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Insects of Eastern Pines

A. H. Rose, O. H. Lindquist and K. L. Nystrom

Natural Resources Canada
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Canada

INSECTS OF EASTERN PINES

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Insectes des épinettes, du sapin et de la pruche de l'est du Canada

Insects of Eastern Larch, Cedar and Juniper
Insectes du mélèze, du thuya et du genévrier de l'est du Canada

Insects of Eastern Hardwood Trees
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Abstract

This handbook is designed to enable people who are interested in trees to identify the insects and mites causing damage to them. About 90 species of insects and mites that have caused noteworthy damage to pines in Canada east of the Rocky Mountains are included. The insect and/or its damage can be identified by means of flow chart keys, and the identity of the insect or mite can be confirmed by reference to about 190 colour illustrations. The accompanying biological sketch for each insect or mite usually includes information, based largely on Forest Insect and Disease Survey records, on the necessity for control. Where control is necessary, methods are suggested. Common names of insects are generally used, but scientific names are also given in the text.

Résumé

Ce guide veut aider les gens qui portent intérêt aux arbres à identifier les insectes et les acariens qui les endommagent. Il traite d'environ 90 espèces de ces ravageurs qui ont causé des dégâts importants aux pins canadiens à l'est des montagnes Rocheuses. Des clés sous forme de diagramme permettent d'identifier l'insecte ou les dégâts qu'il cause, et cette identité peut être confirmée par quelque 190 illustrations en couleurs. La description biologique sommaire de chaque insecte ou acarien, souvent accompagnée d'information sur les besoins de lutte, est puisée en grande partie dans les Relevés des insectes et des maladies des arbres. Dans le cas où la lutte est nécessaire, les méthodes éventuelles sont proposées. En général, les auteurs identifient les insectes par leur nom commun, mais le nom scientifique (latin) est aussi donné dans le texte.

Preface

This handbook of pine insects was made possible because of the farsighted vision of some outstanding entomologists who conceived, nurtured and encouraged the development of a survey organization that has acquired over the past 50 years a large amount of knowledge and expertise on forest insects. During this time many individuals have made valuable contributions to this knowledge both inside the former Forest Insect and Disease Survey organization and outside, and of the latter particular mention should be made of those local specialists who work on the sawflies, bark beetles and borers, and the national specialists, who are mainly at the Eastern Cereal and Oilseed Research Centre (formerly the Entomology Research Institute), Agriculture and Agri-Food Canada. The co-operation of a dedicated and inquisitive field staff has hastened the solution of numerous identification problems, and it is they who have obtained much of the material for the illustrations. This handbook is owed to all of the above; we only accepted the challenge to bring it to fruition.

Contents

Plantation of Scots pine

Ornamental mugho pine

Austrian pine

White pine

Red pine

Jack pine

Pitch pine

Scots pine

Introduction

The Canadian Forest Service (CFS), recognizing the destructiveness of insects in the nation's forests, initiated over 50 years ago a data gathering system to collect, identify, assess and record insect and disease occurrence and injury to forest trees. This vast amount of biological information has been accumulated in a centralized data processing centre in Fredericton. At the same time, Biosystematic staff at the forestry centres have acquired considerable expertise in the identification of the feeding stages of most of the insects collected. From this array of data and knowledge, it is now possible to provide a means of identifying the important insects that attack our valuable forest resource as well as providing information on the biology and control of these pests.

A series of handbooks has been written, each one dealing with the insects attacking a certain tree genus or group of related tree genera. This first book, originally published in 1973 and revised in 1984 and 1999, includes all the important and common insects on pine in central and eastern Canada. For simplicity, the area encompassing the Rocky Mountains and the Pacific coast is not included because both tree and insect species are sufficiently different to warrant separate treatment. The information presented was taken initially from data of the former Ontario Forest Insect and Disease Survey Unit, with which the authors have been closely associated. Additional information has also been drawn from publications of Forest Health Units in CFS regional centres and of provincial collaborators as well as from the entomological literature generally.

