to the generally infested area, it never again attained outbreak status. Two years later a small number of Scots pine were defoliated approximately 25 km north of the Schoharie site in southern Montgomery County. At about this time, the owner of a Scots pine Christmas tree plantation further west in central NY reported an additional problem with the sawfly. These last two infestations did not persist but apparently disappeared without intervention by the landowners.

Current Situation

The fourth and largest outbreak occurs in the Franklin and St. Lawrence County region of northern New York (Fig. 1), approximately 50 km directly south of Cornwall, Ontario. This infestation was first noticed in 1981 and has been expanding slowly ever since. At the original site or epicenter, the insect has defoliated surviving trees to one degree or another annually for 18 years! This stand consists mainly of Scots pine with a small component of white pine. In general, Scots pine is considered a weed in our part of the world and, except for people involved in the Christmas tree industry, insect damage to it is not viewed as serious. Most of the white, Scots and red pine plantations in this area were established either during the 1930s or the 1950s. The sawfly population has expanded slowly for almost two decades and, as of 1998, the infestation affected all white and Scots pine (approximately 5,000 ha of white pine) in small stands and plantations within an area of approximately 231,000 ha. Much of the white pine in this region is commercially valuable. Our concern is that the infestation will continue spreading east and south where forest industry manages some plantations and many natural stands of this conifer. The insect occurs in red pine plantations, but this host has never been noticeably damaged in northern NY.

The Bureau of Lands and Forests has sketch mapped noticeable defoliation from fixed-winged aircraft annually since 1981. The forester who does this is a native of the area, knows the terrain well and is very familiar with the appearance of damaged stands. We are confident in his ability to map three levels of damage; light, medium and heavy. In addition to the main outbreak, two years ago (1996) a small area of heavy defoliation was noticed in the vicinity of Malone, NY north of the general infestation and approximately 15 km south of the Quebec border.

No attempts have been made to control the population (i.e., limit degree of defoliation), but to date approximately 300 ha of white pine sawtimber (43 - 45 cm dbh) have been salvaged (i.e., clear cut). Currently, many more hectares are up for sale and most likely will be liquidated by 2000.

Research Projects

So far our work has been aimed at understanding the general biology of pine false webworm in this region. We are investigating its impact in terms of white pine growth and mortality, developing a hazard rating system for forest owners and identifying and determining the effects of various natural enemies. The soils work associated with the hazard rating project is especially interesting. So far the heaviest and most prolonged defoliation has occurred where the shore of a large post glacial lake (Lake Iroquois), much larger than present Lake Ontario, waxed and waned 10,000 years ago (Reed 1934). This shoreline is represented today by an elongate band of very fine, deep "blowsands", which are associated with the major areas of defoliation. This term also has been used to describe soils where many of the major European outbreaks of pine false webworm have occurred (Schwerdtfeger 1941, Jahn 1967) .

Additionally, we have been working with a chemical ecologist interested in insect pheromones. He and a graduate student are attempting to identify the webworm pheromone. Preliminary work with this subject (Asaro 1996) suggested there is an attractant. If its chemical

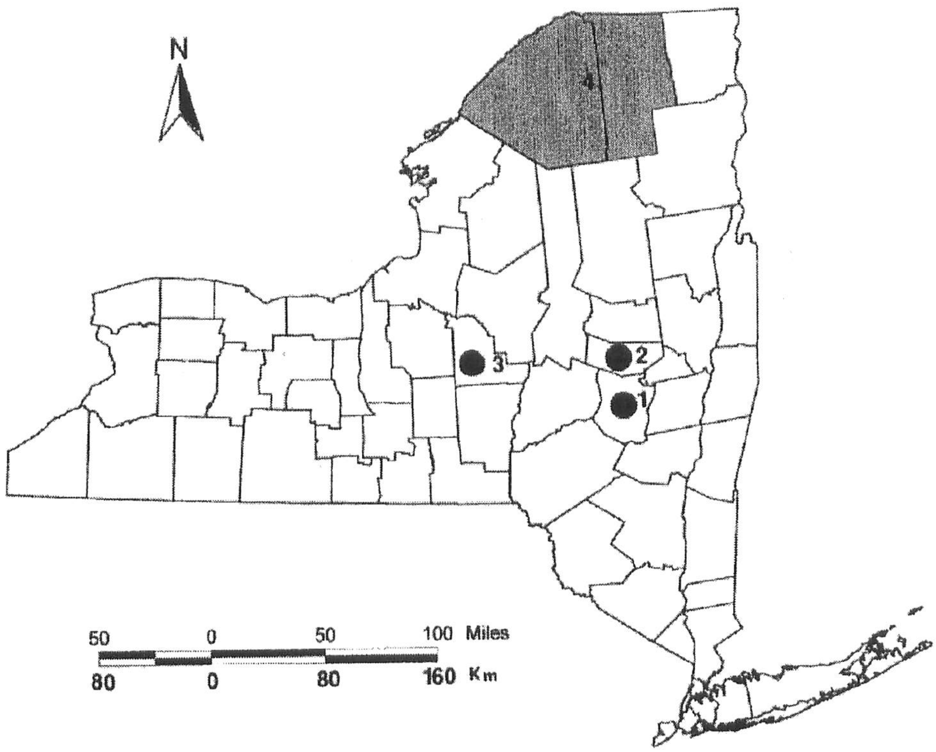

Fig. 1. Location of known infestations of pine false webworm in New York; (1) Schoharie Co., (2) Montgomery Co., (3) Madison Co., (4) St. Lawrence (west) and Franklin (east) Counties.

components can be identified, it would provide an invaluable survey tool.

Our preliminary work on impact showed growth loss in the first 5 m (16 ft) log of sawtimber sized white pine amounted to approximately $US300/ha after seven years of heavy defoliation (all old foliage consumed, partial consumption of current-year foliage). This is a conservative estimate, and we are working on a complete stem analysis to more accurately assess this aspect of damage. Circumstantial evidence suggests white pine mortality, and degrade associated with blue stain, become serious concerns following five to seven years of heavy defoliation. At this time, trees that have been defoliated repeatedly become susceptible to red turpentine beetle, *Dendroctonus valens* LeConte. To date, the heaviest and most prolonged defoliation occur in plantations. The sawfly is present in natural stands at very low levels, but we have yet to see significant damage under these conditions.

It is especially important to provide the forest industry with management guidelines and control recommendations. Hopefully the hazard rating work will contribute to the former. The latter will be difficult, because our pine stands are associated with watersheds for major rivers in the infested region, such as the St. Regis and Raquette, which drain the northern Adirondacks and empty into the St. Lawrence. This environmental concern, along with the fact forest owners and the public are wary of synthetic organic insecticide use in general, dictates that a biological approach to control be developed.

Acknowledgements

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The Impact of the Pine False Webworm on the Ontario Christmas Tree Industry

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Introduction

The 1996 Census of Agriculture (Statistics Canada Agricultural Division 1997) reported that 555,136 Christmas trees were harvested in Ontario from 586 farms in 1996. Valuing each tree at about $15.00, the 1996 sales of Christmas trees would be around $8.3 million. There was a total of 1,345 producers in 1996. The total area in production in 1996 was 11,285 ha (27,887 acres). The main species of trees currently grown include balsam fir, *Abies balsamae* (L.) Mill.; Fraser fir, *Abies fraseri* (Pursh) Poir.; white spruce, *Picea glauca* (Moench) Voss; and Scots pine, *Pinus sylvestris* L.

