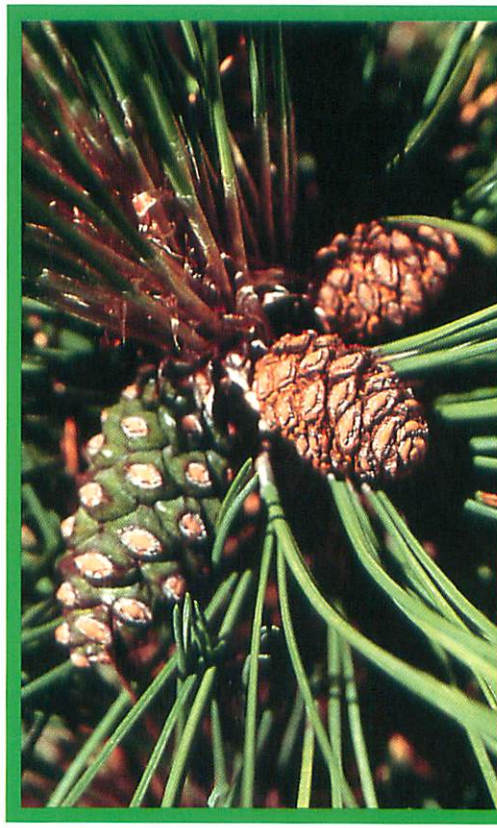

Management of Insect Pests of Cones in Seed Orchards in Eastern Canada

JEAN J. TURGEON & PETER DE GROOT

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PREFACE

Management of insect pests is only one of the many tasks associated with the production of genetically improved seeds. To date, the information provided on insect pest management in seed orchards has usually been limited to the introduction of the major pests and to a list of the pesticides available for population suppression. Insect pest management is much more complex than that and must also be integrated into the resource management scheme of the orchard. Effective and rational pest management requires an accurate identification of the pest, a basic understanding of its biology, methods to monitor its presence and evaluate its abundance, as well as tactics and strategies to prevent or control damage. This guide provides seed orchard managers with fundamental, but essential, pest management information on the most common insect pests encountered in coniferous seed orchards in a simple, concise and comprehensive manner.

This guide is divided into 3 sections. The principle components of seed orchard pest management are presented in the first section. It includes a chapter on the development of a cone crop monitoring system, followed by chapters on general guidelines and methods for monitoring, assessing impact, preventing and controlling cone and seed insects. This section illustrates how pest management can be integrated into a crop management program (cone crop monitoring system) without a duplication of efforts. Also this information should facilitate effective use of the information provided in sections 2 and 3.

The second section is a key to identify damage caused by cone and seed insects of larch, pine and spruce. The keys are accompanied by pictures illustrating, as closely as possible, the damage observed under field conditions. This section should facilitate and expedite pest identification by non-entomologists.

All information currently available on the distribution, general description, life history, damage and management options of the most common cone and seed insects is synthesized in the third section. Tables indicating the feeding periods or the time insects attack their host in relation to host phenology are included. This information should provide a sound basis for pest management decisions.

Sections of this guide will be updated when new knowledge of the biology and management of insect pests of coniferous seed cones is obtained.

COMPONENTS OF INSECT PEST MANAGEMENT IN SEED ORCHARDS

Introduction

Insects can affect the production of seeds directly by feeding on pollen- and seed-cones, or indirectly by damaging foliage, twigs and branches that bear reproductive structures. In this section, we consider only those insects that have a direct impact on pollen- and seed-cones of pines, spruces and eastern larch in eastern Canada. Some of these insects feed exclusively on reproductive structures and cannot develop without them; we will refer to these insects as obligatory. Other insects, which are not dependent on these structures for their survival, but will feed upon them opportunistically (e.g. budworms, needleminers, etc.), will be referred to as facultative. Most obligatory and facultative insects affecting seed production in eastern Canada have been identified by the Forest Insect and Disease Survey of Forestry Canada. Among them, only a few are known to significantly reduce seed production; the remainder have either low or unknown economic importance (Table 1). The objective of insect pest management in seed orchards is to optimize seed production by maintaining insect populations at tolerable levels. Sound insect pest management uses a variety of preventative and suppressive tactics and strategies that are ecologically and economically efficient, and socially acceptable.

To meet this objective, it is essential:

- to monitor your crop regularly to assess its condition and survival over time;
- to determine whether the damage or mortality observed was caused by abiotic factors (e.g. late frost) or by insects, and if it is an insect, to identify it; *and*
- to decide whether protective action is justified, and can be carried out to optimize seed production (Figure 1).

In this section, we will:

- present the basic elements of a cone crop monitoring system;
- discuss the importance of detection and monitoring of insects pests in seed orchards;
- provide some general guidelines on the methods available to assess the potential impact of cone and seed insects;
- identify some seed orchard or cone crop management practices that can influence the occurrence of insect problems;
- list tactics that are available for the prevention and control of cone and seed insect damage;
- present some of the advantages and disadvantages of the equipment available for suppressing insect populations in seed orchards; *and*
- outline the assessment of pest management tactics.

Cone Crop Monitoring

Cone Crop Monitoring Systems (CCMS) are an essential part of any pest management program in seed orchards. Each orchard manager should tailor the CCMS to the management objectives and requirements of the orchard.

The benefits of a CCMS are:

- ability to predict crop size at various intervals of crop development;
- identification of good and poor crop trees in the orchard;
- quantification of cone and seed losses as well as the identification of the damaging insect(s);
- estimation of the efficacy of control measures; and
- increased ability to estimate workloads and requirements.

The basic elements of a CCMS are as follows:

- determine the number of cone-producing trees in the orchard;
- select between 2-5% of the cone-crop-producing trees in the orchard; the proportion usually depends on the management objectives of the seed orchard; proper selection includes such considerations as the level of cone production of the seed orchard, the number and type of pest problems, the accuracy of predictions required, and the available funds and personnel; the number of clones or families represented in the CCMS program also depends on the same variables; the cone crop monitoring sheet currently being used in some seed orchards in Ontario is reproduced in Figure 2;
- count all the receptive seed cones on the sample trees including those dead or damaged, and use this count to estimate the potential number of cones, seeds, and seedlings that could be produced (background data or estimates on the seed potential, extraction, and germination efficiencies are needed), using the formulae given in Table 2;
- select and tag branches and cones; the number of branches tagged per tree will depend on the same variables as those listed for the number of trees per orchard; the recommended minimum number of cones to be tagged per pine and spruce tree are 30 and 25, respectively;
- visit the tagged cones periodically, at least 2-3 times/year, and record the number of healthy and damaged cones; schedule the first visit when insects begin cone attack, the second, when cones are about half their mature length, and the third when cones have reached their full length; the frequency and timing of the visits is usually based on the biology of the major pests encountered in the orchard (see Insect Detection and Monitoring);

- after each visit, use the information to update your predictions on cone (and seed) crop size, and take corrective measures (e.g. insect control, refer to the fact sheet for potential options) to ensure that seed targets will be met;
- collect cones when mature (preferably in late August, or early September); *and*
- extract and germinate seeds, to calculate both the actual seed potential and efficiencies in seed extraction and germination, and compare these with the predictions made at the beginning of the season.

Insect Detection

The results from the CCMS may reveal a potentially severe insect problem. To be of practical value, this detection must occur at the time insects initiate their attack, or before (Figures 3, 4, 5).

Most obligatory insects initiate cone attack by laying eggs when the seed-cones are open to receive pollen, with only a few species (e.g. seed chalcids) laying eggs in seeds when the cones are about half their mature length (Figures 3, 4, 5). Eggs usually are laid between the cone scales, or the bud scales. The detection of most obligatory insects is difficult because their eggs are very small and their larvae develop inside cones or seeds (which offer protection) leaving little or no evidence of their presence. Consequently, obligatory insects are usually detected after their damage has either started or has been completed. Unless obligatory insects are detected at the time they initiate cone attack, or before, there is little the seed orchard manager can do to protect the seed crop.

Facultative insects do not lay their eggs on or near the cones. Their attack is usually initiated by the larvae when the seed-cones begin to burst open. Only a few facultative species initiate their attack after the cones are about half their mature length (e.g. fir coneworm). The damage caused by facultative insects is usually easy to detect visually, but because of the general nature of the damage inflicted, it can be extremely difficult to associate with a given species. The detection of damage in the early stages of attack (see Table 3 for feeding periods), should provide the manager with enough time to assess potential damage and, if warranted, to undertake the control actions.

To identify the insects causing the damage to the cone crop:

- collect a sample which includes the affected cone(s) and, if possible, the insect(s);
- use the key (see Keys to Insect Damage) to external damage, which provides diagnostic characteristics and photographs of damage, to identify the insect causing the damage;

- if you cannot complete the identification, or if you would like to receive confirmation of your preliminary identification, complete a FIDS Identification Service Submission Form (Figure 6), following the specific instructions provided on the back of the form; *and*
- send both the sample (in a mailing tube available from your FIDS Ranger) and the completed form to the address given on the form;
- insects found on the foliage or the trunk, which may also affect seed production, tree vigour or survival, should also be sent for identification using the same procedures; they should be accompanied by a separate identification submission form and mailed in a separate tube.

Once an insect has been identified and considered as a potential problem, it is recommended that a specific monitoring program for this insect be established to determine if their populations are increasing. Traps baited with insect sex pheromones and traps which mimic stimuli originating from cones (e.g. colours) can be used to detect and monitor obligatory and facultative insects before they initiate cone attack. Insects for which such tools are available have been indicated in the fact sheets. Dissection of cones, scale by scale or irradiation (x-ray) of seeds is currently used to detect these insects after cones have been attacked.

Prediction of Insect Impact on Seed Losses

Seed losses to insects vary greatly from year to year. Historically, damage in one year is influenced by the size of the cone crop in the previous year. Crops produced the year following a heavy cone crop are heavily attacked, whereas those preceded by a light crop will normally be lightly damaged. Also, losses in orchards are influenced by crop size in nearby stands. In years of heavy production outside the orchard, losses in the orchards are usually light (see Crop Management Practices).

To determine the need for suppressive action, the potential impact of the insect pest on the annual seed yield must be assessed. This requires the quantification of the orchard's annual seed production (from the CCMS data). The expected level of insect damage is not the only factor that must be considered when deciding whether insect control is justified. Other variables include the seed value (the most important variable), crop size, and the environmental and monetary cost and efficacy of control activities. With this information, realistic damage thresholds and injury levels can be established and control decisions facilitated. Practical methods to predict seed losses from insects infesting the cones and seeds of conifers in eastern Canada are currently being developed. These methods require that the relationships between egg counts and seed losses as well as trap catches of adults, with either pheromone or colour traps, and seed losses be established.

Pest Management Tactics

The amount of time required by the manager to decide if insect pest management is warranted will be influenced by the knowledge of:

- the biology, behaviour, and population dynamics of both the tree and the insect species: this information is needed to identify the windows of opportunity and other possible management tactics and strategies, to develop the sampling schemes required to assess the density of the pest, and to determine the efficacy of the control measures contemplated;
- the type and amount of damage caused by the insect, the value of the crop, and the expected abundance of the crop: this information is needed to predict the impact of the insect at the observed population density; *and*
- the type of control options available, their environmental and economic costs, and their efficacy: this information is needed to determine which tactic will provide adequate protection (to optimize seed production), and whether new control tactics need to be developed.

As a general approach to insect pest management, it is recommended that emphasis be placed on silvicultural and crop management practices that prevent the build-up of insect populations. These practices should be supplemented by insecticidal treatments only when justified. If it has been determined that insecticide use is necessary, the seed orchard manager should then contact the Forest Entomologist, OMNR, to receive up-to-date information, BEFORE proceeding further.

This section outlines some crop management practices, biological and chemical control methods, and insecticide application equipment relevant to insect pest management in seed orchards.

Crop Management Practices

Seed losses to insects vary greatly among sites. Historical seed losses to insects at potential seed orchard sites should be one factor considered in the site selection process. Planting the right species, on the right site, is essential to maintaining any natural resistance tree genotypes may have.

Listed below are some cone crop management practices that can promote, or hinder, the development of insect pest problems in a seed orchard.

- Spacing trees promotes good cone production, but it also increases infestations by cone and seed insects.
- Tree topping may be carried out to facilitate supplemental pollination, and cone collection. It facilitates insecticide application and increases application equipment options. Tree topping also provides some insects with a better microhabitat. The potential impact of topping trees on insect population densities has never been assessed rigorously, but field observations suggest that the fir coneworm is more abundant in plantations where trees have been topped.
- The fertilization of seed-producing trees to increase cone production has resulted in serious insect problems in some seed orchards.
- The stimulation of cone crops in seed orchards during years of low cone production in natural stands may create insect problems; insects may migrate to the seed orchards from nearby cone-poor natural stands.
- The misting of trees with cold water has been successful in delaying the bud burst of seed cones in the orchard sufficiently to reduce pollen contamination from nearby stands. This treatment can also be used to increase the amount of possible cross-pollination between clones which normally would not cross-pollinate because of their significant differences in phenological development. Occasionally, it has also reduced the impact of some major insect pests. This treatment has not been tested on spruces or pines.
- The destruction (or abortion) of unwanted cone crops, in particular those too small to manage as a productive crop or those on root stocks in clonal orchards, can hinder the build-up of insect pests.
- The removal and destruction of all mature cones either from the tree or ground, can prevent a build-up of insect populations on the site, especially those which overwinter in cones.