Pine is a prominent and valuable component of our natural forests, ranking third behind spruce and fir in volume and comprising 10% of the total merchantable timber in central and eastern Canada. It is used widely in reforestation and afforestation, and for aesthetic and utility purposes. Scots pine is planted extensively on a short rotation basis for the Christmas tree industry. Four species of pine occur naturally, and three introduced species are widely planted. About 500 insect species occur on these seven pine species in Ontario, and from this number all beneficial insects and insects that have not caused significant injury in central or eastern Canada have been excluded.

This handbook deals with the remaining 90 important insect species or groups, and these are separated and identified in a series of flow chart keys based on the part of the tree on which the insect or injury occurs, as shown in the table of contents. From an identification box in the key, the reader is directed to a page number in the text where identity can be confirmed by coloured illustrations, indicated by ▭, of the insect and/or type of injury and where some biological information is given on the species involved. In summary, all important insects found on pine in Canada east of the Rockies are included.

If there is any doubt about the identity or importance of any species occurring in large numbers on pine or other trees or shrubs, a representative sample of living larvae and type of injury could be sent to the appropriate Forest Health Unit at the Forestry Centre of the Canadian Forest Service, Natural Resources Canada, serving each of the areas indicated on the map.

Injury

Injury to trees can be caused by such varied factors as climate, microscopic pathological organisms, tiny mites and insects of all sizes, as well as birds, mice, rabbits and porcupines. Humans often cause injury by mechanical means or by interfering with the tree's environment either above or below ground. With a few exceptions, most of what follows relates to problems with insects on trees of all ages. Insect problems involving seedlings in a nursery are quite distinctive and generally concern only a limited number of people; for this reason, they are excluded from this publication. Some common agents of injury other than insects are treated superficially to clarify doubts concerning cause.

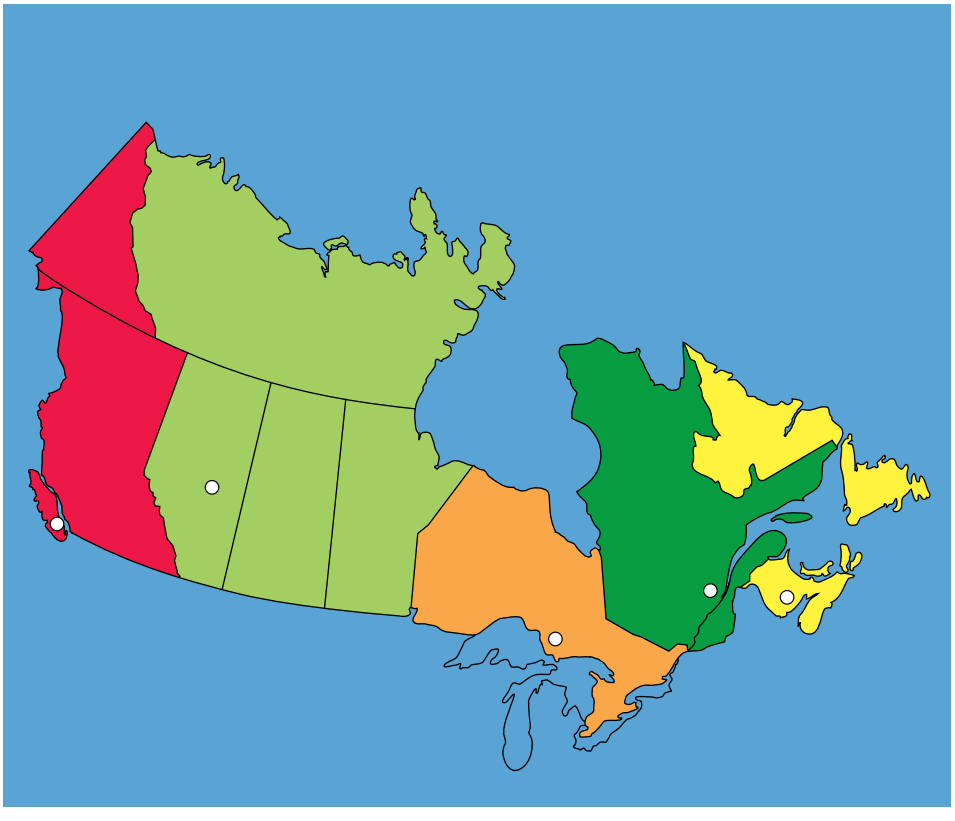
There is no part of a tree that is not subject to attack by some insect; the degree of injury inflicted on the tree, however, is dependent on the number of insects, type of feeding, time of year, point of attack and how vital to survival is the part attacked. Actual loss of parts, such as needles, buds, shoots, etc., is not generally seen until it is extensive, whereas feeding causes a more direct interference to the general circulatory system, often causing contrasting needle colours such as pale yellow or buff, mottled yellow on green, brown and perhaps rusty red, all of which provide good evidence of injury until the affected part is lost. Usually the earlier the damage can be detected, the greater chance there is of determining the causal agent, because secondary insects often move in to feed on the dead or dying part. When the new shoots have completed their annual growth, insect feeding that penetrates the bark to the wood, if it is severe, will result in off-colour foliage that often turns rusty red; these shoots are striking evidence of injury and are usually called "flags". In all cases of foliage discolouration and wilting, the insect causing the damage or the clues to its identity will be found at the junction of living and dead tissues, if examination is carried out early enough.