Impact of Pine False Webworm

The impact of pine false webworm (PFW), *Acantholyda erythrocephala* (L.), on the Ontario Christmas tree industry, is closely correlated to the insect's distribution throughout the province. For growers in areas where PFW populations are well established, it can be a significant problem. To evaluate the impact of PFW on the industry, a telephone and fax survey of Christmas tree growers was conducted during the summer of 1997.

The growers contacted in Peel region, and Dufferin and Simcoe counties were aware of PFW. They had applied some insecticides over the past five years in efforts to control the insect. This does not mean that these areas should be considered infested. Some growers reported up to a 25% loss in the quality of the trees. They also noted that through early monitoring for PFW, it tended to be a manageable insect problem. Growers in southwestern Ontario's Kent county, were unaware of PFW. Its damage had not been observed. In Wellington county and Durham region, growers were aware of PFW. Although a few growers had applied chemical controls for PFW, most of them had never observed any damage. It appears to be a very localized problem. Growers in the Durham region are more concerned about PFW. They are fairly close to established PFW populations in the Ganaraska area.

It is difficult to estimate dollars lost due to PFW. In areas where it is a manageable insect problem, some growers reported losses of about 2% of the harvestable trees. Some of the growers claimed annual costs of about $2,000 for maintenance (corrective pruning) and $5,000 to $7,000 in treating the problem. Growers in Simcoe and Dufferin counties, and Peel region noted that they were losing up to $10,000 because of PFW.

Trends in the selection of Christmas tree species grown by growers has influenced the impact of PFW. Production has shifted away from Scots pine to spruce and fir. This is in response to changes in the Christmas tree consumer's interest in a wider selection of trees. Consequently, the acreage of Scots pine being planted has decreased over the past few years. Most growers did note a continued consumer demand for Scots pine. Pines will probably continue to be planted, although fewer in number. In addition to PFW, other insect and disease problems of pines are encouraging producers to plant fewer pines. Through the phone and fax survey, most growers said they were decreasing pine plantings for maintenance reasons in addition to the changing market.

With careful monitoring, PFW can be a manageable insect problem. Chemical insecticides need to be applied before the web spinning begins. Multiple sprays could be used. The common insecticides being used were carbaryl, acephate, chlorpyrifos and diazinon. Growers are encouraged to always carefully check labels to ensure that they are complying with registered uses.

Developing and Implementing a PFW Program

In 1996, a series of pest management study groups in commercial nurseries was initiated. These were located in different parts of the province. The groups met approximately every other week. The purpose of the groups was to review and discuss current insect and disease problems, and monitoring and management strategies. Pine false webworm was identified as a major problem by the Simcoe County study group. The following year, 1997, with the cooperation of Drysdale's Tree Farm at Egbert, Ontario, a monitoring program was developed and implemented.

The objectives of the monitoring program were: 1) to observe the biology of PFW in a commercial operation; 2) to identify the best time to treat the larval stage and 3) to develop a quick and easy, grower friendly way of monitoring insect development.

Materials. Yellow insect monitoring cards were used. These are similar to the cards currently used in many greenhouse monitoring programs. These boxboard cards were 45 by 22 cm, yellow on both sides, and not sticky. Holes were punched in either end. Twist ties were used to fix the cards to the pines. One side of the card was manually covered with Tanglefoot® (The Tanglefoot Company, Grand Rapids, MI). The treated cards were used to trap adults as they emerged from the soil. Adults could be easily counted and their sex determined.

A field was selected that was identified by the grower as having a past history of PFW. Previous damage, old webs, could be observed in the foliage of the pines. The pines in this field were about 125-150 cm in height. An area of approximately 910 m^2 was selected. This area contained about 500 trees. The yellow sticky traps were placed randomly throughout the area on 50 (10%) of the trees. The trees were flagged with yellow flagging tape for easier identification. The traps were placed in the bottom third of the tree canopy (Fig. 1). Because the cards would catch a wide variety of insects and soil, they were replaced weekly. The field was monitored weekly. The traps were placed out on the 8 May.

Fig. 1. Yellow sticky traps placed in a Scots pine.

Results and Discussion. The first males were caught on 13 May. Table 1 summarizes the numbers caught through the PFW monitoring program. Figure 2 shows PFW caught on the trap. The yellow sticky traps caught many more males than females. This is probably related to previous observations that the males are more active (Lyons 1995). The first eggs were observed on 27 May, 15 days after the first insects were caught (Table 1). On this date, the number of PFW caught on the traps peaked. Egg hatch and the first larval stage were observed on 9 June, 13 days after eggs were observed and 28 days after the first PFW were trapped. On 16 June, 35 days after the first PFW were caught, no adults were caught in the sticky traps.

Fig. 2. Adult PFW were caught on the yellow sticky traps and counted.

The flight period is reported to be 21 days (Lyons 1995). In the area observed, flight was extended for 35 days. Egg hatch occurred over several weeks. Treatment should be applied as young larvae begin feeding but before the webs are constructed. Using the yellow sticky traps, growers could predict their first insecticide application. It should begin approximately two weeks after egg laying begins.

PFW Grower Workshop

In summer in 1997, a workshop on the identification, biology, monitoring and control of PFW was held for Christmas tree growers and the nursery industry. It was held at Drysdale's Tree Farm, Egbert, Ontario. The objective of the workshop was to provide growers with information on the biology and identification of PFW, and discuss management strategies. As part of the workshop,

Table 1. Numbers of pine false webworm caught on yellow sticky traps.

Date	Total PFW caught	Males	Females	Comments
8 May	0	0	0	traps placed out
13 May	34	30	4	
21 May	270	232	38	
27 May	544	534	10	eggs observed
6 June	58	51	7	
9 June	10	10	0	first instars observed
16 June	0	0	0	

Dr. Barry Lyons, Canadian Forest Service, Natural Resources Canada, Sault Ste. Marie, Ontario, outlined the biology and current research in the control of PFW. The PFW monitoring project was also presented. Participants were invited to tour the PFW monitoring project. Unfortunately, a couple of tremendous storms passed through the area and made the field tour difficult.

Future Directions

As part of the PFW telephone and fax survey, growers were asked about other research needed by the industry in regards to PFW. There is a strong interest in biological controls. Growers are particularly interested in controls that could be established in their growing operations, such as parasitoids. As well, growers are looking for more environmentally friendly and more effective controls. Survey participants were also asked to identify what other insect or disease problems they felt were more significant than PFW. Balsam twig aphid, *Mindarus abietinus* Koch, was frequently identified as a major insect problem. This reflects the shift in production from pines to fir. Some other problems that growers identified with pines included gall rusts, weevils, and Diplodia tip blight (*Sphaeropsis sapinea* (Fr.) Dyko & B. Sutton).

Summary

PFW can be a major problem in pine plantations for both nursery and Christmas tree producers. Although it can be relatively easily controlled by current insecticides, growers must begin early monitoring in order to treat the young susceptible larvae before web spinning begins. Monitoring adult emergence provides growers with a guide to insect development allowing for improved timing of insecticides.