It is obvious from the above information that sound crop management practices could influence the amount of insect damage in seed orchards.

Biological Control

Among the biological control agents available, only *Beauvaria bassiana* (Bals.) Vuill, a fungus, and *Trichogramma minutum* Riley, an egg parasitoid, have been tested for the control of insects attacking the cones and seeds of conifers. Although *Bacillus thuringiensis* Berliner *(B.t.)*, a bacterial insecticide, is used to protect foliage in operational programs for control of the budworms, its efficacy in protecting the cones and seeds from budworm and coneworm damage, or any other insect infesting cones and seeds of conifers, has not been established in Canada.

- *Beauvaria bassiana* is pathogenic to several insects infesting cones and seeds. It has been added to soil and dusted on cones near the peak of oviposition of the spruce cone maggot and the spruce seed moth. It is much less effective than insecticides. Additional experimental work is required before *B. bassiana* can be used operationally to control cone and seed insects.
- Inundative releases of the egg parasitoid *T. minutum* have been made against the Douglas-fir cone moth, *Barbara colfaxiana.* Low levels of parasitism were obtained. Additional experimentation is needed to determine whether inundative releases of egg parasitoids could represent a control alternative for other species of insects (e.g. fir coneworm) infesting coniferous cones and seeds.
- Although little information is available on the natural enemies (parasitoids, predators and pathogens) of insects infesting cones and seeds in Canada, some insect populations are supposedly maintained at low densities by their natural enemies.

Chemical Control

Cultural and biological control methods may have to be supplemented with chemical insecticides to meet seed production targets. Chemical insecticides are among the most effective methods to quickly destroy insect pests; however, **their regular and unjustified use may result in other serious pest problems** such as mites and aphids. Furthermore, heavy or excessive insecticide application rates, improper timing, or an unnecessarily broad-spectrum insecticide may cause serious damage to beneficial parasites and predators. Care must be taken in the selection and application of insecticides to maximize their benefits and avoid their potential hazards to human health and the environment.

Recommendations of specific insecticides, application rates, and methods of application are not presented here because of ongoing improvements in formulations and equipment, and because of changes in insecticide registration and use policy. The information on the control of insect pests with chemical insecticides presented on the fact sheets only provides a general statement about the success of past control attempts. Until recently, most insects attacking cones and seeds were considered minor pests; consequently, few methods have been developed for their control. It is therefore essential that the seed orchard manager contact the Forest Entomologist, to receive the latest information on chemical insectides and their application.

For seed protection, two major types of chemical insecticides have been used, as follows:

Systemic: These insecticides can be applied as foliar sprays, injected or implanted in the stem of the tree, or incorporated into the soil (and are also used to prevent damage). Foliar application of systemic insecticides is maximized by spraying cones and the surrounding foliage just before run-off occurs. For some insects, the timing of foliar applications of systemic insecticides is critical and must be done when the cone is at a particular stage of development. Systemic insecticides are absorbed into tree tissue and translocated to the cones; therefore, they can be used to kill insects which are inside the cone.

Contact: These insecticides are applied as sprays and are used primarily to prevent damage. They must be applied when, or just before, the insects are active. Generally, systemic insecticides have an advantage over contact insecticides due to the short exposure time of contact insecticides.

The most practical insecticide application method and equipment will depend on:

- the conditions in the orchard (e.g. tree size, spacing, and terrain);
- the target insect; *and*
- the insecticide to be used.

Insecticide Application Equipment

Choosing the correct spray application equipment is essential to the effective, safe, and economical use of insecticides. For some types of equipment, tree height, crown size and shape, density of foliage, and spacing may impose limitations.

In seed orchards, the choice of equipment will depend on:

- the size of the orchard;
- the size of the trees;
- the environmental sensitivity of the area surrounding the orchard; *and*
- the formulation of the chosen insecticide.

The rate of operation of the equipment is affected by:

- the size and architecture of the tree crown to be treated;
- the topography;
- the ground cover; *and*
- the soil conditions.

There are several types of ground application equipment available, ranging from small tree injectors to large self-propelled airblast sprayers. Some of their features and uses are described here.

The **implantation** or **injection** of systemic insecticides is practised in seed orchards and on high-value, isolated trees such as 'plus trees' or 'seed trees'.

Implantation: This method involves the use of plastic perforated shells that encase a gelatin capsule containing the insecticide. The cartridges are placed in evenly spaced holes drilled into the trunk of the tree, usually 15-45 cm above the ground, preferably in the root-flare area. The number of cartridges per tree is based on the trunk circumference. The tree's sap dissolves the gelatin capsule and distributes the insecticide.

Injection: Tree injectors have a plastic reservoir that holds the insecticide and a tube that feeds the insecticide into a hole drilled into the trunk of the tree. The number of units per tree is based on the tree circumference. A modified form of injection, currently in use, is to apply the insecticide with a syringe into holes drilled into the trunk of the tree. Tree injection usually results in faster translocation of the insecticide to the desired site (e.g. foliage at mid-crown or cones and seeds) than implantation.

Both implantation and injection have several advantages and disadvantages.

Advantages

- greater protection for the user against insecticide spills and contamination because they are closed application systems (nevertheless, pesticide safety equipment is essential because leaks can expose the applicator to the concentrated insecticide, and injectors must be removed and disposed of in an environmentally acceptable manner);
- minimal risk to non-target organisms;
- can be used in any weather;
- no need to invest in heavy equipment;
- the insecticide treatment tends to last longer in the tree than if applied as a foliar spray.

Disadvantages

- phytotoxicity and tree wounding may be potentially serious, particularly for small trees and certain tree species;
- both methods are expensive, limiting their use to high-value trees in the seed orchard, where other methods of insecticide application are uneconomical or impractical.

Backpack sprayers are operator-carried machines designed to apply small quantities of spray. They are mainly used for spot treatments of individual trees and for broadcast treatments in small stands. There are basically two types of sprayers available: pressurized containers that are carried by hand or with a shoulder strap, and knapsack sprayers that are carried on the back.

Advantages

- precision targeting of an insecticide, particularly where there are environmental concerns;
- initial low purchase price, low operating costs, light weight;
- simple to operate and easy to clean, maintain, repair, and store;
- ideal for small-scale operations.

Disadvantages

- require frequent refilling because the tank is small;
- high risk of contact necessitates that protective equipment be worn;
- may be uneconomical for use in large areas or where high volumes are applied to individual trees;
- reduced efficacy on trees taller than 3-4 m.

Backpack mistblowers use forced-air to produce and move spray droplets. They may be used for the control of insects in young and small seed orchards (usually less than 10 ha). Individual trees 8 m in height and seed orchards with trees 3-4 m in height can be treated with most mistblowers.

Advantages

- simple to operate, maintain, and calibrate;
- versatile machines that can be used to treat individual trees or stands quickly and efficiently.

Disadvantages

- the small tank capacity (usually 10-15 L) limits their use to treating small areas;
- more expensive to purchase and operate than backpack sprayers;
- high risk of contact necessitates that protective equipment be worn;
- the size of an area where mistblowers become inefficient in terms of cost and efficacy will depend on the size and spacing of the trees, how much of the tree is being treated, the volume of spray being applied, and the work rate of the operator; in larger seed orchards, or for large trees,where there is good access to the trees and fairly level topography, airblast or hydraulic sprayers may have cost advantages over backpack mistblowers.

Airblast sprayers use the energy of an airstream to transport and distribute spray droplets. Nozzles dispense the spray into a high velocity air current generated by a fan. The fans are powered by an engine, or they can be driven by the power takeoff from a tractor. Airblast sprayers may be mounted on a trailer or directly on a tractor.

Advantages

- the small droplets produced provide good penetration and coverage of the tree;
- the model of the sprayer can be selected according to the size of the trees to be sprayed;

Disadvantages

- large, expensive, and require good access and maneuverability within the area to be treated;
- produce a high number of small droplets that are prone to drift and for this reason should not be used in

- the sprayer can be adjusted to the volume of the spray required; the volume is dependent on the size of the tree, the foliage density, and the coverage required for the insect pest;
- trees receive good coverage with rather low volumes.

environmentally sensitive areas, or when weather conditions are inappropriate;
- requires full protective clothing.

In **powered hydraulic sprayers,** the liquid is put under pressure by a pump, then transferred to the nozzles, which break up the stream of liquid into droplets. The size of the droplets depends on the pressure applied to the liquid and/or the type of nozzle selected. Hydraulic sprayers are designed to deliver large volumes of dilute spray under high or low pressure. There are two configurations used: those equipped with a boom, and those equipped with hand-held, trigger-type spray guns. Gun-type sprayers are used to treat trees in shelterbelts, seed orchards, and roadside plantations, or to treat individual high-value trees. As with the airblast machines, hydraulic sprayers can either be trailer- or tractor-mounted. The spray is often applied to the point of run-off to ensure thorough coverage. These sprayers are excellent for penetrating dense foliage. Where conditions permit, the trend has been away from hydraulic gun-type sprayers to airblast sprayers, because airblast sprayers give an equivalent coverage in less time, with a greatly reduced liquid volume.

Improvements in the equipment and changing pesticide application regulations, make specific published recommendations quickly obsolete. The seed orchard manager is therefore advised to contact the Forest Entomologist for the latest information on equipment technology, and recommendations for their use.

Assessment of Pest Management

The effectiveness of insect management tactics and strategies to protect the seed crop must be assessed. This assessment is usually done by comparing insect densities before and after treatment, but a reduction in insect densities does not always translate into a significant reduction in seed loss. Consequently, seed quantity and quality, either on a cone or a tree basis (preferably both), must also be evaluated and compared to the values forecasted at the beginning of the season (given background data are already available). Most of this information can be obtained from the CCMS; however, additional cone samples and methods (e.g. x-ray of seeds, phytotoxicity) may be required.

KEYS TO INSECT DAMAGE
Introduction

The keys on insect damage provide diagnostic characteristics and photographs to aid in the identification of insects attacking the cones and seeds of pine, spruce, and eastern larch, in eastern Canada. For each tree genus, a description of damage caused by insects is accompanied by a photograph. To facilitate identification, the damage caused by insects leaving external evidence of damage has been separated from that of insects leaving no external evidence. For insects leaving external evidence of damage, the external damage is described first, and is followed by a description of internal damage which can be observed by bisecting the cone. Insects leaving no external evidence of damage have been divided into two groups based on the presence or absence of visible damage to the seeds, once the cone is bisected. Upon matching your damage to a photograph or a description, read the name of the insect, and the page number (in brackets) where you will find its fact sheet.

Key to Insect Damage on Pine Cones

INSECTS LEAVING EXTERNAL EVIDENCE OF DAMAGE

J. Turgeon

- distinctive yellow pitch tube, either on, or near, the cone petiole; pitch tube turns grey; cone becomes hard and dry with a shrivelled appearance.
  white pine cone beetle (27)
  (*Conophthorus coniperda*)

P. de Groot

- transverse groove in cone base; resin accumulation mixed with fecal and boring debris at entrance hole; cone turns brown and hardens; interior of cone contains fine brown powder.
  red pine cone beetle (29)
  (*Conophthorus resinosae*)

E. Rayner

- one to all cone scales shrivelled and brown; dry resin flakes may be present on cone exterior; fluid resin between attacked cone scales; no tunnelling or debris present; cones may be smaller than normal.
  cone resin midge (37)
  (*Asynapta hopkinsi*)

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- one or more ragged holes; conspicuous, coarse frass and webbing around the entrance hole; extensive tunnelling inside the cone, usually free of debris.
  fir coneworm (57)
  (*Dioryctria abietivorella*)

Key to Insect Damage on Pine Cones

INSECTS LEAVING EXTERNAL EVIDENCE OF DAMAGE

B. Aelick

- single conspicuous hole near cone base with tightly webbed semi-coarse reddish-brown frass over the entrance hole; large excavation deep within seed-bearing region of cone containing dried resin, frass, and webbing.
webbing coneworm (59)
(*Dioryctria disclusa*)

T. Arcand

- cone peppered with many small holes and covered with patches of extruding frass; cone interior is packed with a mixture of frass and resin; extensive tunnelling in cone.
white pine cone borer (65)
(*Eucosma tocullionana*).

E. Rayner

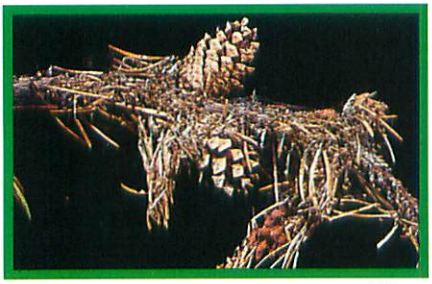
- numerous very small, round holes, or a few oblong holes in upper half on side of cone; exterior of cone almost always free of frass; no webbing found inside cone; cone interior packed with mixture of frass and resin; extensive tunnelling in cone.
red pine cone borer (63)
(*Eucosma monitorana*)

Key to Insect Damage on Pine Cones

INSECTS LEAVING EXTERNAL EVIDENCE OF DAMAGE

P. de Groot

- one or more brown shrunken cone scales; resin can occur between scales; no tunnelling or debris is present; damaged seeds are brown.
cone midges (45)
(*Resseliella* spp.)