Control

The Insect Identification and Diagnostics Laboratory in Ontario is regularly asked for a recommendation on which insecticide to use to control an insect found on trees. In contrast to the wide use of chemical control measures a few years ago that seemed to offer immediate freedom from pest species, a more constrained approach is now being taken. Chemicals that were acceptable pesticides a few years ago are no longer available, and more restrictions are

regularly being imposed on others as undesirable side effects are discovered.

In addition, other methods that place greater emphasis on biological control or are more selective and less deleterious to the environment may be proposed. The necessity for control is indicated, based on past experience, and the most vulnerable stages in the pest's life cycle are suggested. Because the type of feeding (chewing or sucking) and habit (open feeder or miner) will also influence the selection, suggestions are made regarding the required mode of action (contact, stomach, systemic or fumigant) of the pesticide. If chemical control measures are necessary, the advice of specialists should be sought regarding the currently acceptable pesticide. In addition, the labels on pesticide containers list all the registered uses along with the concentration to be used and the precautions to be taken.



Forestry Centres

Pacific Forestry Centre
506 West Burnside Road, Victoria, British Columbia V8Z 1M5

Northern Forestry Centre
5320-122 Street, Edmonton, Alberta T6H 3S5

Great Lakes Forestry Centre
Box 490, Sault Ste. Marie, Ontario P6A 5M7

Laurentian Forestry Centre
Box 3800, Sainte-Foy, Quebec G1V 4C7

Atlantic Forestry Centre
Box 4000, Fredericton, New Brunswick E3B 5P7

Native pines

White pine

Red pine

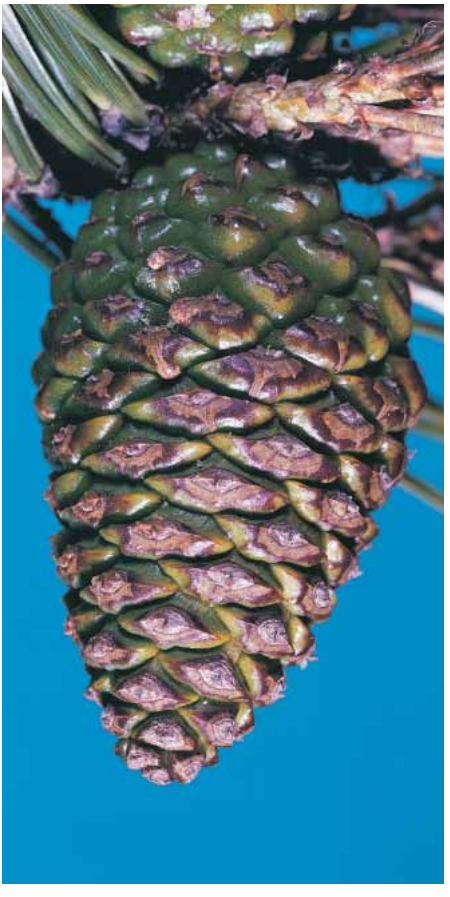
Jack pine

Pitch pine

Introduced pines

Scots pine

Mugho pine



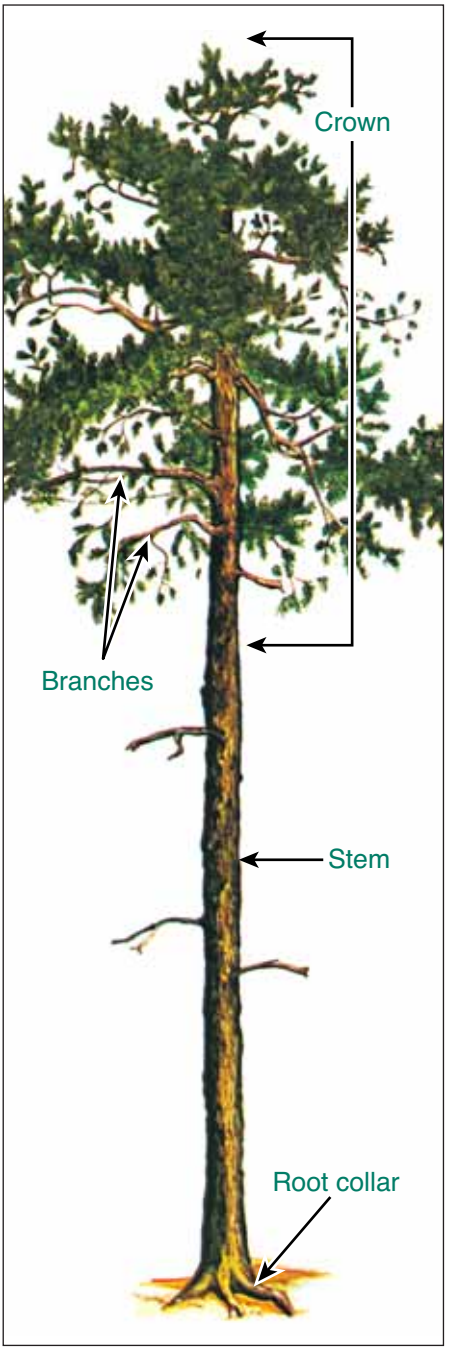
Austrian pine

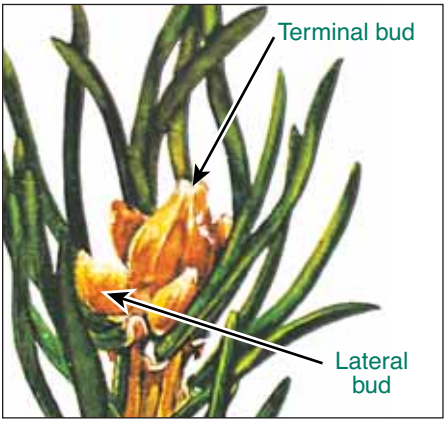
Of the seven most common pines in eastern Canada, four are natives and three are introduced. Three of the native pines, jack, red and white, are widely distributed, whereas pitch pine is found only along the upper St. Lawrence River. Scots pine, frequently called “Scotch”, has been widely planted and is cultivated for Christmas trees. Mugho, usually with a low spreading form, is a common ornamental. Austrian pine has been used as a roadside tree, especially in southern Ontario.