Acknowledgements

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Panel Discussion

Following the formal presentations, a panel consisting of the Workshop presenters (Doug Allen, Blair Helson, Gord Howse, Chris Kessel and Barry Lyons) was convened and fielded questions from the Workshop attendees. This was followed by an open forum. These sessions were moderated by Taylor Scarr (M). The following is an edited transcription of the panel discussion. We have attempted to preserve the content of the questions and answers while enhancing their readability. The identities of the questioner (Q) and responder (A) are noted when known.

Q: (Penwell). On the clearcut sites in New York, is there a lot of white pine regeneration coming up and is the regeneration being severely defoliated? What are they doing as far as silviculture treatments after clearcutting?

A: (Allen). The same summer after clearcutting, they went back and planted red pine, not realizing there was an existing red pine problem in Canada. We have been looking at these seedlings pretty closely. The ground was full of webworms when they planted. We looked at these seedlings the following summer and found they were infested, but had a good growth of current year's needles at the end of the first season. We again looked at these seedlings last summer and they looked fine. It appears the insect just does not cause problems to red pine in this location. In most of these areas, they have done nothing. This is county land and the county has a different perspective on the value of the land. Lack of available funding limits what they can do. They are hoping that hardwood regeneration will replace the plantation. The red pine that was planted at one time will probably do very well.

Q: (Reese). Is there a predictor of when the problem jumps from younger plantations to overstory in a particular area? Is this due to population variance, different sources of the population or a trend in a local area?

A: (Allen). In New York, it has always been in the overstory, but they oviposit on the understory as well. There is clearly no preference. In the New York situation, the outbreak is in the stands not on the edge initially.

Q: (Reese). In Ontario, has the pine false webworm previously been on younger red pine stands.

A: (Lyons). I suspect it is really not a change in the insect itself but a change in the forest. The mature or semi-mature red pines have somehow changed over the years. Decadent pockets have been the focus of outbreaks of pine false webworm. Historically, in European populations, pine false webworm has been a pest of young trees before crown closure. In some locations, we have seen an edge effect. The insects build up on edges of clearcuts or roadways and as the plantation thins out, this creates habitat more favorable for more webworm, resulting in a wave of defoliation expanding from these epicentres. We have seen this effect in young plantations for a number of years, for example a frost pocket might serve as a focus of an outbreak. We are starting to see the same thing in plantations of large red pine where something has happened in a part of the plantation and an outbreak has developed.

Q: (Smith). Would you say the stands were decadent or contained pockets of decadence with some vigorous trees? At sites in our area, these red pine stands are reaching harvestable age and have not been thinned and have been left relatively unmanaged, growing on hardwood sites.

A: (Lyons). I have not been over to look at the Ganaraska Forest area yet. Someone from that area might comment on what you are seeing there, because again that is a whole new situation, something we have not seen before in Ontario. The situation sounds a lot like what is going on in New York State.

A: (Penwell). Originally, there was minor defoliation by pine false webworm on young plantations in the 1980s. We then saw the insect move to the larger stands. Peculiar to Ganaraska, most of the infestation seems to be occurring on the upper elevations. The forest is located on the Oakridges Moraine, with fairly high elevations and deep sandy soils. Defoliation seems to be occurring mostly on the highest elevation, both on red pine and white pine. On these upper elevations, these red and white pine are under great stress because the sites they are on have high carbonate soils. The trees are very short on these sites. Pine false webworm seems to hopscotch the upper elevations and defoliate white pine much worse than red pine. However, where the red pine is pure, the pine false webworm will do a real number on it as well. Is there a relationship between elevation and stressed trees and the pine false webworm?

Q: (Lyons). Is there a relationship between aspect, in terms of slope, and defoliation in these areas at Ganaraska, for example southern versus northern aspect?

A: (Penwell). Yes, I would say from observations that the aspect being hit is mostly on southern slopes. They have lots of smaller areas hit since 1992, not a lot of larger areas of defoliation. After the first year of defoliation, the edge of the severe defoliation at these upper elevations has not expanded. As you start to come down the slope you go from severe defoliation to almost negligible defoliation over a very short distance.

Q: (Lyons). Do the stem densities vary between the sites?

A: (Penwell). Most of these stands have been well thinned. One stand with severe defoliation is a 30-year-old red pine plantation, with a 5 by 5 m planting. More mortality seems to be occurring in this stand than elsewhere.

Q: (Lyons). Are there differences in stem densities at the top of these hills as compared to the lower elevations stands?

A: (Penwell). No not really, they are all stands that have been thinned fairly consistently with the same conditions, pine false webworm just seems to run out as we come down the slopes.

Q: (Lyons). Prior to pine false webworm was there a difference between crown densities at upper and lower elevations in these stands?

A: (Penwell). Yes, physically the amount of foliage was less on the upper elevations where the trees are stressed.

Q: (Lyons). What about the soil types at the two elevations?

A: (Penwell). Both the upper and lower elevations have sandy soil. At the upper elevation stands, the topsoil has washed away leaving carbonate close to the surface. At the lower elevation, erosion has not occurred and the soil is much better. The first area that they clearcut in 1992, was a thinned stand and that year the pine false webworm showed up. This 15-acre (6.1-ha) clearcut was replanted to white pine. After looking at this replant last fall, there was no evidence of pine false webworm on the seedlings and there was 80-85% survival. There was still pine false webworm in an adjacent red pine stand.

Q: (Czerwinski). It sounds like we are dealing with two species here, when we compare host preference for white pine in New York and for red pine in Ontario. Has anyone looked at the DNA of this species?

A: (Lyons). There is always that possibility that we have two different strains of pine false webworm, however, it is unknown at this point. I have not visited the New York site but Doug Allen has been to sites in Ontario.

A: (Allen). The biggest difference between Ontario and New York State is that in Ontario the red pine were in small plantations, Christmas tree size, as compared to New York with small saw timber to timber size white pine stands of all ages. Some stands have a lot of regeneration and this has suffered mortality. Stand conditions were totally different.

A: (Lyons). The possibility of two strains might be something to look at in the future.

Q: (Munt). Is most of the work being done in pure red or white pine stands? Is there any work being done in red pine stands with hardwood undergrowth mix?

A: (Lyons). In Ontario, all the work we have done is predominantly in red pine plantations and only recently have we worked in white pine plantations. We have not worked in mixed stands.

A: (Allen). In New York, we have worked in plantations with mixed blocks of white and red pine. The red pine looked fine. We have not worked in any natural stands yet because infestations have not gotten to damaging levels.

M: (Scarr). Do you want to comment on the types of forests you have in Ganaraska?

A: (Penwell). The Ganaraska forest is 10,000 acres (4,057 ha) and it is roughly a 50:50 ratio of plantation to natural forest. The natural forest is predominantly red oak but there are remnants of large older white pine in those forests. Some areas of these forests have been substantially defoliated. The plantations are fairly young, reforestation started predominantly in the late 1940s. Part of the forest is the old Durham regional forest planted in the 1920s. We have not seen any evidence of defoliation in that older forest. Quite a number of the plantations contain a mixture of red and white pine. Where this mixture occurs the white pine crown is quite a bit thinner than the red pine. The defoliation on the white pine seems to be a lot more substantial. Although you have to look at that in perspective because looking at these dry sites, the white pine has had a struggle because the red pine is over top of it. Generally speaking you have white pine with much smaller less foliated crowns with a lot less there to eat, so the impact on these trees comes quicker. Where there is a combination of white pine and red pine, the red pine is defoliated but not to as great an extent. The white pine is substantially defoliated. There is quite a bit of defoliation on the old white pines that stand above the canopy. If you look at those trees there is a lot of red rot and weakness. How much effect this has on defoliation is unknown.