E. Rayner

- one or more holes may be present on cone surface; feeding on cone surface and surrounding needles with frass and webbing adhering to remaining needles; cone may be distorted due to destroyed conductive tissue.
jack pine budworm (73)
(*Choristoneura pinus pinus*)

Key to Insect Damage on Pine Cones

INSECTS LEAVING **NO** EXTERNAL EVIDENCE OF DAMAGE

P. de Groot

Damage to seeds is visible

- tunnelling in cone axis; seed coat partially destroyed; remainder of seed coat glued to the scale, and filled with a mixture of frass and resin.

eastern pine seed moth (69) (*Cydia toreuta*)

G. DeBarr

Damage to seeds is not visible

- seed ovules, damaged before seed coat hardening, are small or flattened; seeds damaged after seed coat hardening can only be detected by x-rays, to be totally or partially empty.

shield-backed pine seed bug (49) (*Tetyra bipunctata*)

Key to Insect Damage on Spruce Cones

INSECTS LEAVING EXTERNAL EVIDENCE OF DAMAGE

T. Arcand

- ragged holes on cone surface; small amounts of frass and resinous material around entrance holes.

spruce cone loopers (55)
(*Eupithecia albicapitata*)
(*Eupithecia mutata*)

E. Rayner

- small entrance hole in the lower half of the cone surface; granular, fine, reddish-brown frass trapped in webbing on outside of cone below the hole.

spruce micro moth[1]
(*Endopiza piceana*)

B. Aelick

- from late June or early July, a small exit hole can be found on cone surface; infested cones usually smaller than healthy cones; spiral tunnel around cone axis filled with resin and frass; seeds and scales partially or totally consumed with small amounts of brown boring and fecal debris.

spruce cone maggot (31)
(Strobilomyia neanthracina)

[1] There is insufficient information to prepare fact sheet.

Key to Insect Damage on Spruce Cones

INSECTS LEAVING EXTERNAL EVIDENCE OF DAMAGE

J. Turgeon

- conspicuous reddish-brown, coarse frass and webbing holding several cones together; one or more ragged holes; extensive tunnelling inside cone, usually free of debris.
  fir coneworm (57)
  (*Dioryctria abietivorella*)

E. Rayner

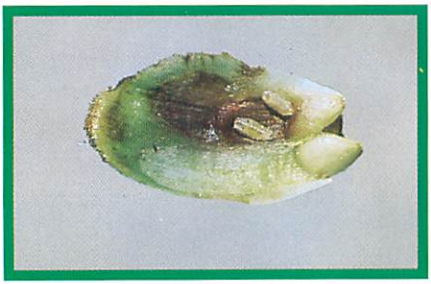
- cone exterior partially consumed; webbing and coarse frass adhering to surface of cone and surrounding needles.
  eastern spruce budworm (71)
  (*Choristoneura fumiferana*)

T. Arcand

- infested cones and surrounding shoots enveloped in coarse frass and webbing; severely infested cones hollowed out.
  spruce coneworm (61)
  (*Dioryctria reniculelloides*)

Key to Insect Damage on Spruce Cones

INSECTS LEAVING NO EXTERNAL EVIDENCE OF DAMAGE



D. Ruth

Damage to seeds is visible

- resin can occur between scales; no tunnelling or debris is present; damaged seeds are brown.

cone midges (45)
(*Resseliella* spp.)

E. Rayner

- silk in tunnels between seed pairs; small holes with fine frass on either side of cone slice; seeds partially to completely consumed and fused to scale.

spruce seed moth (67)
(*Cydia strobilella*)

Y. Prévost

- spiral tunnel around cone axis filled with resin and frass; seeds can be partially or totally consumed; small amounts of brown boring and fecal debris.

spruce cone maggot (31)
(*Strobilomyia neanthracina*)

D. Ruth

- infested seeds are larger than normal seeds.

spruce seed midge (43)
(*Mayetiola carpophaga*)

Key to Insect Damage on Spruce Cones

INSECTS LEAVING **NO** EXTERNAL EVIDENCE OF DAMAGE

G. Miller/Oregon State University

- attacked seeds are flat and dark brown; can contain resin.

seed maggots (47)
(Earomyia spp.)

N. Nelson

Damage to seeds is not visible

- seeds can be slightly enlarged but show no other form of damage; endosperm consumed entirely by the insect.

spruce seed chalcid (51)
(*Megastigmus atedius*)

D. Ruth

- small swelling or gall on the inner surface of cone scales or near the seed, which may prevent seed extraction.

spruce cone gall midge (39)
(*Kaltenbachiola canadensis*)

T. Arcand

- small chamber in cone axis; seeds show no apparent damage.

spruce cone axis midge (41)
(*Kaltenbachiola rachiphaga*)

Key to Insect Damage on Tamarack Cones

INSECTS LEAVING EXTERNAL EVIDENCE OF DAMAGE

Y. Prévost

- cone enveloped in coarse frass and webbing in early June.
spruce coneworm (61)
(*Dioryctria reniculelloides*)
(shown here on black spruce).

Forestry Canada

- cone partially consumed; webbing and frass adhering to surface.
eastern spruce budworm (71)
(*Choristoneura fumiferana*))

N. Nelson

- conspicuous, coarse frass and webbing around tip of cone in late June; extensive tunnelling inside cone.
fir coneworm (57)
(*Dioryctria abietivorella*)

Key to Insect Damage on Tamarack Cones

INSECTS LEAVING **NO** EXTERNAL EVIDENCE OF DAMAGE

N. Nelson

Damage to seeds is visible

- spiral tunnelling around cone axis; all seeds totally consumed; large amounts of filamentous and granular frass.

larch cone maggot (33)
(*Strobilomyia laricis*)

N. Nelson

- spiral tunnelling around cone axis; seeds partially to totally consumed; small amount of filamentous frass.

tamarack cone maggot (35)
(*Strobilomyia viaria*)

N. Nelson

- resin can occur between scales; no tunnelling or debris is present; damaged seeds are brown.

cone midges (45)
(*Resseliella* spp.)

Oregon State University

- small amount of frass present; attacked seeds become flat, resinous, and dark brown.

seed maggots (47)
(*Earomyia* spp.)

Key to Insect Damage on Tamarack Cones

INSECTS LEAVING NO EXTERNAL EVIDENCE OF DAMAGE

E. Rayner

- tunnel around the axis; small granular frass present.
spruce micro moth[1]
(*Endopiza piceana*)

Forestry Canada/FIDS

Damage to seeds is not visible

- seeds appear normal; endosperm consumed entirely by the insect.
larch seed chalcid (53)
(*Megastigmus laricis*)

[1] There is insufficient information to prepare fact sheet.

FACT SHEETS ON INSECT PESTS
Introduction

A fact sheet has been prepared for most obligatory and some of the major facultative insects found in eastern Canada. The information available on other facultative insects that frequently attack cones of conifers (e.g. *Endopiza piceana, Holcocerina immaculella, Barbara mappana, Hapleginella conicola,* etc.,) is currently insufficient to prepare a fact sheet. Each fact sheet provides a brief synthesis of the known distribution and importance of the insect, its general description, its life history and habits, the type of damage it causes, and the management options available. The fact sheets have been arranged by Insect Order (e.g. Coleoptera, Diptera, etc.). The scientific, french common, and english common names for the insects are provided in Appendix A.

The life cycle of each insect has been presented graphically. The presence of a given life stage is indicated by the presence of a dot. For practical reasons, each month contains only four dots, each representing an equal portion of the month. The periods indicated are not specific to any particular region of eastern Canada. For specific information on the period insect attack is initiated or on the feeding periods refer to Figures 3, 4 and 5, or Table 3, respectively.

COLEOPTERA

E. Rayner

J. Turgeon

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					...	....	.					
Larva					.	....	....	...				
Pupa						..	....	....	..			
Adult	....	....	....	....	....	...	..	....	....	....	....	....

White pine cone beetle - *Conophthorus coniperda* (Schwarz)

References: 6, 17, 18, 22, 26, 29, 31, 39, 40, 41, 68, 71, 89

HOST: eastern white pine

IMPORTANCE & DISTRIBUTION: up to 100% of a cone crop can be destroyed; seed mortality is 100% within each cone; one female can kill as many as 4 cones; found throughout the range of eastern white pine

INSECT DESCRIPTION:

Egg: pearl white; 0.7-0.8 by 0.5 mm; ovoid; laid in galleries cut along centre of cone

Larva: creamy white with light brown head; 1.0-3.0 mm long; curved; legless; two instars; develops in dead cone

Pupa: white when first formed; after 4 or 5 days, the mouth parts, eye areas, and the end of the elytra darken; develops in dead cone on the ground

Adult: shiny black; 2.4-3.0 mm long; stout; cylindrical-shaped; covered with erect hairs; beetle usually overwinters in dead cone on ground

COLEOPTERA

DAMAGE: entrance hole at cone and petiole junction surrounded by a distinctive yellow-brown pitch tube, which later turns greyish; conductive tissue severed near entrance hole causes seed development to cease; all seeds destroyed; cone becomes brown, shrivelled, and hard

DETECTION & MONITORING: dissect cone to find all life stages; look for dead cones on ground after mid-July; barrier trap baited with sex pheromone is available

CONTROL: References: 6, 18, 26, 66, 68, 89

Silvicultural: raking and burning beetle-infested cones in the fall, or in the spring before beetle emergence, effectively reduces populations

Biological: none available

Chemical: soil application or stem implants of systemic insecticides have reduced populations; contact insecticides on small trees can be effective if foliage does not obstruct deposition of insecticide on the petiole and base of the cone

NOTES:

COLEOPTERA

B. Aelick

B. Aelick

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	....	.					
Larva					.	....	....					
Pupa						.	....	..				
Adult	....	....	....	....	....	...	..	....	....	....	....	....

Red pine cone beetle - *Conophthorus resinosae* Hopkins

References: 6, 13, 34, 39, 50, 53, 57, 63, 66, 67, 75

HOSTS: red and jack pine

IMPORTANCE & DISTRIBUTION: between 60-100% of cones can be destroyed; 100% of seeds per cone are destroyed; one female can destroy up to 15 cones; found throughout the range of red pine

INSECT DESCRIPTION:

Egg: pearl white; 0.9-1.0 by 0.5-0.8 mm; ovoid; laid in niches cut in gallery in centre of cone

Larva: creamy white with light brown head; 1.0-4.0 mm long; curved; soft-bodied and legless; two instars; develops in dead cone

Pupa: white when newly formed, darkening first on mandibles, eyes, and ends of elytra; 2.8-3.3 mm long; develops in dead cone on the tree

Adult: shiny black; 3.0-3.5 mm long; cylindrical-shaped beetle with sparse pubescence; overwinters in red pine shoot on forest floor

COLEOPTERA

DAMAGE: cone dry and shrivelled; traverse groove at base of cone; resin accumulation mixed with fecal and boring debris near entrance hole; cone contains fine, granular frass; young adult leaves the cone and bores into a branchlet, usually within 2 cm of bud tip; beetle-infested bud breaks off and drops to the ground, beginning in August

DETECTION & MONITORING: dissect cone to find all life stages; look for adults in buds on the ground after mid-September and before early May; barrier trap baited with sex pheromone is available

CONTROL: References: 66, 67

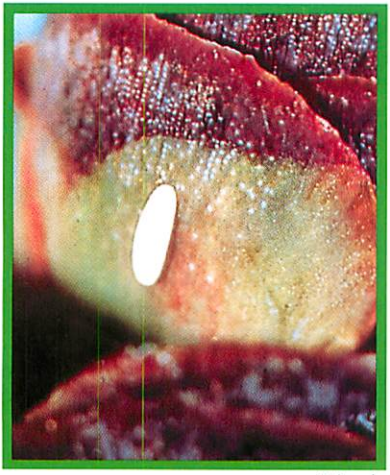
Silvicultural: raking and burning beetle-infested buds in the fall, or in the spring before beetle emergence, effectively reduces populations

Biological: none available

Chemical: none available

NOTES:

DIPTERA



T. Arcand

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	..						
Larva					.	....	..					
Pupa	....	....	....	....	..	..	....	....	....	....	....	....
Adult					....	.						

Spruce cone maggot - *Strobilomyia neanthracina* Michelsen
(*Lasiomma (= Hylemyia= Delia= Pegohylemyia) anthracina* (Czerny))

References: 6, 12, 23, 25, 35, 39, 43, 65, 66, 72, 74, 84, 92

HOSTS: black and white spruce (possibly all species of spruce native to North America)

IMPORTANCE & DISTRIBUTION: between 40-100% of the cones can be attacked; one larva can destroy 50-75% and 55-65% of the filled seeds per black and white spruce cone, respectively; two or more larvae usually destroy 100% of the seeds per cone; found throughout the range of spruce

INSECT DESCRIPTION:

Egg: pearl white; 1.6 by 0.5 mm; nearly ovoid with one end flat; laid singly between cone scales; during pollination; hatches within 5-10 days of being laid

Larva: creamy white; 5.0-7.0 by 1.5 mm when mature; cylindrical without definite head capsule; three instars, the first moult occurs within the egg; develops in cone, tunnels out and drops to the ground after 3-4 weeks of feeding

Puparium: reddish-brown; 4.0-6.0 by 1.2-1.4 mm; nearly ovoid; overwinters in soil under the tree; capable of extended diapause

Adult: black; 3.9-4.6 mm long; resembles a housefly

DIPTERA

DAMAGE: infested cone usually smaller than healthy one; small hole found on cone surface in late June or early July after larva leaves cone; larva tunnels around cone axis and fills it with frass and resin; larva consumes scales and seeds

DETECTION & MONITORING: dissect cone shortly after it closes to find egg, and thereafter until late July to find larva; no trap available; colour trap is being developed for adults

CONTROL: References: 12, 23, 24, 25, 26, 27, 74, 83

Silvicultural: none available

Biological: none available; additional work is required with *B. bassiana* (Bals.) Vuill

Chemical: foliar spray, tree implant, and stem injection of systemic insecticides have been effective in reducing populations

NOTES:

DIPTERA

J. Turgeon

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					...	...						
Larva					..	....	..					
Pupa	....	....	....	....	..	..	....	....	....	....	....	....
Adult				.	....	..						