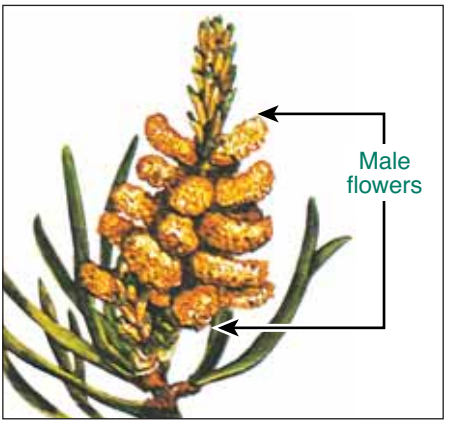
All needle photographs have a common scale (1:2.5). Additional information on the native and introduced pines including needle length can be found in *Trees in Canada*.

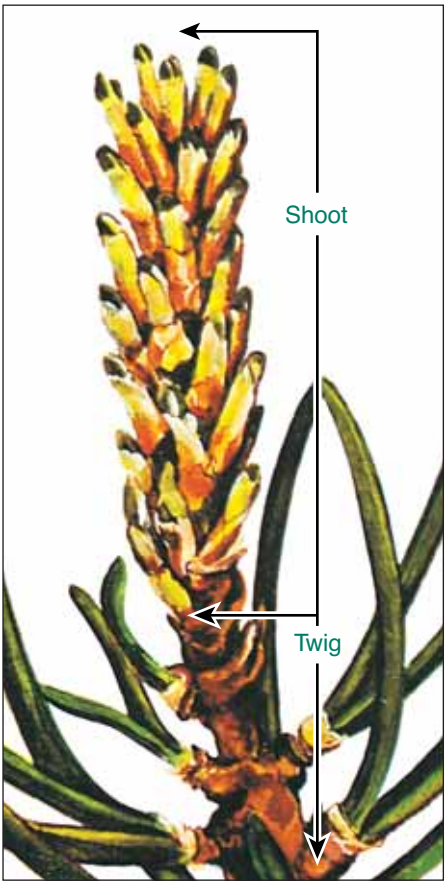
Parts of tree

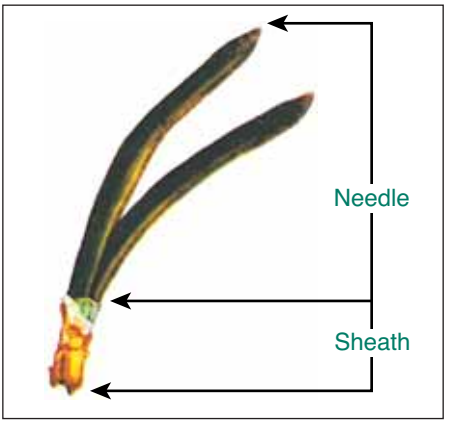
All parts of a tree are subject to insect attack. Because some of the parts grade almost imperceptibly into one another, they can best be delineated by an understanding of the seasonal growth of the tree. In the winter a relatively large terminal bud and two or more small lateral buds are found at the tips of the branches. In the spring the buds elongate and the tiny needle clusters, which are enclosed in a sheath of scales, separate to reveal the new shoot, i.e., current growth. As the shoot elongates, the basal portion is often bare or encircled with small spherical clusters of male flowers. These mature in early summer when the yellow pollen is shed. At this time, the tiny female flowers near nodes or the tip of the shoot (see conelet on red pine cone illustration, page 14) are fertilized. The resulting cones take 2 years to mature, except those of Austrian pine, which require 3 years. Needle and shoot growth occur simultaneously, and the needles soon outgrow their sheath of scales, most of which is subsequently shed except on red pine, where a large part of the sheath persists for a year. By mid-July the buds that will develop in the succeeding year are evident. For purposes of this handbook, shoot is defined as linear growth in the current year and twig is growth of the previous year. A branch is any portion of the crown that is older than 2 years excluding the main stem, the apical portion of which is called the leader.