A: (Liljalehto). In Ganaraska, we have large expanses of deciduous trees with remnant large white pines over several thousand acres. An aerial survey indicated that all the white pine were red in color in the spring and early summer and were intermixed with all kinds of deciduous species in deciduous stands. The pine false webworm was not restricted to mainly a conifer cover type.

A: (Penwell). There are also large areas where the large white pines were intermixed in the hardwood forest and there is no substantial defoliation. Geographically, the forest is 20 miles (32.2 km) from end to end. The pine false webworm has hopscotched across the upper elevations across the entire forest.

Q: (Munt). Will there be monitoring occurring for 1998? Is the Forest Health Unit of Canadian Forest Service (CFS) going to have any response?

A: (Howse). Yes, monitoring will continue.

Q: (Liljalehto). What about forecasting?

A: (Howse). That is another subject for another workshop.

Q: (Reid). Do you know for sure that this insect is not being transported in wood?

A: (Allen). In New York state, I think it is being transported depending on when they cut. If they cut and move logs at the right time of year, they could move adults around. It has not been a major cause of spread, because it has taken 17 years for the population to attain that size and it has been a very small progression. The interesting question is why did it start where it did in 1981? It started in an area called Fort Jackson, which is in the middle of nowhere. There was a Scots pine plantation there, but it is off the beaten path, but it started right there.

A: (Lyons). We could see from Gord Howse map's that the pine false webworm is pretty much throughout Ontario. It is probably throughout Quebec and it is probably in New Brunswick. It was introduced into Newfoundland with nursery stock, and I suspect that is how it has moved around. The records show that it is now in the city of Edmonton, as Gord Howse mentioned, so it has spread a considerable distance, maybe some of it naturally, but there are definitely incidents of man helping it along. I am sure that is how it arrived in Ontario in the first place. It was probably introduced into North America on nursery stock from Europe.

Q: (Sutherland). For those of us who are dealing with mature and semi-mature stands, what do we do now?

A: (Lyons). You tell us what you want us to do and we will figure out if we can do it. We have some potential answers. As a researcher, I want to know what the forest managers want us to do. What are the burning questions and issues that you want answered? If it is to come up with a control strategy, we can do that provided we can get funding. Blair Helson, Ed Kettela and I met a week ago in Sault Ste. Marie and discussed some potential strategies. We will require funding to develop these strategies. There are products we can test that have potential. It is just a matter of finding out how dramatic you want these control solutions to be and how expensive they will be to implement?

Q: (Sutherland). Is everything we have heard today pretty well prohibitive on a practical scale?

A: (Lyons). We can recommend options for you to carry out, but that is really not our role. Our role is to provide forest managers with management options. We can develop some options for you, but it is not our job to implement these options. We can tell you what is available and we can look for new alternatives to make available.

A: (Sutherland). Options are what we need as forest manager. It is nice to know the biology of the insect, but the ultimate goal for managers is options.

A: (Liljalehto). To fortify this concern, scientific knowledge and history have shown us that once we get an infestation it spreads from a few acres to 400,000 acres (162,280 ha) in New York. The spread seems to be perpetuated and can be promoted by the combination of red pine and white pine together, whether there is advantage for spread caused by climate fluctuations, when those two are together. We get mortality in white pine after 5-7 years. I am quite sure in Ontario in semi-mature to mature stands, we are getting 70% mortality in high quality red pine stands in sometimes 3 years and that mortality just seems to continue. Growth loss has been quantified at $120 U.S. over 5 years. We do not want to be crying wolf all the time when a new pest appears in our forest. History shows us that this is not a catastrophic pest like budworm. We can predict it is here and we know it is going to spread. The level of infestation seems to go up and down. They will remain at low levels for a few years and suddenly an outbreak will occur like this past spring in Simcoe county, Ganaraska forest and in Orangeville. We need a strategy. We have spent the last 3-4 years carrying out good science. This workshop is an excellent opportunity for scientists and forest managers to come up with questions if not answers. We need to have a predictability or hazard rating system and also need to know what our options are.

Q: (Liljalehto). What registered product can we use from the air to control this pest?

A: (Helson). No product is registered for aerial application against pine false webworm. There could be products developed and registered for aerial application.

Q: (Liljalehto). So there are no control options now except to cut the stand down? This is not really a good forestry option.

A: (Helson). There are possibilities of getting registrations fairly quickly through minor use programs. Dylox was registered for yellow-headed spruce sawfly in a short period of time (1 year).

A: (Lyons). Some of these programs are client driven. These requests have to come from the forest managers who want to have these products available for use. There are several of these minor use programs available, for example the label expansion programs. If there is already a product registered for use in Canada and there is good efficacy data on what you want to control, there is a potential for expanding the label for use in Canada. There is a new program in the works that will allow you to register products that are registered in the U.S. This makes it possible for a minor use registration for neem or Dimilin, which are registered in the U.S. This is dependent on having some efficacy data on the product, having the support of the forest managers who want to use the product, and whether the companies that produce these products want to be bothered with a forestry application.

Q: (Huff). Do you have any idea whether the companies are interested in producing for this market?

A: (Helson). It depends on the product, each company is different. Sevin is an old well-established insecticide. I have not talked to the company, but I do not foresee any problem utilizing this product. Carbaryl will get support from the company quite readily. Dimilin, which looks very effective against pine false webworm, is not currently registered in Canada except for special use against gypsy moth, by quarantine officials. It is not available and not readily used in Canada so we would have to contact the company. They were not interested in registering Dimilin for forestry use a few years ago, but I am unsure about it now. There could be an interest in developing neem through a minor use program.

Q: (Lyons). I would like to redirect this question to the forest managers. What products might be acceptable for use on your forests?

A: (Munt). York region would never use a chemical on its forests because it would not be acceptable. As a land manager, I would need to stick to biological control options such as neem. A chemical is not an appropriate option. The pine false webworm is coming our way if it is not there already.

A: (Sutherland). Simcoe county people would be the most tolerant of all the counties involved, but they would never agree to Sevin or any hard chemical. We need a biological agent of some sort. Something that would not cause 16 politicians to lose votes.

Q: (Nicolson). What is the total area at risk right now? What is the upper limit a land manager would be willing to invest?

A: (Sutherland). In Simcoe county, the total area at risk, including private land, is approximately 25,000 ha. The total area on strictly Simcoe county land at risk is approximately 7,000 ha.

A: (Howse). Based on the current year's infestation, it was less than 1,500 ha of moderate to severe defoliation as mapped by the forest health officers.

Q: (Howse). How many poles/ha are produced?

A: (Sutherland). Five hundred poles/ha of class 1 poles. In 75 acres (30.4 ha) clearcut, Simcoe county made $105,000. This works out to over $1,400/acre ($3400/ha).

A: (Penwell). Ganaraska and York region made $80.00 for a standing pole. These are very high value softwood stands. This pest is a problem, but it is not a big enough problem to change our management strategy totally.

A: (Munt). This insect is inconspicuous, it is not like gypsy moth. In York, if the pest is a problem in household yards, then the sky is the limit. People would pay anything for control of the pest, because extensive subdivisions are involved.

A: (Sutherland). In Simcoe county, they had only two private landowners call about the pine false webworm problem.