Larch cone maggot - *Strobilomyia laricis* Michelsen (*Lasiomma laricicola* (Karl))

References: 1, 39, 43, 65, 72, 82, 88

HOST: tamarack

IMPORTANCE & DISTRIBUTION: attacks are localized, with up to 100% of the cones attacked even when cones are abundant; one larva can destroy 100% of the filled seeds per cone; found throughout the range of tamarack

INSECT DESCRIPTION:

Egg: creamy white; 1.0 by 0.4 mm; nearly ovoid with one end flat; laid singly between the seed cone bud scales

Larva: creamy white; 4.0-6.0 by 1.5 mm; cylindrical without definite head capsule; three instars; develops in cone

Puparium: reddish-brown; 3.0-5.0 by 1.2 mm; nearly ovoid; overwinters in soil under tree; capable of extended diapause

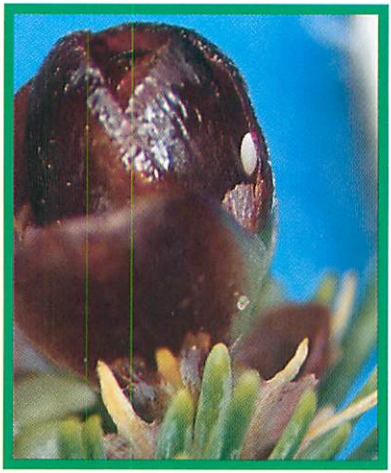
Adult: black; wing length 3.7-4.3 mm; resembles a housefly

DIPTERA

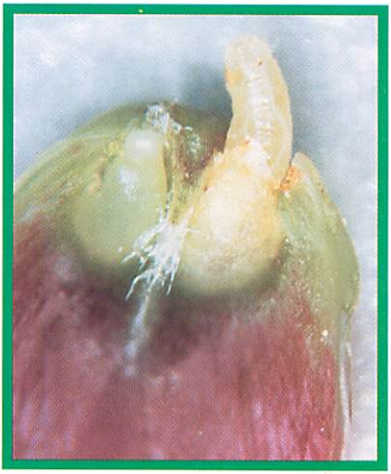
DAMAGE: attacked cone appears similar to healthy cone; larva tunnels around the cone axis and feeds on seeds and scales, leaving large amount of filamentous and coarse frass
DETECTION & MONITORING: examine the scales at the base of cone to find egg, and dissect cone for larva; no trap available; colour trap is being developed for adults
CONTROL: References: 1, 82
Silvicultural: none available
Biological: none available
Chemical: foliar and soil applications of systemic insecticides have been effective in reducing damage

NOTES:

DIPTERA



N. Nelson



J. Sweeney

MONTH ➤➤	J	F	M	A	M	J	J	A	S	O	N	D
Egg					.	....						
Larva						....	...					
Pupa	....	....	....	....	.	.	....	....	....	....	....	....
Adult					...	...						

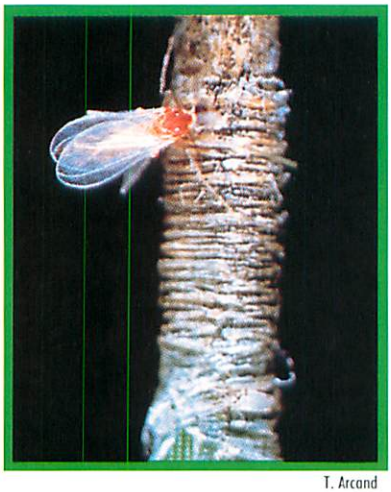
Tamarack cone maggot - *Strobilomyia viaria* (Huckett)
(*Lasiomma (= Hylemyia= Delia) viarium* Huckett)
References: 1, 6, 39, 43, 65, 72, 82, 88
HOST: tamarack
IMPORTANCE & DISTRIBUTION: attacks are localized with up to 100% of the cones attacked; one larva can destroy 100% of the filled seeds per cone; found throughout the range of tamarack
INSECT DESCRIPTION:
Egg: pearl white; 1.1 by 0.3 mm; nearly ovoid with one end flat; laid singly between cone scales
Larva: creamy white; 4.0-6.0 by 1.5 mm; cylindrical without definite head capsule; three instars; can be differentiated from *S. laricis* by the shape of the mouthparts; develops in cone
Puparium: reddish-brown; 3.0-5.0 by 1.2 mm; nearly ovoid; overwinters in soil under tree; capable of extended diapause
Adult: black; wing length 3.3-4.0 mm; resembles a housefly

DIPTERA

DAMAGE: attacked cone appears similar to healthy cone; larva tunnels around the cone axis and feeds on seeds and scales, leaving small amount of filamentous frass
DETECTION & MONITORING: dissect the cone to find egg and larva; no trap available; colour trap is being developed for adults
CONTROL: References: 1, 82
Silvicultural: none available
Biological: none available
Chemical: foliar and soil applications of systemic insecticides have been effective in reducing damage

NOTES:

DIPTERA



T. Arcand

E. Rayner

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	...						
Larva						...	....					
Pupa	....	....	....	...	...		..	...	....	....	....	....
Adult					...	..						

Cone resin midge - *Asynapta hopkinsi* Felt (*Asynapta keeni, Rubsaamenia keeni*)

References: 6, 12, 13, 22, 34, 39, 44, 47, 52, 53, 75

HOSTS: jack and red pine

IMPORTANCE & DISTRIBUTION: typically less than 10% of the cones are attacked; rarely more than 15% of the seeds per cone are lost; widely distributed

INSECT DESCRIPTION:

Egg: no description available

Larva: young midge almost colourless, 0.5 mm long; mature midge white, 2.0-3.0 mm long; slightly dorso-ventrally flattened with small head capsule; no spatula evident on underside; found in clusters between cone scales

Puparium: brown; sclerotized; found in cone or in the soil beneath tree

Adult: pink abdomen; clear wings; antennae are 2.0 mm

DIPTERA

DAMAGE: distorted and brown cone scales; flakes of crystallized resin on exterior; notably free of any boring debris

DETECTION & MONITORING: dissect cone to find larva; no trap available

CONTROL: References: 26, 77

Silvicultural: none available

Biological: none available

Chemical: soil application of systemic insecticides has been effective in reducing populations

NOTES:

DIPTERA

J. Sweeney

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	...						
Larva	....	....	....	....		...	....	....	....	....	....	....
Pupa				...	..							
Adult					...	..						

Spruce cone gall midge - *Kaltenbachiola canadensis* (Felt) (*Dasineura canadensis* Felt)

References: 6, 12, 37, 38, 39, 74, 86, 87

HOSTS: white, black, and red spruce

IMPORTANCE & DISTRIBUTION: up to 90% of the cones can be infested, seed mortality is rare; individual trees can suffer heavier losses; if gall is adjacent to the seed(s), one larva can prevent extraction of 1-2 healthy seeds; found throughout the range of spruce

INSECT DESCRIPTION:

Egg: whitish; 0.3 by 0.1 mm; oblong; smooth chorion; laid in groups of 2-3 on receptive cone scale during pollination

Larva: orange and about 3.0 mm long when mature; slightly dorso-ventrally flattened with small, faintly sclerotized head capsule; spatula present on underside near front end; head capsule no wider than spatula; without prominent lobes at hind end; antennae small; three instars; develops and overwinters in cone scales below seed wing or near seed; capable of extended diapause

Pupa: whitish in early stages, turning darker as it matures; about 2.5 mm long; antennal horn stout with two small, equal-sized teeth; found in a white cocoon in the same cavity as larva

Adult: pale brown; about 2.0 mm long; mosquito-like

DIPTERA

DAMAGE: larva burrows through the seed wing or near the axis below the seed, forming a small gall; if the gall is adjacent to developing seeds, extraction can be difficult, otherwise the damage is minimal

DETECTION & MONITORING: dissect cone before it closes completely to find egg, and thereafter for other life stages; no trap available

CONTROL: References: 12, 24, 26

Silvicultural: remove infested cones from the seed orchard

Biological: none available; probably maintained at low densities by parasitoids

Chemical: soil application of systemic insecticides has been effective in reducing populations

NOTES:

DIPTERA

Y. Prévost

N. Nelson

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	...						
Larva	....	....	....	....		...	....	....	....	....	....	....
Pupa				..	..							
Adult					...	..						

Spruce cone axis midge - *Kaltenbachiola rachiphaga* (Tripp) (*Dasineura rachiphaga* Tripp)
References: 6, 12, 39, 73, 78, 86, 87, 92
HOSTS: black, red, and white spruce
IMPORTANCE & DISTRIBUTION: up to 60% of the cones can be infested; 1 to 3 larva(e) per black spruce cone have little impact on seed production and viability; more than 5 larvae per cone could impact on seed production; found throughout the range of spruce
INSECT DESCRIPTION:
Egg: whitish; 0.3 by 0.1 mm; oblong; laid at extreme base of seed cone scale or near the rachis when cones are open for pollination
Larva: yellowish-orange; about 3.0 mm long when mature; slightly dorso-ventrally flattened with small, faintly sclerotized head capsule; spatula present on underside near front end; head capsule no wider than spatula; without prominent lobes at hind end; antennae small; three instars; develops and overwinters in the cone rachis; capable of extended diapause
Pupa: whitish in early stages, turning darker as it matures; about 2.5 mm long; antennal horn stout, rounded with one sharp tooth; found in a white cocoon in the same cavity as larva
Adult: dark brown; about 2.2 mm long; mosquito-like

DIPTERA

DAMAGE: larva creates a small cavity in the cone axis; this cavity does not affect the seed production or viability, but could disrupt the flow of nutrients to the seed
DETECTION & MONITORING: dissect cone before it closes completely to find egg, and thereafter for other life stages; no trap available
CONTROL: References: 12, 24, 25, 26, 74
Silvicultural: remove infested cones from the seed orchard
Biological: none available; additional work is required with *B. bassiana*; probably maintained at low densities by parasitoids
Chemical: foliar application of systemic insecticides has been effective

NOTES:

DIPTERA

D. Ruth

D. Ruth

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	...						
Larva	....	....	....	....		...	....	....	....	....	....	....
Pupa				..	..							
Adult					...	..						

Spruce seed midge - *Mayetiola carpophaga* (Tripp) (*Phytophaga carpophaga* Tripp)
References: 6, 12, 38, 39, 78, 86
HOSTS: black, red, and white spruce
IMPORTANCE & DISTRIBUTION: up to 35% of the seeds may be destroyed; individual trees can be heavily attacked; each larva destroys one seed; found throughout the range of spruce
INSECT DESCRIPTION:
Egg: whitish; 0.3 by 0.1 mm; oblong; smooth chorion; laid near young seed ovules
Larva: yellowish-pink; about 3.0 mm long when fully developed; slightly dorso-ventrally flattened with small, faintly sclerotized head capsule; spatula present on underside near front end; head capsule no wider than spatula; without prominent lobes at hind end; antennae small; three instars; develops and overwinters in the seed, or falls to the ground if the seed is released from the cone; capable of extended diapause
Pupa: brownish; about 3.0 mm long; antennal horn short, with two small teeth of unequal size, the larger of which has a small notch; found in a white cocoon in the seed
Adult: about 2.4 mm long; mosquito-like

DIPTERA

DAMAGE: the infested seed ovule becomes shiny brown, brittle, and distorted as the larva matures; infested seed is hollowed out and twice as large as a normal seed, and cannot be extracted from the cone

DETECTION & MONITORING: dissect cone before it closes completely to find egg, and dissect seed thereafter for other life stages; no trap available

CONTROL: References: 12, 26

Silvicultural: remove infested cones from the seed orchard

Biological: none available

Chemical: stem injection of systemic insecticides has been effective in reducing damage

NOTES:

DIPTERA

Y. Prévost

D. Ruth

MONTH ➤➤	J	F	M	A	M	J	J	A	S	O	N	D
Egg					.	....						
Larva						...	....	....				
Pupa	....	....	....	....	....			..	....	....	....	....
Adult					..	..						

Cone midges - *Resseliella* spp.