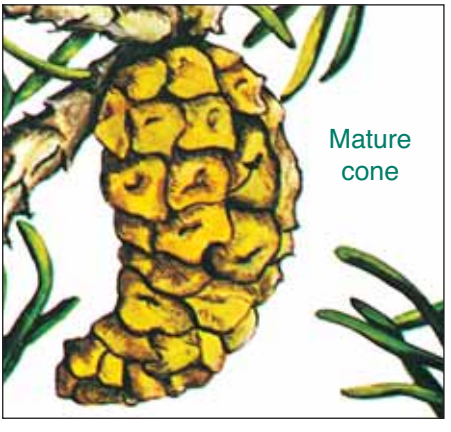



Terminal bud
Lateral bud

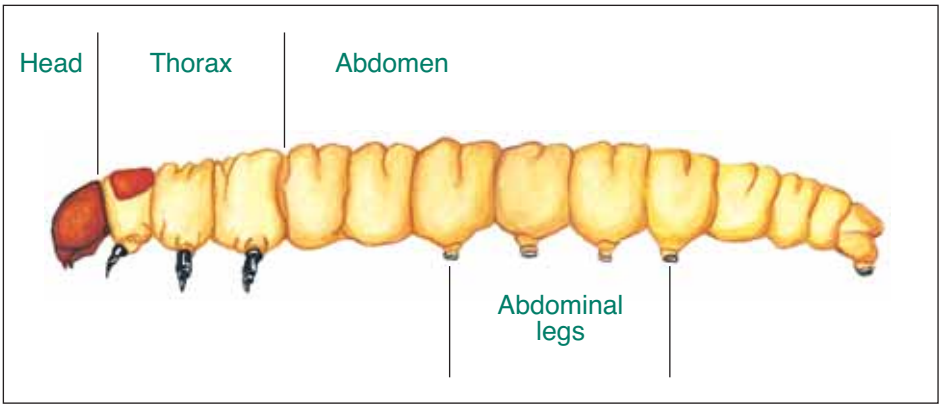

Male flowers


Shoot
Twig

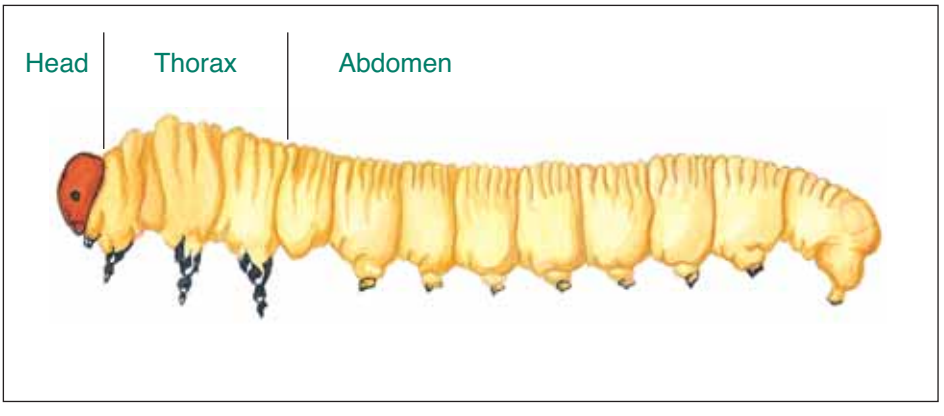

Needle
Sheath


Mature cone

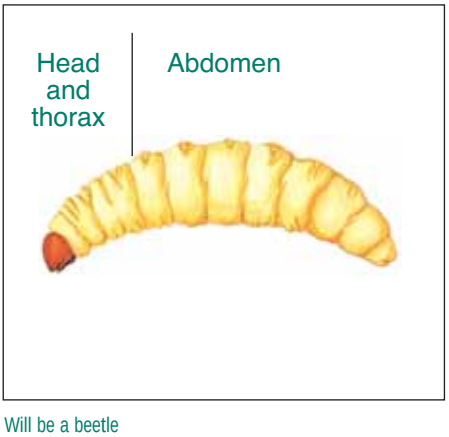