A: (Munt). York Region has not had any calls.

A: (Howse). I have a file full of letters from Christmas tree growers going back to the late 1970s, including the association and individual producers. This insect has been a chronic problem for 20 years

Q: (Howse). What proportion of Christmas tree growers have had a problem with pine false webworm?

A: (Kessel). A telephone survey was conducted and of 20 growers polled, probably 3% said they had a problem with pine false webworm. All the growers polled said they will be or have decreased the number of Scots pine being planted and now are maintaining the number they have.

Q. (Howse). Do they feel the problem is manageable for both monitoring and control by growers themselves?

A: (Kessel). Yes.

A: (Howse). This is another segment of society in Ontario, dealing with trees at a slightly different stage of things, where the insect is manageable at one end and it is not manageable at the other. This obviously hinges on whether you are prepared to use a chemical insecticide or not. If not, you are going to have to be prepared to accept the limitations present with what we currently have.

A: (Allen). In New York, Sevin is registered and the state would allow you to use carbaryl. It is unlikely that they would use it. Clearcutting was done by International Paper on the land that was infested because they wanted to get every dollar out of the logs they could. Whether clearcutting will continue and for how long is not clear at this point, if the insect continues to spread. There are no options unless they are willing to use carbaryl. They would have a difficult time with that.

Q: (Lyons). What is the purpose for developing a hazard rating system? There seems to be a need for a hazard rating system in Ontario. New York state is working on one now. Clearcutting is the only management option. So if the hazard rating system says you are going to loose material, is the solution clearcutting at this point in time?

M: (Scarr). Before you get into a management program, you have to get out and determine if you have to do one, so we need more impact information. We now know that impact can be at least as high as 75%, but we need a hazard rating system to determine when and where it will occur. Impact can be very minimal in some sites and very high in others. Then, you have to do some preparatory work to do your forecast as Harri suggested. What do we have to do now to know whether there will be an infestation on this site. For example, how many overwintering larvae will determine how much defoliation will occur next year and what is the importance of the prolonged diapause? This should definitely be the direction of research in the future.

A: (Allen). From a pragmatic standpoint, we know that white pine can withstand 5-7 years of heavy defoliation before mortality appears. How much growth loss will industry or forest managers be willing to put up with prior to that time? I am trying to provide this information rather than trying to predict when first defoliation is likely to occur. Both types of information are important in different instances. We seem to have lead time before mortality, turpentine beetles, blue stain and degrade occurs. This is important information for managers.

Q: (Czerwinski). Are there other organisms affecting the mortality of these red pines in Ontario or is the pine false webworm working alone and causing mortality?

A: (Lyons). This is a chicken or egg question. When we assess the trees, we see bark beetle, buprestid and *Armillaria* damage, but we can not definitely say what actually killed the tree. If there is 100% defoliation by pine false webworm, the tree's vigor has been reduced to such a point that an other organism come in and kill the trees. I suspect some level of defoliation, possibly 75% or higher, weakens the tree, secondary agents come in and the tree will likely die. If defoliation is less than 75%, vigor is not reduced to a level where other agents will come in. It is difficult to quantify You can not specifically say pine false webworm killed those trees.

Q: (Czerwinski). So Sevin is not an option in the near future and neem is a possibility through a minor use program. If neem is used in an aerial application, what other insects will be affected by the neem?

A: (Helson). Neem is a selective insecticide and is only active on the larval stage of other insects. Neem is not active on adults so they will have no toxic effects. It is likely to be quite selective for pine false webworm.

A: (Lyons). The biodiversity of a red pine plantation would be lower than in a natural or mixed stand. If we do conduct an aerial spray program with neem, we would work strictly in red pine plantations and the potential impact would be minimized.

A: (Helson). Barry Lyons and I have done research on the effects of neem on *Trichogramma*. There could be the possibility of an integrated management strategy incorporating the release of *Trichogramma* followed by a treatment program with neem. The laboratory results indicated there was no effects on *Trichogramma* using neem at a dose of 50 g A.I./ha.

Q: (DeVillers). What solution can we give to the private landowner who has 10 to 15 acres (4.1 to 6.1 ha) of land with mature trees infested with pine false webworm? If his option was to cut, he has nothing left. What can they do?

A: (Helson). Systemic treatment has potential for this situation, on a small-scale basis, using neem and possibly other products. It will be labour intensive, but there is a lot of time available that the treatments can be done (2 months). Acecaps are also available for use. It is a capsule of acephate that you insert into a drilled hole in the trees. The number used depends on the diameter of the tree. It has not been tested for pine false webworm yet, but it will likely work. It is a product used for a number of insects and it would probably be fairly easily registered for pine false webworm. It is labour intensive and a relatively expensive technique.

M: (Scarr). Aerial application is an option for the private landowner because it is a landowner decision. Using a regulated product governed by the Ministry of Environment (MOE) is acceptable, but for those land managers managing land in trust, it is a different story.

A: (Kettela). If you read the label on Sevin with its loosest interpretation, you will see that it allows you to spray sawflies aerially. In gypsy moth days in Ontario, landowners had a free-for-all concerning what they could use. This probably still applies. With land in trust, forest managers have to contend with politicians. There are all sorts of levels of potential use here. Anyone doing ground applications has the most options. Christmas tree growers are already doing ground applications using carbaryl or orthene. They could also use permethrin, which is registered. In the next 2-3 years, we have to seriously consider using an option like neem, which is a biorational naturally-derived product. This would not be an easy sell because someone will read the azadirachtin chemical formula and figure out it is a chemical. The same applies to Spinosad the actinomycetes fermentation byproduct. They will read the chemical formula and come to the same conclusion. In this 2-3 year time frame, aerial spray trials need to be conducted so those use patterns are on these product's labels for potential in aerial use down the road. In 1996, in New Brunswick, aerial spray trials using neem against yellow-headed spruce sawflies were conducted with a fair degree of success. Neem was also used against balsam fir sawfly in Newfoundland in an aerial spray application. So it is getting a track record of proven efficacy. The real problem with neem will be the expense in terms of product itself. It could cost up to $1500.00/ litre.

A: (Helson). I think $150.00/litre is a better estimate.

A: (Kettela). There are a number things that can be done depending on the constituency you are looking at. For example, to sharpen up the label for Sevin, how many more trials with Sevin need to be done to prove it is effective against pine false webworm? I suggest none. Blair Helson has all the information there already, let us pursue it and see if they will put it on the label and have it as part of the aerial application package specifically. Then landowners with 10-15 ha will not have to punch holes to systemically treat all their trees. They will spend the rest of the year doing that. This is an opportunity to get a lot of things on the labels. This is also an opportunity to put into place novel ways to deal with this insect. We must also consider a virus, if one exists and the development of a pheromone for monitoring or control. The insect is patchy with a low spread rate so these techniques should work very well. These are long term horizons but they are products that the forest managers can use.

M: (Scarr). Landowners can do ground applications if the trees are small enough. If you have a few trees you can treat systemically or use Sevin aerially if the label actually does say sawflies. If holding land in trust, it is unlikely you will be given support for aerial treatment of large trees so there are not too many options. However, one option might be to invest in research.

A: (Helson). If controlling pine false webworm is the way to go, how long will we continue to do this? It seems to be a continuous problem in the stands. Will control need to be done year after year or can it be done once every 3 or 5 years. This might allow the tree to recover and at least stay alive. Pine false webworm is not a cyclical insect, it stays for a long period of time.