References: 1, 6, 12, 13, 35, 37, 38, 39, 92

HOSTS: tamarack; jack, red, and white pine; red, black, and white spruce

IMPORTANCE & DISTRIBUTION: up to 5% of the tamarack and jack pine seed crops can be destroyed; undetermined on other species; widely distributed

INSECT DESCRIPTION:

Eggs: whitish; about 0.5 mm long; cylindrical; on tamarack, laid on needles near seed cones, location unknown on pine and spruce

Larvae: near white to orange; 1.5-3.5 mm long; slightly dorso-ventrally flattened with small, faintly sclerotized head capsule; spatula present on underside near front end; spatula with two lobes at front end; antennae small; two prominent, pointed lobes at hind end; develops in cone between scales

Pupae: brownish; overwinters in cones or in the forest litter

Adults: yellowish; about 2.0 mm long

DIPTERA

DAMAGE: cone scale(s) shrivelled, and brown; dried resin flakes on exterior and fluid resin between scales; larva leaves no frass; damaged seeds become brownish black and dry or are completely empty

DETECTION & MONITORING: examine foliage near cone to find egg, dissect cone to find larva; no trap available

CONTROL: Reference: 1

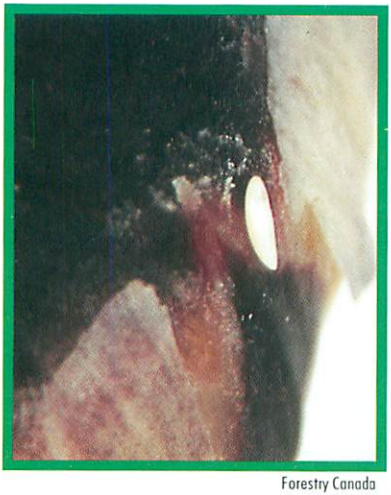
Silvicultural: none available

Biological: none available

Chemical: none available; soil and foliar applications of systemic insecticides have been unsuccessful

NOTES:

DIPTERA



Forestry Canada

Forestry Canada/FIDS

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	...						
Larva						...	....	...				
Pupa	....	....	....	....	..			...	....	....	....	....
Adult					...	..						

Seed maggots - *Earomyia* spp.

References: 6, 39, 47, 59, 60

HOSTS: spruce; tamarack

IMPORTANCE & DISTRIBUTION: typically less than 5% of the cone crop is damaged; the seed destroying capacity of a single larva is unknown, but believed to be low; found throughout the range of spruce and tamarack

INSECT DESCRIPTION:

Eggs: white; cylindrical; found on scales of seed cones

Larvae: creamy white; shiny; elongated with distinct sharp black mouth hooks

Puparia: dark brown; 4.5 by 1.5 mm; oblong; found in the cone or the duff beneath tree; capable of extended diapause

Adults: blue-black; shiny; halteres always black; wing length is about 4.0-5.0 mm

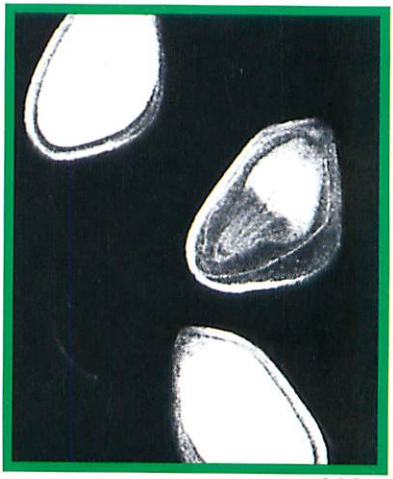
DIPTERA

DAMAGE: no external evidence of cone attack; larva tunnels toward the axis by boring through the cone while feeding on seeds and other tissues; attacked seeds become flat, resinous, and dark brown; only a very small amount of fine frass is produced
DETECTION & MONITORING: dissect cone to find egg and larva; no trap available
CONTROL: References: none available
Silvicultural: remove infested cones from the seed orchard
Biological: none available
Chemical: none available

NOTES:

HEMIPTERA

P. de Groot



G. DeBarr

MONTH ➵	J	F	M	A	M	J	J	A	S	O	N	D
Egg						...	.					
Nymph						..	....	...				
Adult	....	....	....	....	....	...		....	....	....	....	....

Shield-backed pine seed bug - *Tetyra bipunctata* (Herrich-Schäffer)

References: 6, 9, 14, 16, 19, 28, 30, 39, 44, 75

HOSTS: eastern white, jack, and red pine

IMPORTANCE & DISTRIBUTION: typically up to 10% of the cones, and 85% of seeds per cone, are damaged; found throughout the range of pine

INSECT DESCRIPTION:

Egg: pale green, changing to reddish as embryo develops; 1.7 by 1.4 mm; ovoid to nearly spherical; laid on cones or in two parallel rows on needles

Nymph: greyish when young, becoming reddish-brown with black mottling as they mature; broadly oval, flat in appearance; 5 stages; found on cone surface

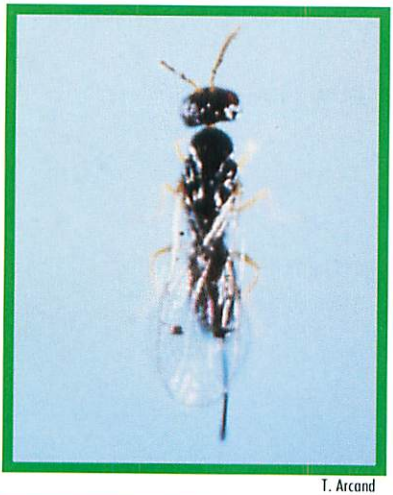
Adult: yellowish to dark reddish-brown; densely marked with pits and grey-black mottling; 11.0-15.0 mm long; oval-shaped; overwinters in loose bark, logs, or soil

HEMIPTERA

DAMAGE: exterior of cone appears normal; seeds attacked before the seed coat becomes hard are small and flat, those attacked after are completely or partially empty
DETECTION & MONITORING: visual inspection or sieving of soil and litter for adults in fall; extract and irradiate (x-ray) the seed to assess seed loss; no trap available although trapping methods are being investigated
CONTROL: References: 9, 10, 15, 16, 19, 26, 70
Silvicultural: none available
Biological: none available; ground and aerial applications of *B.t.* have been ineffective
Chemical: foliar and soil applications of systemic insecticides have been effective in reducing damage

NOTES:

HYMENOPTERA



T. Arcand

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg						...	.					
Larva	....	....	....	....	...	.	....	....	....	....	....	....
Pupa					...	..						
Adult					.	....						

Spruce seed chalcid - *Megastigmus atedius* Walker (*Megastigmus piceae* Rohwer)

References: 6, 12, 37, 38, 39, 78, 81

HOST: white and red spruce; possibly eastern white pine

IMPORTANCE & DISTRIBUTION: typically less than 10% of the cones are attacked; each larva destroys one seed; found throughout the range of spruce

INSECT DESCRIPTION:

Egg: no description available; laid into ovules of developing cones when cones are closed and firm, about 2 weeks after cones reach the pendant position

Larva: white, with dark brown to black mandibles; curved; legless; segmented; 5 instars; feeds in one seed throughout the summer (6-8 weeks); overwinters in the seed within the cone on the tree, or on the ground; capable of extended diapause

Pupa: no description available

Adult: black thorax and abdomen; 2.5-3.0 mm long; membranous wings; female has noticeably long ovipositor

HYMENOPTERA

DAMAGE: attacked seeds are similar to healthy seeds; each larva consumes the entire contents of the seed

DETECTION & MONITORING: dissect seed to find larva; extract and irradiate (x-ray) the seed to assess seed loss; no trap available

CONTROL: References: 18, 26

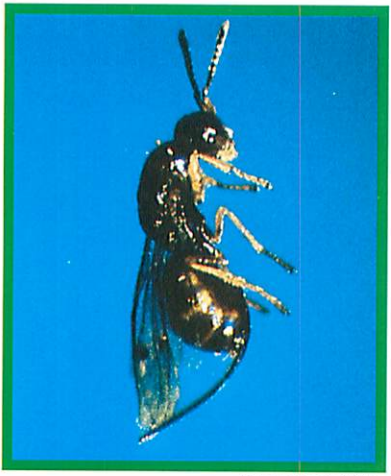
Silvicultural: none available

Biological: none available

Chemical: stem injection of systemic insecticides has been effective in reducing damage; soil application of systemic insecticides has been unsuccessful

NOTES:

HYMENOPTERA



Forestry Canada/FIDS

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg						...	.					
Larva	....	....	....	....	...	.	....	....	....	....	....	....
Pupa					...	..						
Adult					.	....						

Larch seed chalcid - *Megastigmus laricis* Marcovitch

References: 1, 6, 38

HOST: tamarack

IMPORTANCE & DISTRIBUTION: up to 20% of the cones can be attacked; up to 10% of seed crop can be destroyed; each larva destroys one seed; found throughout the range of tamarack

INSECT DESCRIPTION:

Egg: no description available; laid into developing ovules

Larva: white, with dark brown to black mandibles; curved; legless; segmented; 5 instars; feeds in one seed throughout the summer (6-8 weeks); overwinters in the seed within the cone on the tree, or on the ground; capable of extended diapause

Pupa: brown; found in seeds within the cone on the tree or in the seed on the ground

Adult: dark brown to black head, black thorax except yellow spot under wing, with brownish-yellow spots on the sides of the black abdomen; 1.5-2.0 mm long; membranous wings; female has noticeably long ovipositor

HYMENOPTERA

DAMAGE: no external evidence of seed damage, entire contents of seed consumed
DETECTION & MONITORING: dissect seed to find larva; extract and irradiate (x-ray) the seed to assess seed loss; no trap available
CONTROL: Reference: 1
Silvicultural: none available
Biological: none available
Chemical: none available; foliar and soil applications of systemic insecticides have been unsuccessful

NOTES:

LEPIDOPTERA

T. Arcand

E. Rayner

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg						..	...					
Larva							..	....	.			
Pupa	....	....	....	....	....	.		.	....	....	....	....
Adult						....	..					

Spruce cone loopers - *Eupithecia mutata* Pearsall & *Eupithecia albicapitata* Packard

References: 12, 49, 55, 61

HOSTS: black, red, and white spruce; eastern hemlock; balsam fir

IMPORTANCE & DISTRIBUTION: damage is localized with minimal damage to cone crop; found throughout the range of spruce

INSECT DESCRIPTION:

Eggs: no description available

Larvae : *E. mutata* has a slender, pale pink body (without stripes) with small brown pinacula on thorax and abdomen; prominent black thoracic shield; about 1.9 by 10.0 mm when fully grown; *E. albicapitata* is a stout grub-like larva with pale reddish stripes on a pale pink or brown body; about 2.5 by 10.0 mm when mature; both species have brown heads and only the 6th and 10th abdominal segments have pseudopodes

Pupae: brown for both species; overwinters in the soil

Adults: *E. mutata* and *E. albicapitata* are smoky grey with intermittent tan bands at base and tip of the wing, bordered by black and grey markings; 17.0-23.0 mm wingspan

LEPIDOPTERA

DAMAGE: larva leaves ragged holes on exterior of cone with small amounts of frass and resinous material; larva burrows and tunnels through seeds and scales
DETECTION & MONITORING: dissect cone to find larva; no trap available
CONTROL: References: none available
Silvicultural: none available
Biological: none available
Chemical: none available

NOTES:

LEPIDOPTERA

T. Arcand

Forestry Canada

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					?	?	?					
Larva	....	....	....	....		?	....	....	....	....	....	....
Pupa				?	?	?						
Adult					?	?	?					

Fir coneworm - *Dioryctria abietivorella* Groté (*Dioryctria abietella* D&S in part)

References: 6, 12, 13, 34, 35, 39, 47, 49, 51, 53, 74

HOSTS: white, black, and red spruce; eastern white, jack, red, and scotch pine

IMPORTANCE & DISTRIBUTION: damage varies; up to 100% of the seed and cone crop can be destroyed; widely distributed

INSECT DESCRIPTION:

Egg: whitish-green, turning orange as they mature; 0.6 by 1.0 mm; oval; probably laid on bark near cones

Larva: early instar has brown head and amber body which becomes darker as it matures; rows of brown spots along the back; deep amber-brown head and thoracic shield when mature; 18.0-20.0 mm long when mature; develops in cone

Pupa: amber to reddish-brown; about 11.0 mm long

Adult: grey, narrow forewings with transverse lighter bands bordered by black; whitish-grey hindwings without markings; about 25.0 mm wingspan

LEPIDOPTERA

DAMAGE: two to three cones held together with coarse frass and webbing; one or more ragged holes; extensive tunnelling inside of cone usually free of debris
DETECTION & MONITORING: dissect cone to find larva; no trap available
CONTROL: References: 34, 36
Silvicultural: none available
Biological: none available
Chemical: foliar applications of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA

B. Aelick

E. Rayner

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg							..	...				
Larva	....	....	....	....	....	....	.	...	....	....	....	....
Pupa						.	...					
Adult							...	.				

Webbing coneworm - *Dioryctria disclusa* Heinrich

References: 6, 12, 13, 34, 44, 51, 53, 57, 58, 64, 75, 91

Hosts: jack, red and scotch pine

IMPORTANCE & DISTRIBUTION: 40-60% cone loss can occur, with complete seed loss per attacked cone: each larva probably destroys 2 cones: found throughout most of eastern Canada

INSECT DESCRIPTION:

Egg: creamy white; 0.5 by 0.4 mm; oval; lightly striated; laid beneath bark scales

Larva: greyish-buff to olive green; first instar larva has eleven stripes; mature larva 15.0-25.0 mm long; 5 instars; develops in cone; over winters in hibernaculum beneath bark scale

Pupa: mahogany brown; 9.0-4.0 mm long; rounded at the apex; heavily sclertized; caudal hooks are lyre-shapped; found in cone

Adult: goldish-orange to reddish-brown, narrow forewing; pale smoky tan hindwings; 21.0-27.0 mm wingspan

LEPIDOPTERA

DAMAGE: single conspicuous hole near cone base with tightly webbed semi-coarse reddish- brown frass over the entrance hole; large excavation deep within seed-bearing region of cone containing dried resin, frass, and webbing

DETECTION & MONITORING: dissect cone to find larva; sticky trap baited with sex pheromone is available

CONTROL: References: 17, 26, 70, 77

Silvicultural: none available

Biological: none available

Chemical: foliar applications of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA

T. Arcand

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg							·	....				
Larva	....	....	....	....	....	....	..	...	....	....	....	
Pupa						·	....					
Adult							...	..				