Types of larvae



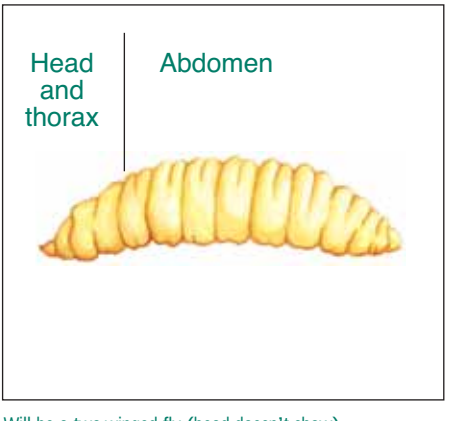
Will be a moth



Will be a sawfly



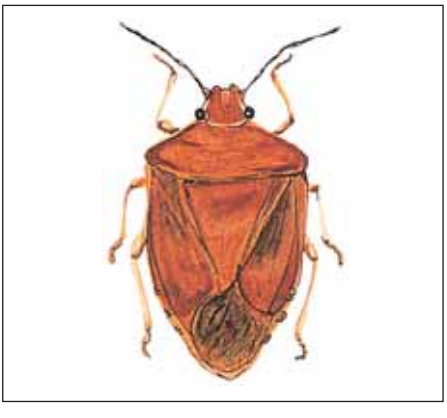
Will be a beetle



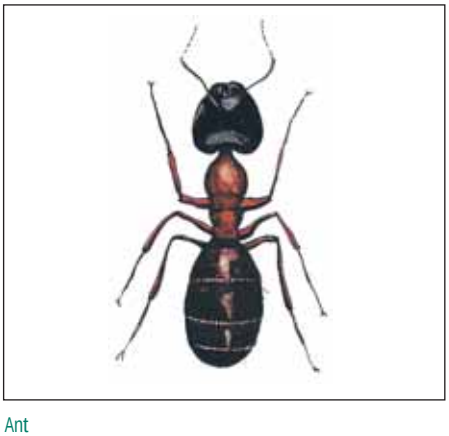
Will be a two-winged fly (head doesn't show)