M: (Scarr). What will this insect do over the next several years? Will it continue to expand into the rest of the red and white pine resource here and in New York?

A: (Allen). In New York, there is no reason to believe otherwise. It has been going for 17 years and we have not observed much population mortality. What will happen when it moves from plantations to natural stands? That will be the question. The change in soil types to a lesser sand component might change the insect's potential. We are interested in this when we get into developing hazard rating systems and start looking at soils.

A: (Howse). In Ontario, can you predict what the weather will be like 2 or 5 years from now, this will be a determining factor.

A: (Lyons). I suspect populations will increase, as has been the trend historically. When a stand becomes infested with the insect it seems to stick around forever. We have seen that in New York and also in plantations in Ontario. I have only seen a couple of populations disappear. One example was a plantation near Anten Mills where I suspected populations disappeared because of bird predation. The webs were torn apart by huge flocks (grackles) when the pine false webworm female larvae were in the trees. The next year when we returned to the plantation, the population was skewed towards males. The population then collapsed. At another plantation near Lakehurst, which was on a poor site, the population disappeared because the trees died. From our experience, when the insect gets into a plantation it sticks around.

M: (Scarr). The insect has been here since 1950 but only recently have we seen it become an outbreak species. Why?

A: (Lyons). It has probably taken a while for the population to build up, and the forest has changed. The trees all seem to be getting to the same age and were probably planted at about the same time. The site, where clearcutting occurred near Craighurst, was not a site where red pine should have been planted. They are letting it regenerate back to hardwoods. Part of what we are seeing is a result of changes in forestry practices, changes in the forests resulting from man's interventions such that the insects continue to increase. I see no reason why this will change in the future.

Q: (???). In the large outbreak over the 17 years, has there been any noticeable increase in parasitism? You would think with such a long history and large area those trends would show up.

A: (Allen). In New York, we have not looked at that at all. Defoliation occurs and is visible in those stands year in and year out.

Q: (Munt). What does CFS want from the forest managers?

A: (Lyons). We want the questions from you. What sort of control strategies should we be pursuing? What kind of information do you need to manage the forest? There seems to be a clear need for a hazard rating system for Ontario involving soil and forest types, understanding of the geographic variation in prolonged diapause, and knowledge of the spatial distribution of parasitism. New situations are occurring all the time that we have never seen before.

Q: (Helson). It would be helpful to know what is practical in terms of cost?

Q: (Lyons). What kind of control strategies can forest managers use?

A: (Penwell). Ganaraska would be willing to invest a lot of money to alleviate the problem or control the insect, but we need to know whether we will need to treat year after year. It is a frustrating insect, each year we hold out on taking any control measures because there are no answers yet and we hope that maybe next year it will collapse

A: (Lyons). We think that neem has a good potential for control in the near future, as well as classical biological control strategies using the parasite from Europe. We are worried that this research component might have been lost when Rob Bourchier left the Canadian Forest Service. We need resources to keep his work going. The *Myxexoristops* project was only a small part of the research Rob was involved in.

M: (Scarr). Can people here and others interested in the benefits of biological control put effective pressure on CFS and what they do?

A: (Lyons). Yes, you can write a letter to our Director General, Ed Kondo.

M: (Scarr). The federal government has a vacant program, and if it is a priority for us and if we do not let them know, it will not be a priority for them.

A: (Lyons). In terms of pest management, biological control has been identified as one of the highest priority areas and now we have lost our biological control specialist. CFS-Sault Ste. Marie is supposed to be the lead centre for biological control.

M: (Scarr). One option is to write to the Director General of CFS at Sault Ste. Marie and let him know that your interests are biological control, hazard rating and this insect in particular. If you want these people (CFS) to do things for you, you must give them support as well, because they will be competing within their own programs for resources.

Q: (Munt). Simcoe county has been participating with CFS and Ontario Ministry of Natural Resources (OMNR) by supporting research, and the Region of York would like to support research as well. I need to know where the support should go and how best to put that support forward. The problem does not exist yet in York region but it is an investment for the future. Where should the dollars go to best put it to work?

A: (Liljalehto). Some folks have to deal with this pest problem tomorrow (e.g., forest manager has to talk to Ganaraska Conservation Authority), but the answers will not be there tomorrow. We need a multi-year, multi-level strategy, to deal with this pest. We should not leave this room today without a consensus that one or a group of us work together to come up with a both a long-term and a short-term strategy, with a number of tactics we are going to take. There has been lots of good science and preparatory work going on, but maybe this workshop is an opportunity where we can bring it all together and we will come up with some real products, so we will be in a real position in 2-3 years to have some viable options. We need to have pine false webworm officially put on a number of labels. It might be neem, it might be Sevin. These lands that are held in trust might never be able to use Sevin, but if pine false webworm does become catastrophic, the landowners will have the option of using Sevin in 2-3 years, if the necessary preparatory work is done. There is all kinds of other science that can go forward at the same time and continue on the work that has already been done by Barry Lyons, Doug Allen and others. We need to come up with real impact information. The bug has been around long enough that we can actually put numbers on dollar values on volumes lost. We need to have a strategy so we can come up with some hard numbers to convince people and tell them seriously what the impacts are as far as timber and ecosystem loss. Is there a strategy to look into and deal with viruses? Parasites and a number of biological control options have been investigated. Biological control strategies should not be allowed to die. We as a group need to support this control agenda and build it into our strategy. We need to come up with forecasting mechanisms. If confronted with a landowner group, they will probably ask whether the pine false webworm will be a problem next year or is it going to go to an endemic level. So we need to have a predictive capability. Tied to the predictive capability, as Doug has mentioned, is a hazard rating system. Maybe the soil is the controlling factor, maybe it is aspect, maybe it is restricted to certain latitudes. So let us move ahead on this agenda. There is no silver bullet here. We need a multi-pronged strategy and I think we are making great progress on a number of fronts, but this workshop is the opportunity to bring it all together for a number of people to be working for the strategy. We have the CFS, that does this type of work, and we have other research agencies, like University of Toronto, that may be able to get involved. They can cooperate with New York and others. It is not one strategy that is going to work. We have to position ourselves over time. We need to be somewhere one year from now as well as somewhere else five years from now, if pine false webworm continues to expand the way it is predicted.

M: (Scarr). We are talking about strategies for dealing with pine false webworm. Immediate and long-term needs must be identified. There are a variety of groups here with individual needs including: 1) researchers; 2) policy people; 3) land managers and 4) suppliers for the pesticide industry. Any suggestions on how we should proceed from here?