Spruce coneworm - *Dioryctria reniculelloides* Mutuura & Munroe (*D. reniculella* Grotè)
References: 6, 12, 33, 39, 49, 54, 62, 66, 74, 78, 92
HOSTS: white, black, and red spruce; possibly jack pine and tamarack; rarely found on balsam fir
IMPORTANCE & DISTRIBUTION: up to 100% cone mortality can occur; found throughout the range of spruce
INSECT DESCRIPTION:
Egg: creamy white, turning cinnamon brown before hatching; 1.0 by 0.7 mm; flat and striated; found in bark cracks and fissures of stems, and on twigs and needles
Larva: first instar is cinnamon brown with 9 broken stripes; fifth instar has three cinnamon coloured and two dark brown longitudinal stripes, a dark brown head; about 17.0 mm long when mature; develops in cone; overwinters as first instar
Pupa: dark brown; about 10.0 mm long; rounded to spined anterior projection; 6 even-length hooked setae
Adult: brownish-grey forewings with two sharp white crossbands; dark grey hindwings with pale subterminal bands and dark fringes; about 25.0 mm wingspan

LEPIDOPTERA

DAMAGE: first instar mines one or two needles; infested cones and surrounding shoots are enveloped in coarse frass and webbing; severely infested cones are usually hollowed out and all seeds are destroyed; larva often feeds under surface of cone

DETECTION & MONITORING: dissect cone to find larva; sticky trap baited with sex pheromone is available

CONTROL: References: 6, 12, 24, 26, 35, 74, 76

Silvicultural: none available

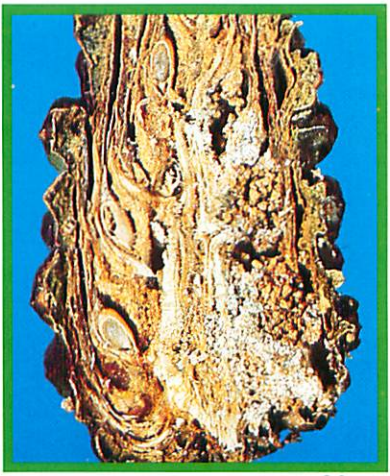
Biological: foliar application of *B.t.* has reduced populations

Chemical: foliar and soil applications, stem injections and implants, of systemic insecticides have been effective in reducing damage; contact insecticides have generally provided little to no control

NOTES:

LEPIDOPTERA

E. Rayner



E. Rayner

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	.						
Larva						....	....	.				
Pupa	....	....	....	....	..		...	....	....	....	....	....
Adult					...							

Red pine cone borer - *Eucosma monitorana* Heinrich

References: 2, 3, 6, 13, 39, 44, 52, 53, 75

HOSTS: red and jack pine

IMPORTANCE & DISTRIBUTION: cone attack seldom exceeds 40%, but can reach up to 90%; each larva kills 1-2 cones, destroying all of the seeds; found throughout the range of red pine

INSECT DESCRIPTION:

Egg: orange; about 0.8 mm long; ovoid; laid on or near cone

Larva: greyish-white, with brown head and pronotum; about 12.0 mm long when mature; 5 instars; develops in cone

Pupa: dark brown; 7.0-8.0 mm long; found in the soil beneath tree

Adult: reddish-brown, with tan and silver markings on forewings; pale to dark grey hindwings with paler fringe; 13.0-16.0 mm wingspan

LEPIDOPTERA

DAMAGE: numerous very small, round holes, or a few oblong holes in upper half of cone; exterior of cone almost always free of frass; no webbing found inside the cone; cone interior is packed with a mixture of frass and resin; extensive tunnelling in cone

DETECTION & MONITORING: examine cone to find egg; dissect cone to find larva; no trap available

CONTROL: References: 26, 77

Silvicultural: none available

Biological: none available

Chemical: soil applications of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA

T. Arcand

T. Arcand

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg					?	?	?					
Larva						?	?	?				
Pupa	....	....	....	....	....		?	....	....	....	....	....
Adult					?	?						

White pine cone borer - *Eucosma tocullionana* Heinrich

References: 22, 39

HOSTS: eastern white pine; possibly spruce, balsam fir, and eastern hemlock

IMPORTANCE & DISTRIBUTION: up to 40-50% of the cone crop can be destroyed; found throughout the range of white pine

INSECT DESCRIPTION:

Egg: no description available

Larva: pale ivory-yellow to greenish-brown; pale anal shield; develops in cone

Pupa: brown; found in the soil beneath tree

Adult: distinct patches of alternating dark brown and light tan scales on forewings; dark brown hindwings with brownish-grey fringes; 12.0-19.0 mm wingspan

LEPIDOPTERA

DAMAGE: cone peppered with many small holes and covered with patches of extruding frass; cone shrivels, discolours, hardens, turns brown and falls to the ground; cone interior is packed with a mixture of frass and resin as the larva feeds on scale and seed tissue, hollowing out and killing the cone

DETECTION & MONITORING: dissect cone to find larva; no trap available

CONTROL: References: 18, 26

Silvicultural: none available

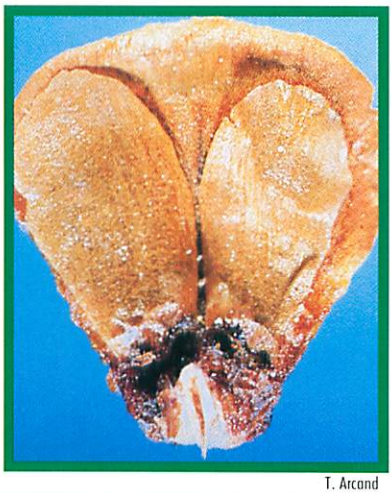
Biological: none available

Chemical: soil applications of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA

T. Arcand



T. Arcand

MONTH ➤	J	F	M	A	M	J	J	A	S	O	N	D
Egg					..	..						
Larva	....	....	....	....	.	....	....	....	....	....	....	....
Pupa				..	..							
Adult					...	.						

Spruce seed moth - *Cydia strobilella* Linneaus (*Cydia (= Laspeyresia) youngana* Kearfott)
References: 6, 7, 12, 24, 32, 37, 39, 78, 85, 87
HOSTS: white spruce or, possibly black and red spruce
IMPORTANCE & DISTRIBUTION: up to 70% of the cone crop can be destroyed; each larva destroys about one third of the seeds in a cone; found throughout the range of spruce
INSECT DESCRIPTION:
Egg: pale to dark orange; about 0.5 mm in diameter; spherical, but become flat after cone scales close; laid in small overlapping clusters between cone scales near apex of seed cone
Larva: creamy white with a brown head and thoracic shield; about 10.0 mm long when mature; 4 instars; overwinters in cone axis; capable of extended diapause for up to 3 years
Pupa: light amber turning deep brown to black prior to emergence; about 5.5 mm long with males usually 0.8 mm shorter than females; found in cone axis
Adult: smoky brown with four crossbands of silver and four shining coastal spots on forewings; 8.0-11.0 mm wingspan

LEPIDOPTERA

DAMAGE: no external evidence of damage; internally, seeds are partially to completely consumed and fused to the scale; silken tunnels between seed pairs are evident
DETECTION & MONITORING: dissect cone to find egg, larva, pupa; sticky trap baited with sex pheromone is available
CONTROL: References: 12, 24, 26, 27
Silvicultural: remove infested cones from the seed orchard
Biological: none available
Chemical: foliar and soil applications, stem injections and implants of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA

P. de Groot

P. de Groot

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg						..	..					
Larva	....	....	....	....	....	.	....	....	....	....	....	....
Pupa					..	...						
Adult						...	.					

Eastern pine seed moth - *Cydia toreuta* (Groté) (*Laspeyresia toreuta* (Groté))

References: 6, 22, 34, 39, 44, 45, 46, 52, 53

HOSTS: jack and red pine

IMPORTANCE & DISTRIBUTION: 15-80% of the cones can be attacked; up to 75% of the seeds per cone can be destroyed; one larva can destroy as many as 8 seeds; found throughout the range of pine

INSECT DESCRIPTION:

Egg: white; about 0.2 by 0.3 mm; ovoid with reticulated flat surface; laid between cone scales

Larva: yellowish -white; last instar is about 10.0 mm long; body devoid of easily visible setae; slender body; 4 instars; develops in 2nd year cones

Pupa: 6.0-8.0 mm long; pointed head; posteriorly projecting spines on the dorsum of the abdominal segments; remain in the cone or drop to the ground

Adult: chocolate brown with 2 black-bordered silver bands on forewing; 12.0-15.0 mm wingspan

LEPIDOPTERA

DAMAGE: no external evidence of damage; internally, larva tunnels between seeds and cone axis, leaving a trail which appears as brown lines against the white internal cone material; larva invariably approaches a seed at its upper end; seed coat of attacked seeds is partially destroyed; the remainder of seed coat is glued to the scale and filled with a mixture of frass and resin

DETECTION & MONITORING: dissect cone to find egg and larva; no trap available

CONTROL: References: 10, 26, 77

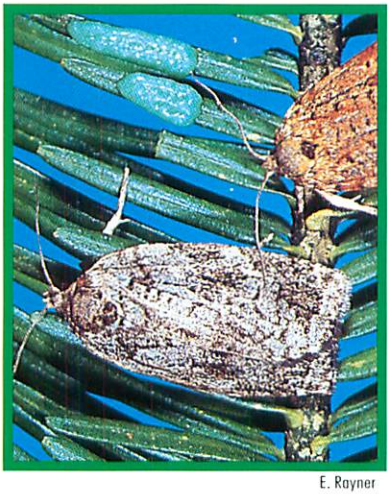
Silvicultural: remove infested cones from the seed orchard

Biological: *B.t.* and *B. bassiana* dusted on cones can be effective

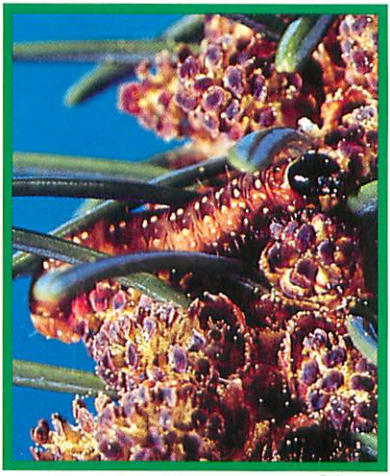
Chemical: stem injection, implants, foliar sprays, and soil applications of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA



E. Rayner



E. Rayner

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg							...	..				
Larva	....	....	....	....	....	....	.	....	....	....	....	....
Pupa						...	...					
Adult						.	....	.				

Eastern spruce budworm - *Choristoneura fumiferana* Clemens
(*Archips fumiferana* Clemens)

References: 6, 11, 12, 39, 56, 74, 80

HOSTS: balsam fir; red, black, and white spruce; occasionally tamarack

IMPORTANCE & DISTRIBUTION: up to 100% of the seed cones of certain tree species can be destroyed; when at epidemic levels, the spruce budworm is one of the most serious pests of cones of several conifers in eastern Canada

INSECT DESCRIPTION:

Egg: bluish-green; about 1.0 mm long; flattened and ovoid; laid in masses of 2-4 rows, on the underside of the needles, with each mass containing about 20 eggs

Larva: first instar is yellowish with dark brown head; last instar is reddish-brown with 2 rows of whitish spots along the back and has dark brown thoracic shield and legs; 18.0-24.0 mm long when mature; 6 instars; develops on foliage or in cone and overwinters as second instar in hibernaculum

Pupa: yellow to reddish-brown; attached to foliage

Adult: brownish-grey to grey, with mottled wing pattern; 20.0-30.0 mm wingspan

LEPIDOPTERA

DAMAGE: cone is partially to completely consumed; webbing and coarse frass adhering to surface of cone and surrounding needles

DETECTION & MONITORING: examine foliage to find egg masses and larva; examine seed cone at bud burst and thereafter, to find larva; sticky or bucket trap baited with sex pheromone is available

CONTROL: References: 12, 26

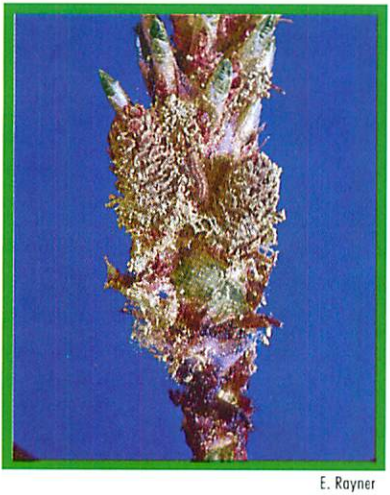
Silvicultural: none available

Biological: foliar application of *B.t.* has been effective in reducing populations and defoliation

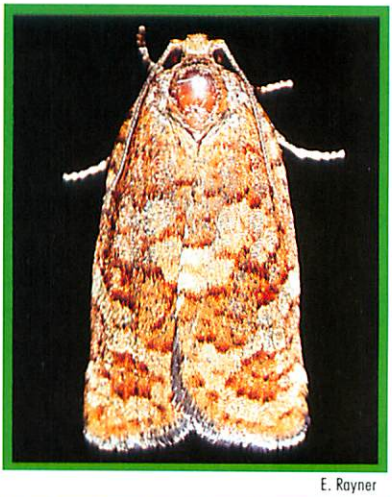
Chemical: foliar and soil applications of systemic insecticides have been effective in reducing damage

NOTES:

LEPIDOPTERA



E. Rayner



E. Rayner

MONTH ➳	J	F	M	A	M	J	J	A	S	O	N	D
Egg							..	....				
Larva	....	....	....	....	....	....	.	....	....	....	....	....
Pupa						..	...					
Adult							....	.				