A: (Nicolson). There are no affected private landowners present today, but they do have an option. That option is carbaryl and it works out to about $40.00 per hectare plus the cost of application. So someone who has 10 or 20 acres (4.1 to 8.1 ha) of private forest can take care of it on their own. Whether it is on the label or not, this is not a large issue. To get it added to the label is no problem. Those phone calls can be made in no time. It is just a matter of getting a Christmas tree grower to run it through some program where it is client driven. What we are looking at here are people who are concerned about pine false webworm. The spin off for private landowners is that the product, material and strategies are developed on public land and they eventually fall off to private landowners. To be enticing to the private landowner, the cost has to be comparable to Sevin, possibly $100.00 per hectare. It has to be something that is economically justifiable for such a small market. It might be possible to develop something for sawflies as a group, but to develop something strictly for pine false webworm immediately, that is difficult. Traditionally the bacterial insecticide, *Bacillus thuringiensis* (*B.t.*), does not work on this pest and it may not work as well as on other species even after improving it for sawflies. It might take some playing around looking at the strains and trying to come up with improved efficacy. Some bacteria have been isolated from sawflies this year and we have some information on that. If you are in Simcoe county you are worried about pine false webworm, if you are in Newfoundland you are worried about another sawfly. From a pesticide supplier's perspective, researchers need to broaden what they are doing on this sawfly maybe to other pests. Support CFS by supporting their biological control research. My interest lies in conducting some small formal or informal trials, in the laboratory or field, with the current products. It is never economically justified to develop a product for this insect pest alone.

M: (Scarr). The pesticide industry needs the clients and customers to recognize that it is not profitable for companies to invest in products for this pest alone.

A: (Nicolson). It is not profitable for OMNR or CFS to contribute money into developing a product for this pest. We have a problem because the problem is not large enough except for a few chemicals.

M: (Scarr). If it is widespread across the country then it would be profitable.

A: (Czerwinski). It is in the best interest of all managers, whether it be CFS or OMNR, to look at it now before it becomes a wide-spread problem in the country.

M: (Scarr). That is the perspective of the OMNR, because we want something now and something down the road if it continues to spread. But to convince a manufacturer of a pesticide to spend a minimum of $20 million dollars to develop a pesticide to prevent a problem, where they would not make money, is not going to work for the company. Basically the need of the pesticide supplier is support (people to work with you on these projects) and some money to do some of this work.

A: (Nicolson). Normally the suppliers are the ones providing the research funds, but this is no longer the case. We should not consider a large research program. If we can do limited investigations with *B.t.*, where we can find some efficacy, maybe at higher dose rates than for lepidopterans, this may be the answer. The total sawfly market in North America might be 10% of the total forest pest market. If I could elicit some interest, talk to a few people, maybe we could put something together, but I do not want to raise anyone's expectations. It might or it might not work.

A: (Lyons). I think what Steve has said is there is no way, because of the very small market, that we will be able develop anything specifically for this insect. We may expand some labels for products like neem, but we have to do this in the context of sawflies in general. That does not preclude us from getting some efficacy data for this insect. It is absolutely necessary. Ed Kettela, Blair Helson and I have had some discussions about where we thought things were going. I picked up on a few things today that we could incorporate in a proposal that we have been discussing. The source for funding could possibly come from OMNR. Part of this project would be an experimental aerial application of neem. Another aspect should be the development of a hazard rating system for Ontario. This would be all part of one package.

A: (Kettela). We need key elements for integrated pest management of pine false webworm such as a hazard rating system, development of tools, expedite the label expansion for Sevin for small private landowners for aerial application, and the use of neem or Spinosad a little farther down the road. The goal is to work at putting in place a biological control program, which you know will take time. We need to fix up the forest managers or private landowners now but work towards a lot of the other things for the future. An example of this would be the development of a virus for this insect. There have been a lot of precedents where CFS has developed a virus for an insect pest of plantations (e.g., *Neodiprion sertifer).* Viruses, however, have a limitation for controlling insect pests, because they will never be economical. However, government might decide this is a good thing. When you are putting together the whole package, we need to look at the funding and where it is going to come from. In the long term we need to be putting into place biological control systems, perhaps using pheromones, viruses and parasites. It is important to write letters to the Director General of CFS to express support for these systems. If we get enough people interested, you can massage a program so everyone will be comfortable with it. Simcoe County will get a solution, certainly not today, maybe not this year, but possibly the next year. Who knows where the bug is going.

A: (Lyons). An infestation is in the city of Edmonton, and they are quite concerned because it is also in lodgepole pine. The city of Edmonton is right in the middle of the transition zone between lodgepole and jack pine forests. The potential impact of this insect could be enormous in this situation.

A: (Kettela). We always tend to say, for example, this is not an east coast problem why should we in the east be concerned. If we look at some of the trends in pine culture on the east coast, such as a greater interest in developing white pine as a pulp and saw-timber resource, we would find that some people would reconsider developing the resource in case this insect showed up. Unlike here, the landowners on the east coast would have no problem doing whatever they had to do to control this insect. We need to narrow down the things we want to do and put them into time sequences. What is the time horizon to put a hazard rating system into place. Biological control must also be part of the program because in the long term it may have the best impact.

M: (Scarr). What I have heard here are about five components of a strategy. We have to decide what you would do with the components, the time line of delivery and who will do it. The strategies include the development of: 1) useable products (e.g., insecticides, pheromone); 2) hazard rating system (give the land manager a means of setting priorities); 3) biological control (long term); 4) basic biology; and, 5) forecast and predictive tools (e.g., how may insects in the soil equals defoliation the next year, more impact information such as what are the time lines for when the impact starts showing up in the tree and is the tree's fate sealed in the 2nd year of defoliation).

A: (Kettela). We need to narrow this work down to a small group of people and appoint someone to head it up.

A: (Lyons). Blair Helson, Ed Kettela and I have had this discussion and have sorted out bits and pieces among ourselves. Blair Helson's input will be product development and testing. Ed Kettela has expressed an interest in leading an aerial spray program. He is also interested in working with Graham Thurston in developing nematodes as a pathogen for pine false webworm. I would head the project and take the lead in writing a proposal with the three of us as authors. We have already made some inroads into developing predictive tools and I would continue to take the lead in that component. This would also lead into the development of a hazard rating system as well. One component where we need some help is biological control. I have assured my management that I would be prepared to see the *Myxexoristops* project through to completion. This project has the most potential for success. If someone, like Sandy Smith or a graduate student, was interested in the project, I would be content to give up the lead and just be a participant. A former student of Sandy's, who is currently working in Delemont with the International Institute of Biological Control (IIBC) under the supervision of Marc Kenis, has expressed an interest in the project. I will discuss this further with Sandy. It is very unlikely that additional funding to support this work will be available through the CFS Pest Management Network. There are several other projects that Rob Bourchier was undertaking related to pine false webworm that may fall by the wayside.

A: (Smith). Historically, viruses have been very successfully used in controlling sawflies in Canada. CFS must be made aware that the use of viruses is a long-term solution that they need to support. I would be willing to make it known to managers at CFS by phone or letter that this is important. It is bigger than just the webworm issue.

A: (Kettela). Since we have discussed this at some length, I think we should charge Barry Lyons with putting together a detailed proposal outlining these components and what we should discuss is some of the details.

M: (Scarr). To whom should this proposal be submitted?

A: (Lyons). A generic proposal was originally submitted by Ed Kettela to the Spray Efficacy Research Group (SERG). If there was money available in Ontario it would probably go from Taylor Scarr (OMNR) to SERG to us. The benefit of going through SERG is that there might be a partner who sees a potential down the road with a reason for concern in their own jurisdiction.

M: (Scarr). SERG is a partnership of research organizations from Manitoba to New Brunswick, including Quebec and Newfoundland. Membership includes Canadian Forest Service, provinces, and Natural Sciences and Engineering Research Council (NSERC), and they jointly fund research programs on controlling forest pests.

A: (Lyons). SERG has no money per se, partners in SERG can contribute money for research programs that they think have merit.

A: (Munt). I think the issue is bigger than just pine false webworm. The issue should be a process to deal with potential forest pests. Funding is a second issue. There are 56 agreement forests that have been let go in the region of York. They are now on their own. Some are and some are not making money. They are going to have to look at this research as an investment in the forest. I feel they should be contributing some money for research. Ed Sutherland (Simcoe county) contributed for some research. There are 56 agreement forests that have red pine. The Region of York is willing to budget some money for the future.

A: (Kettela). It is strictly a dollar issue. Until you see the detailed proposal with some estimates beside each aspect, you really do not know what part you are or are not interested in. We need enough organizations interested and willing to put money into this proposal for it to go. The CFS has contributed scientists' time, laboratory space and a lot of operating funds that amounts to thousands of dollars into these types of projects.

A: (Munt). Partnership is not just pure dollars, it's research space, forest sites.

A: (Kettela). All money translates into arms and legs and things that you have to use. How it comes does not matter, but it has to come from somewhere.

A: (Lyons). Blair Helson, Ed Kettela and I will be writing a proposal that will outline what we hope we can accomplish and what it will cost. Then it is up to others to determine who has money and how much they have. We can give you a wish list.

A: (Helson). I can put together a proposal on what products could be tested and the next step for someone is to decide what they are really interested in being tested or have the most practicality. The big question here still is where does the proposal go?

A: (Kettela). Let us discuss that for a moment. The proposal to SERG submitted by me is still on the table, however, the request needs to be clarified. We must clarify the various components that might be included in the proposal, for example biological control. We need to know such items as how we go about getting a post-doctoral fellow and funding for one. There will be some leg work involved. We have York, Simcoe and Ganaraska all having some interest as aggregates. Where do you want to go with this stuff?

A: (Smith). For the biological control component you could go to NSERC. However, you need matching money these days. So you need industry support and I am unsure whether agreement forests fall into this category. I will look into this further. You could follow up that control if you have some committed dollars.

A: (Dobesberger). There is a new program called matching initiative incentive (MII) from the Canadian Food Inspection Agency (CFIA) involving industry and universities. You need to have industry involved.

A: (Liljalehto). Everyone in the room has indicated they want to work towards a solution. There can be many different partners here, maybe we can talk about where they see their role. I know everyone wants cash, but there are other things to think about. If we can get people's names beside an expression of interest that is all we can expect today and maybe a strategy to bring in more partners.

A: (Kettela). If, for example, we were going to conduct a neem trial, I will be working in Balsam Lake Provincial Park with an airplane from Forest Protection Limited in New Brunswick. The airplane could be made available for this trial at no extra cost. This would be a $5,000 contribution from New Brunswick. The neem product will probably be free as well. Again a $5,000 value for nothing. This is how a project can be built. However, we will be needing some funding from someone to do some things such as hire needed arms and legs. Who will do what? For useable products, what information do we have to get to whom to get pine false webworm on the Sevin label for aerial application. It may be as simple as finding the right group to sponsor this project, such as a county. There is a lot of behind the door work that goes into place that makes things look like someone else initiated the action.

A: (Penwell). Although I can not speak for the Ganaraska Conservation Authority, they might have some excess money in the forestry account that they may be willing to give to this process, because we have the pine false webworm problem.

A: (Sutherland). I can tell you about Simcoe county, which is one of the largest counties with this problem and probably the wealthiest, because we are making money. I have convinced them to contribute to Barry Lyons' work last year and I am 99 3/4% sure they will contribute again this year and probably one more year. Then they are going to ask when are we going to see some results from it. By results they mean dead bugs. York Region, I suspect, will probably be able to contribute something after they have a problem. I suspect he can not until they do. Only three of the 56 agreement forests have the slightest interest in this problem. They do not have a problem and they do not have enough of an area of forest to warrant worrying about it. Simcoe county would provide the land base for any experimentation you want to do, providing you are not using hard chemical. I think I can convince the politicians to allowing this.

A: (Mach). Speaking for Dufferin county, I think what Ed Sutherland said is true. We are neighbours to Simcoe and we do not have the problem yet, so I think it is going to be hard to convince politicians to spend money on a problem they do not have.

A: (Sutherland). All municipalities are very short sighted. Dufferin does not talk to Simcoe at a political level. There is no network for forestry, where we can all get together, if we are interested in a problem and say we are going to support it collectively. We need someone to develop a network.

M: (Scarr). SERG used to be that way. The provinces worked alone before SERG. Now, for example, if a research proposal is submitted for work on the white-marked tussock moth in Nova Scotia because it is a serious problem there, the province of Ontario might contribute to the project. Ontario might rationalize that although we do not have the problem, there are some basic biological questions we need answered if it becomes a problem in the future. Because it is a Nova Scotia problem, they put up the majority of the funding for an aerial trial that results in a registration of a new product. Ontario might contribute a lesser amount for that effort. Quebec might decide to wait for another year and New Brunswick might match Ontario's contribution. Now we have a larger project and we all get the answers.

A: (Sutherland). That network exists for the provinces, unfortunately it does not for the counties. No monetary support comes from one municipality to support another.

A: (Reese). What is the role of the OMNR District office? I can see a role for a district taking a lead and trying to get together a meeting of affected or potentially affected forest land managers. That would give a voice for support that is needed for these interesting and needed projects. It could also bring together some of the municipalities at a political level, if something did come out of this like guidelines, and management options based on what we know now about pine false webworm on public land. Some options we would like to have, that we do not have at present, would be biological controls. Midhurst District for instance could facilitate a meeting like that for affected people. A meeting before the spring and a field visit in the spring and fall to some of the different areas could be arranged. That is how I see the district's input from my perspective.

M: (Scarr). And you are also going to be asked the question by the owner of a 20-acre (8.1-ha) woodlot, what do I do with my trees?

A: (Reese). A product could come out of that, as well as building some contacts and a network of affected and potentially affected parties. We could get the landowners involved as well, to express their interests and experience with this bug. There is no network, so maybe this will trigger network building. There is interest among the Huronia woodland owners and stewardship coordinators to hold some information sessions. They are interested in forest health.

A: (Huff). I am a director of the Huronia Woodland Owners Association and will be taking this information back to them for comment and impressions in the association.

M: (Scarr). If Barry Lyons were to draft up a strategy and proposal, would you be willing to distribute it for comment?

A: (Huff). I would be willing to take it to the association. It will be definitely be mentioned tomorrow night at the a general meeting at Wye Marsh.

A: (Reese). If there are a few groups meeting together and discussing the pine false webworm problem who knows it might show up in the Barrie Examiner. This is very good because it will raise awareness about the unknown.

A: (Huff). Department of National Defence (DND) is an interested party and you can have access to forests at Base Borden. Within DND, there is a pest management advisory committee. I will discuss the pine false webworm problem with the members to see if anything is possible from them. DND has lots of land, mostly dry pine land.

Q: (Kettela). How soon do we want this ready?

A: (Lyons). If we are going to do anything this season, we need to get going. We also wanted to get the proceedings for this meeting published in the very near future. Taylor Scarr and I will work on this together.

A: (Kettela). Tentatively, on 2 April there will be a meeting of the SERG steering committee and this proposal can be on the agenda.

A: (Dobesberger). CFIA has some interest in the issue but funding is unknown.

A: (Lyons). I have started to create an internet web site on the pine false webworm and will send everyone the address when it is ready.

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