Jack pine budworm - *Choristoneura pinus pinus* Freeman

References: 4, 5, 11, 20, 21, 42, 48, 56, 69, 79

HOSTS: jack, red, scotch, and eastern white pine

IMPORTANCE & DISTRIBUTION: significant loss of young pollen- and seed-cones may occur; found throughout the range of jack pine

INSECT DESCRIPTION:

Egg: yellow-green; laid in 2 rows on underside of needles in clusters of about 40

Larva: last instar brownish to yellow head; 2 rows of white dots along the back; dark brown almost black prothoracic shield; yellowish anal shield; 20.0-22.0 mm long; 7 instars; overwinters in second instar in hibernaculum

Pupa: dark grey or dark brown; attached to shoots or within webbed foliage

Adult: tawny grey with mottled wing patterns

LEPIDOPTERA

DAMAGE: one or more holes can be present on cone surface; feeding on cone surface and surrounding needles, with frass and webbing adhering to remaining needles; cone can be distorted due to destroyed conductive tissue

DETECTION & MONITORING: dissect cone to find larva; sticky or bucket trap baited with sex pheromone is available

CONTROL: References: 8, 90

Silvicultural: none available

Biological: foliar application of *B.t.* has been effective in reducing populations and defoliation

Chemical: foliar applications of contact insecticides have been effective in reducing damage

NOTES:

GLOSSARY

abdominal segment - a subdivision of the abdomen delineated by constrictions

aborted - having ceased development, so as to be unfit for normal function; atrophied

anal hook - spines on the hind end of the pupa of various lepidoptera, frequently used as a means of attachment of a pupa to substrate material

anal shield - the upper part of the last abdominal segment of Lepidoptera larvae, plate-like in appearance

antennal horn - a prominent point arising from the antennae

axis - of cone, the central rod-like core of a cone to which scales and bracts are attached

brood - all of the individuals that hatch at about the same time from eggs laid by a series of parents and that normally mature at the same time

caudal hook - hooks found at, near, or toward the tip of the abdomen

chorion - the outer shell or covering of the insect egg

cocoon - a covering, made partially or entirely of silk or other fibres, spun by a larva as a protective envelope for the pupa

diapause - a temporary interruption of growth or arrested development; a condition of suspended animation

elytra - the chitinous wings of beetles, serving as coverings for the hindwings

frass - solid larval excrement

gall - an abnormal swelling of a plant tissue

halteres - the wing balancers in Diptera, situated one on each side of the thorax and representing the hindwings

head capsule - the sutured segments or sclerites of the head which form a hard protective case

hibernaculum - a tent or sheath made out of foliage, or other material, in which a larva hides or hibernates

instar - the period or stage between moults in the larvae, numbered to designate the various periods; e.g., the first instar is the stage between the egg and the first moult

larva (pl. larvae) - the immature stage, between the egg and pupa, of an insect which undergoes complete metamorphosis (egg, larva, pupa, and adult)

mouthhook - cuticular claw-like structures, one on each side of the pre-oral opening; the substitute jaws of dipteran larvae

moult - to cast off the outgrown skin when the larva or nymph changes from one instar to another

nymph - the immature stage of insects with an incomplete metamorphosis (e.g. Hemiptera); although similar in form to adults, nymphs have incompletely developed wings and genitalia

ovipositor - structure used to lay eggs

GLOSSARY

pheromone - a substance, secreted in a gland and released into the air by an insect, that causes a specific reaction in a receiving insect of the same species; e.g., sex pheromone

pinaculum - (pl. pinacula) small chitinized plates on the outer covering of a larva to which body setae are attached

pitch tube - a cylinder of resin and often frass surrounding the entrance hole made by an insect

pollen cone - the male strobili of conifers which produce pollen

proleg - the fleshy, unjointed abdominal legs of lepidoptera, and some sawfly, larvae

pronotum - the upper (dorsal) surface of the prothorax

prothoracic shield - the plate-like upper part of the prothorax, especially of lepidoptera larvae

prothorax - the first segment of the thorax of an insect bearing the first pair of legs

pubescence - a covering of short, fine, soft, erect hair

pupa (pl. pupae) - the resting inactive stage between the larva and the adult in insects that undergo complete metamorphosis

puparium (pl. puparia) the thickened, hardened barrel-like larval skin of diptera within which the pupa is formed

rachis - axis of cone, central rod- like core of a cone to which scales and bracts are attached

reticulated - covered with a network of lines; meshed; netted

sclerotized - portions of insect cuticle that are hardened by substances other than chitin

seed coat - the outer coat of the seed, usually hard and brittle

seed-cone - the female strobili of conifers which receive pollen and produce seeds

seta (pl. setae) - a rather short, stiff, pointed hair

spatula - a spoon or spoon-shaped unicellular process, structure, or out-growth of the body wall; the breast of a cecidomyiid larvae

striated - marked with parallel, fine, impressed lines

subterminal - below the end, or not quite attaining the end

thorax - the intermediate region of the insect body between the head and the abdomen bearing the true legs and wings

DEVELOPING AN INSECT PEST MANAGEMENT SYSTEM FOR A SEED ORCHARD

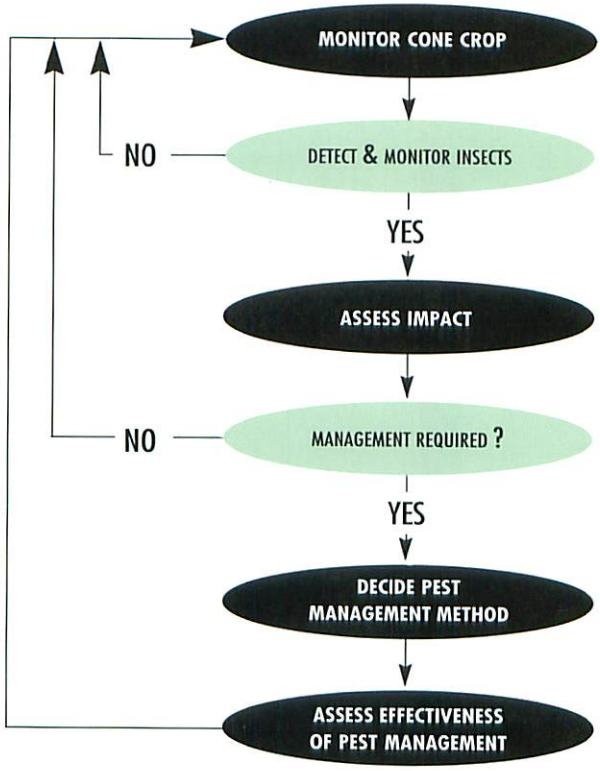


Figure 1

Figure 2

CONE CROP MONITORING RECORD SHEET

Orchard ID
Orchard Name: _____
Orchard Number: _____
Type (sdlng/clnl): _____
District: _____
Species: _____
Assessment Year: _____

Tree ID
Rep: ☐ Row: ☐ Fam/Cln No: ☐
Block: ☐ Col: ☐ Yr planted: ☐
Set: ☐ Tree No.: ☐

Total Counts

	# or class	Date
Initial Seed-cones:		
Mature Seed-cones:		
Pollen-cones:		

Periodic Samples

Codes

CC	Cone Condition
1	healthy
2	missing
3	aborted
4	attacked & live
5	attacked & dead
6	diseased
7	malformed

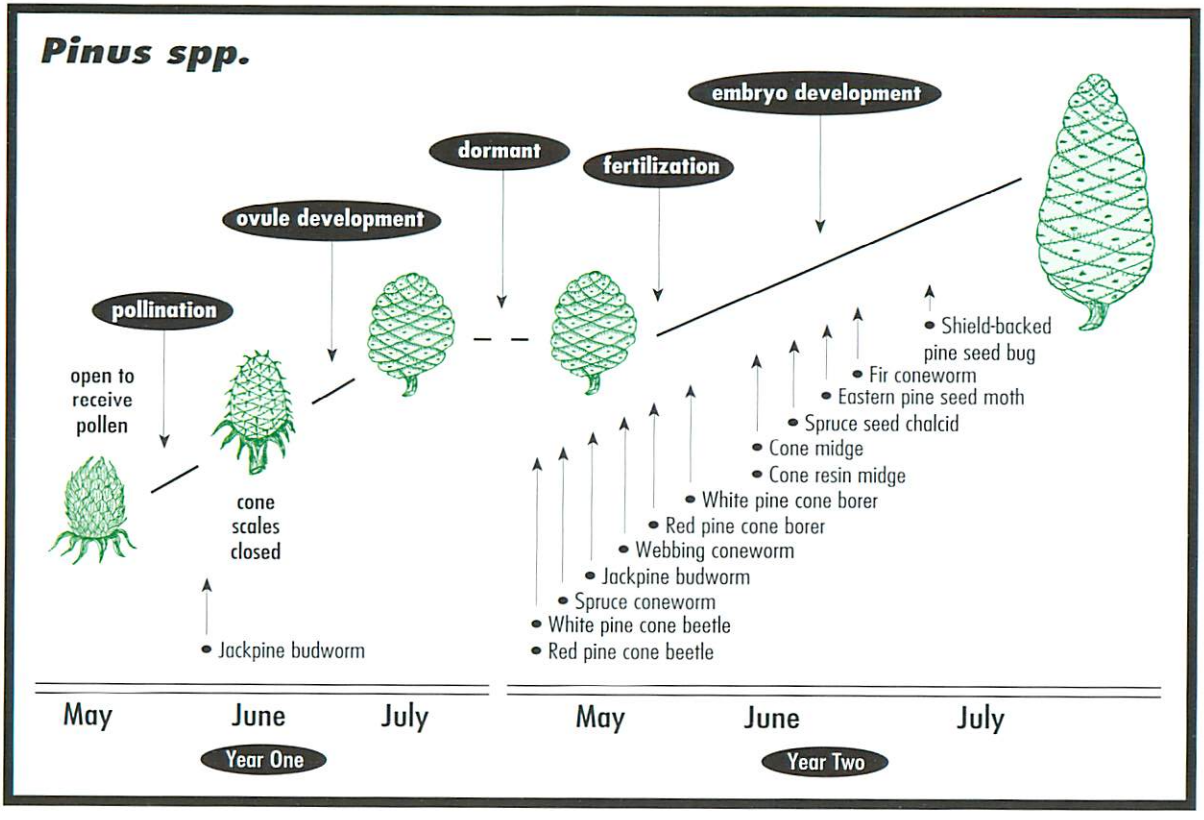
MF	Mortality Factor
1	healthy
2	missing
3	aborted
4	unknown
5	mechanical damage
6	squirrels
7	lepidoptera
8	fir coneworm
9	spruce budworm
10	spruce cone maggot
11	spruce coneworm
12	spruce needle miner
13	spruce cone rust
14	jack pine budworm
15	jack pine tip beetle
16	pine conelet bug
17	cone midge
18	red pine cone beetle
19	webbing coneworm
20	red pine cone borer
21	resin midge

Date																Notes
Cone	Quad	CC	MF	CC	MF	CC	MF	CC	MF	CC	MF	CC	MF	CC	MF	
Assessor:																

DATA ENTRY FORM FOR CONE CROP MONITORING SYSTEM
IN ONTARIO SEED ORCHARDS

Management of Insect Pests of Cones in Seed Orchards in Eastern Canada

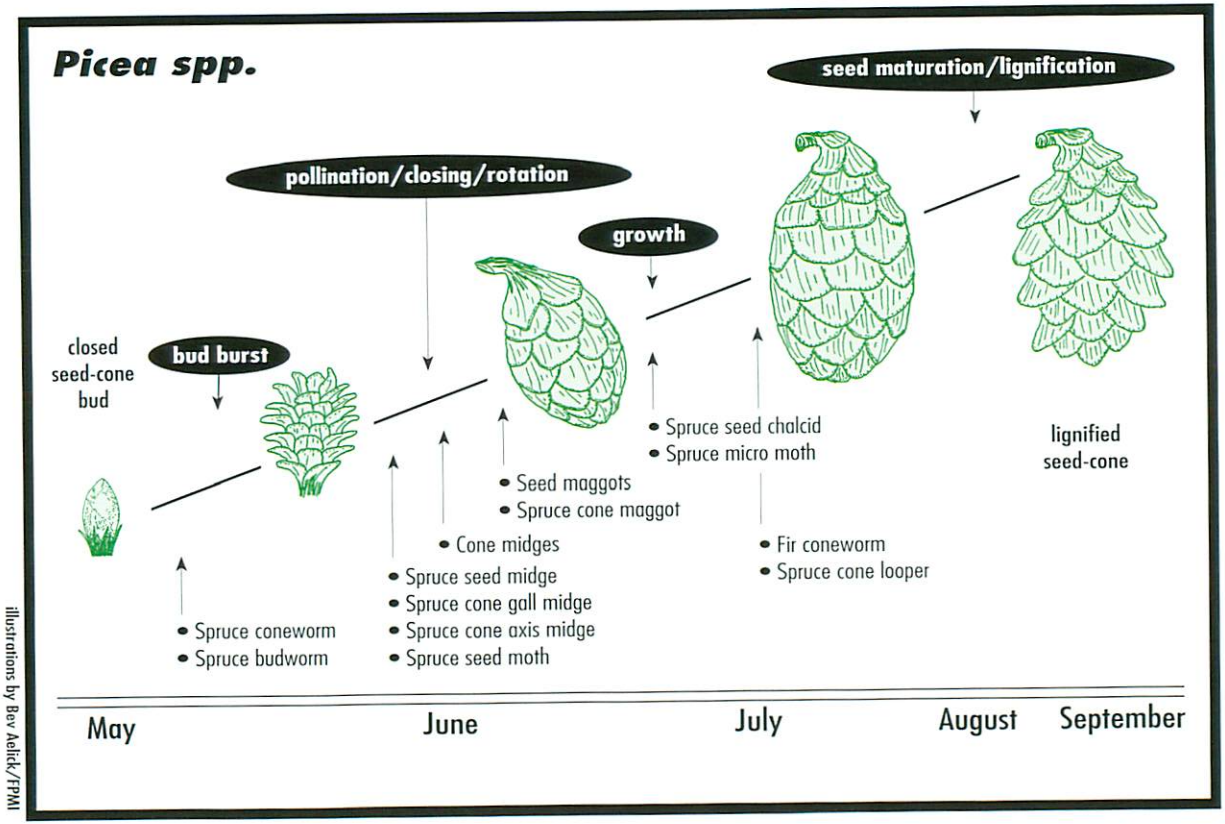
RELATIONSHIP BETWEEN THE TIME INSECTS INITIATE CONE ATTACK & CONE PHENOLOGY OF PINE, *PINUS SPP.*



illustrations by Bev Aalick/FPMI

Figure 3

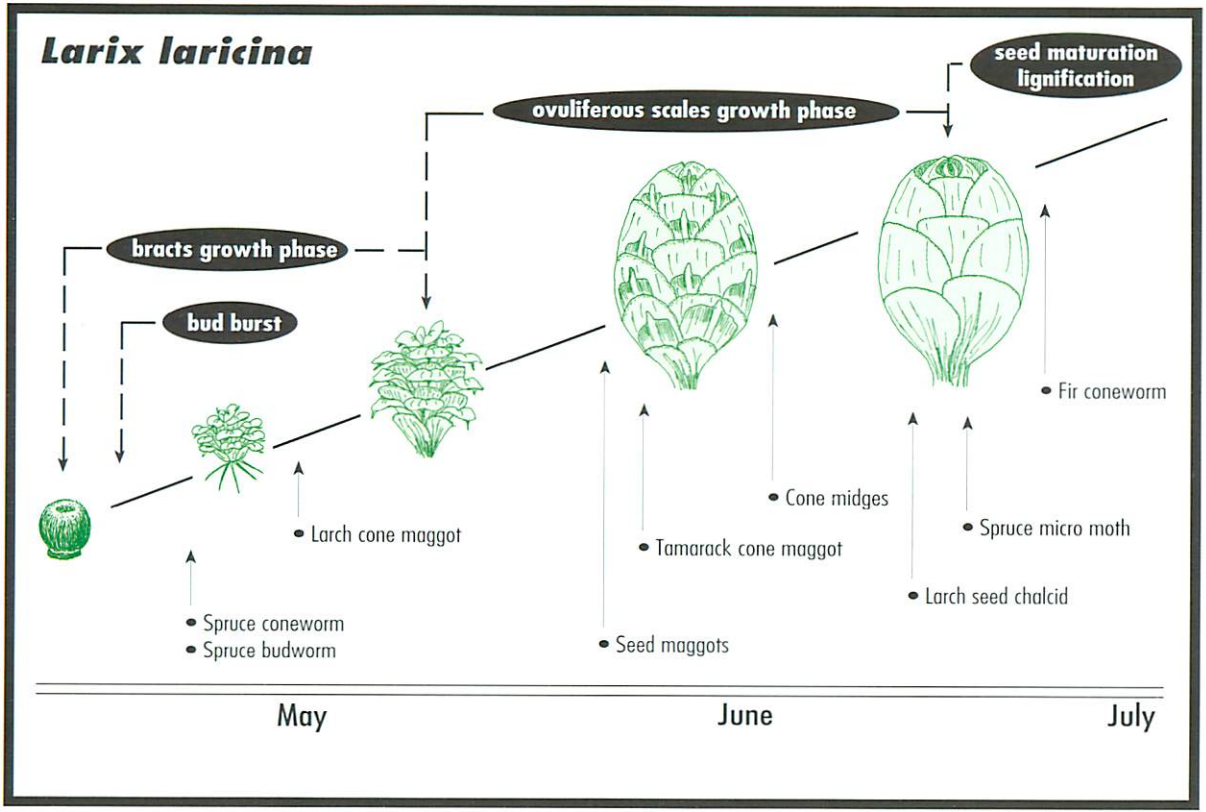
Figure 4



illustrations by Bev Aelick/FPMI

RELATIONSHIP BETWEEN THE TIME INSECTS INITIATE CONE ATTACK & CONE PHENOLOGY OF SPRUCE, *PICEA SPP.*

RELATIONSHIP BETWEEN THE TIME INSECTS INITIATE CONE ATTACK & CONE PHENOLOGY OF TAMARACK, *LARIX LARICINA*



illustrations by Bev Aelick/FPMI

Figure 5

FOREST INSECT AND DISEASE SURVEY IDENTIFICATION SERVICE SUBMISSION FORM (modified)

FORESTRY CANADA

Collection Point	Nearest Post Office

Forest District	County	Township

STAND INFORMATION (circle only one in each category)

Description	History	Maturity
1. Nursery	1. Undisturbed	1. Seedling (nursery)
2. Ornamentals	2. Clear cut	2. Transplant
3. Plantation (Nat. Sp.)	3. Selective cut	3. Seedling (forest)
4. Plantation (Exot. Sp.)	4. Burned	4. Sapling
5. Shelterbelt	5. Insect damaged	5. Young growth
6. Hedgerow	6. Disease damaged	6. Semi-mature
7. Woodlot	7. Animal damaged	7. Mature
8. Natural Forest	8. Climate damaged	8. Over-mature
9. Treed Swamp	9. Wind damaged	
10. Scattered individuals	10. Water damaged	
	11. Unknown	

Tree species	No. of trees sampled

Abundance of Insect or Disease	Part of Tree Affected	
1. Negative	1. Flower	7. Branch
2. Trace	2. Fruit	8. Stem
3. Low	3. Buds	9. Butt
4. Moderate	4. Old foliage	10. Root
5. High	5. New foliage	- Duff or soil
6. N/A	6. New shoot	+ N/A

Collector	Date

Address

Describe condition of tree and/or abnormalities

Other remarks

* see reverse side for instructions

Figure 6

FOREST INSECT AND DISEASE SURVEY IDENTIFICATION SERVICE SUBMISSION FORM

INSTRUCTIONS

1. Select a good representative sample of the organism or abnormality.
2. Leaf feeding insects: package carefully using sealed cellophane, plastic or aluminum bags containing sufficient fresh foliage for three days travel.
3. Moths should be killed with a killing agent such as moth crystals and shipped dry.
4. Other insects should be preserved in alcohol.
5. Put fungi in paper bags.
6. Complete form as fully as possible making sure that NAME and ADDRESS are clearly printed and place in an envelope inside a sturdy package or mailing tube.
7. Do not leave containers with insects in sun or near heat.

ECONOMIC IMPORTANCE OF INSECTS ATTACKING CONIFEROUS CONES & SEEDS

Significant	Low or Unknown
White pine cone beetle	Cone resin midge
Red pine cone beetle	Spruce cone gall midge
Spruce cone maggot	Spruce cone axis midge
Tamarack cone maggot	Spruce seed chalcid
Larch cone maggot	Cone midges
Larch seed chalcid	Seed maggots
Spruce seed moth	Eastern pine seed moth
Webbing coneworm	Spruce cone loopers
Spruce coneworm	Shield-backed pine seed bug
Fir coneworm	Spruce seed midge
Eastern spruce budworm	Spruce micro moth
Jack pine budworm	
Red pine cone borer	
White pine cone borer	

EQUATIONS TO CALCULATE VARIOUS SEED PRODUCTION EFFCIENCIES IN SEED ORCHARDS

1. **Cone Efficiency (CE)** = $\frac{\text{no. harvested seed-cones/tree}}{\text{no. receptive seed-cones/tree}}$

2. **Seed Potential (SP)** = no.fertile scales X 2

3. **Seed Efficiency (SE)** = $\frac{\text{no. filled seeds/cone}}{\text{SP}}$

4. **Extraction Efficacy (EE)** = $\frac{\text{no. seeds extracted/cone}}{\text{no. seeds/cone}}$

5. **Germination Efficacy (GE)** = $\frac{\text{no. germinated seeds/cone}}{\text{no. filled seeds/cone}}$

6. **Seed Orchard to Nursery Efficiency (SO-NE)** = CE x SE x EE x GE

Table 2

FEEDING PERIODS OF INSECTS ATTACKING CONES & SEEDS OF CONIFERS

MONTH ➤ ➤ ➤ ➤	A	M	J	J	A	S	O
White pine cone beetle		...	...				
Red pine cone beetle		...	...				
Spruce cone maggot		.	...				
Larch cone maggot		...	..				
Tamarack cone maggot		.	....				
Cone resin midge		.	...				
Spruce cone gall midge		..	...				
Spruce cone axis midge		..	....				
Spruce seed midge		.	...				
Cone midges			...	....	....		
Seed maggots		..	..				
Shield-backed pine seed bug			..	....	....	...	
Spruce seed chalcid			..	.			
Larch seed chalcid			.	...			
Spruce cone loopers				..	....	.	
Fir coneworm				...	....	...	
Webbing coneworm		.	....	..			
Spruce coneworm		..	....				
Red pine cone borer			....	...			
White pine cone borer			...	....	.		
Spruce seed moth		.	...				
Eastern pine seed moth			..	..			
Spruce budworm		..	....				
Jack pine budworm		.	....	.			

Table 3

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INSECT INDEX

APPENDIX A

Scientific Name	French Common Name	English Common Name
Asynapta hopkinsi	Cécidomyie de la résine des cônes (T. Arcand)*	Cone resin midge
Barbara colfaxiana	Perce-cône du Douglas	Douglas-fir cone moth
Choristoneura fumiferana	Tordeuse des bourgeons de l'épinette	Eastern spruce budworm
Choristoneura pinus pinus	Tordeuse du pin gris	Jack pine budworm
Conophthorus coniperda	Scolyte des cônes du pin blanc	White pine cone beetle
Conophthorus resinosae	Scolyte des cônes du pin rouge	Red pine cone beetle
Cydia strobilella	Tordeuse des graines de l'épinette	Spruce seed moth
Cydia toreuta	Tordeuse séminivore des pins	Eastern pine seed moth
Dioryctria abietivorella	Pyrale des cônes du sapin	Fir coneworm
Dioryctria disclusa	Pyrale rousse des cônes du pin	Webbing coneworm
Dioryctria reniculelloides	Pyrale des cônes de l'épinette	Spruce coneworm
Earomyia spp.	Mouches conophages (J.Turgeon)*	Seed maggots
Endopiza piceana	Tordeuse verte des cônes (T. Arcand)*	Spruce micro moth
Eucosma monitorana	Perce-cône du pin rouge	Red pine cone borer
Eucosma tocullionana	Perce-cône du pin blanc	White pine cone borer
Eupithecia mutata	Petite arpenteuse des cônes	Spruce cone looper
Kaltenbachiola canadensis	Cécidomyie galligène des cônes de l'épinette	Spruce cone gall midge
Kaltenbachiola rachiphaga	Cécidomyie des cônes de l'épinette (B. Boulet)*	Spruce cone axis midge
Mayetiola carpophaga	Cécidomyie séminivore de l'épinette	Spruce seed midge
Megastigmus atedius	Chalcis granivore de l'épinette	Spruce seed chalcid
Megastigmus laricis	Chalcis séminivore du mélèze	Larch seed chalcid
Resseliella spp.	Cécidomyies des graines des cônes (T. Arcand)*	Cone midges
Strobilomyia laricis	Mouche granivore du mélèze (B. Boulet)*	Larch cone maggot (J.Turgeon)
Strobilomyia neanthracina	Mouche granivore de l'épinette	Spruce cone maggot
Strobilomyia viaria	Mouche granivore du mélèze laricin (B. Boulet)*	Tamarack cone maggot (J.Turg
Tetyra bipunctata	Tétyre biponctuée (A. Larochelle)*	Shield-backed pine seed bug

*these common names have been submitted for approval to the Insect Common Names and Cultures Committee of the Entomological Society of Canada.