Some common adults

Lady beetle



Stink bug

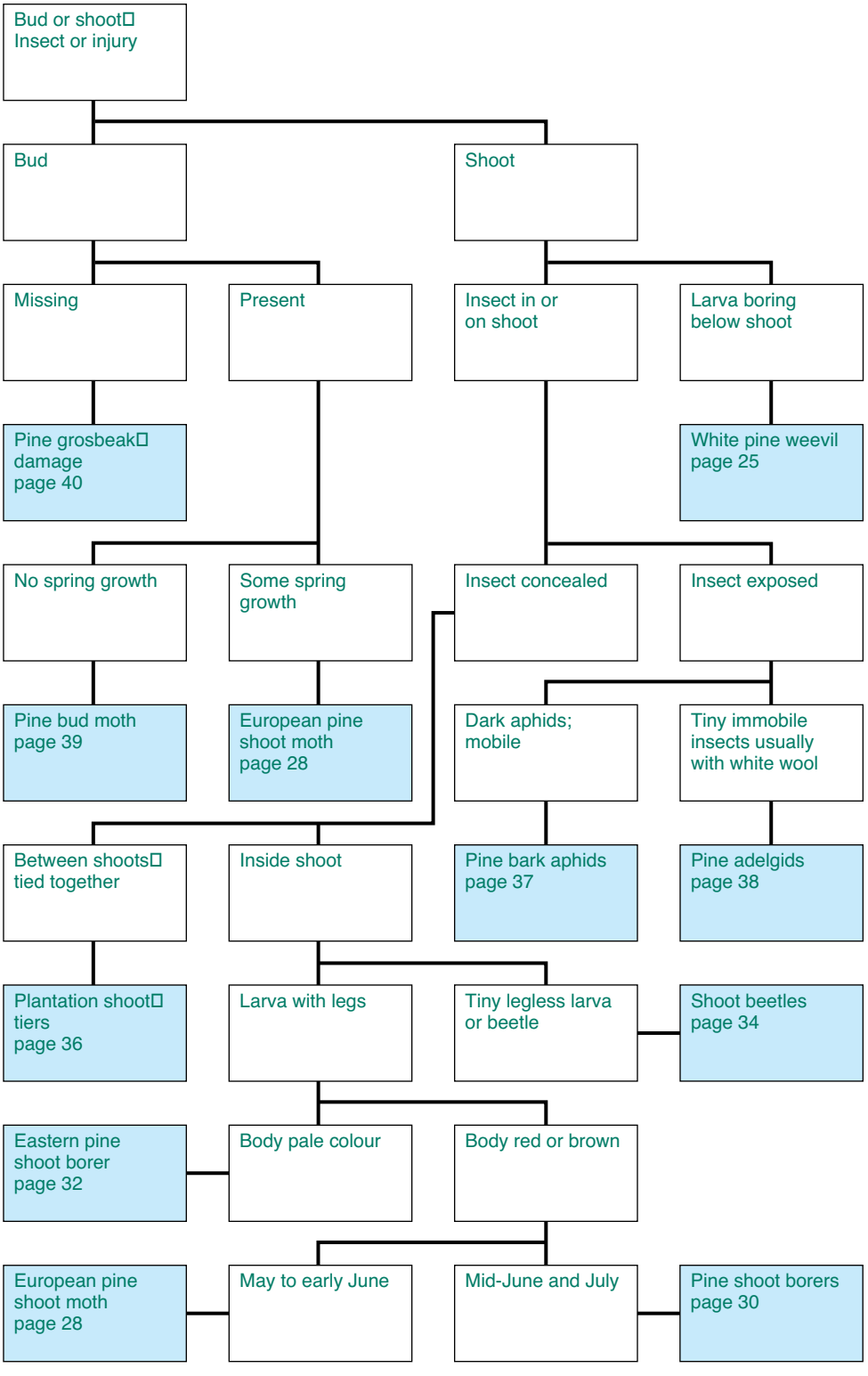


Ant

Most injury by insects is caused by worm-like creatures referred to variously as caterpillars, worms, grubs, maggots and larvae. These are the immature forms of adult moths, sawflies, beetles or two-winged flies. Typical forms are illustrated here, and pertinent parts are labelled. For examples of the developmental stages of two important forest pests, see pages 48 and 58. Some adults also cause injury by feeding, and these will be discussed later in the appropriate sections. However, most adults found on trees during the day, even when large flights are observed, are of little consequence because the ones that lay their eggs or feed on the tree usually do so at night. Three kinds of adults commonly found on pine are illustrated here. The lady beetles and stink bugs are common predators of harmful insects and are, therefore, beneficial. Ants, although not injurious to trees, are often found in large numbers associated with aphids.

Bud or Shoot

Bud or shoot


Bud or shoot
Insect or injury
Bud
Shoot
Missing
Present
Insect in or on shoot
Larva boring below shoot
Pine grosbeak damage page 40
White pine weevil page 25
No spring growth
Some spring growth
Insect concealed
Insect exposed
Pine bud moth page 39
European pine shoot moth page 28
Dark aphids; mobile
Tiny immobile insects usually with white wool
Between shoots tied together
Inside shoot
Pine bark aphids page 37
Pine adelgids page 38
Plantation shoot tiers page 36
Larva with legs
Tiny legless larva or beetle
Shoot beetles page 34
Eastern pine shoot borer page 32
Body pale colour
Body red or brown
European pine shoot moth page 28
May to early June
Mid-June and July
Pine shoot borers page 30

White pine weevil

Throughout the range of white pine in eastern North America probably no insect is a more prevalent conifer pest than the white pine weevil, *Pissodes strobi* (Peck). Although white pine is the most common host, all pines and spruces may be attacked. By attacking and killing the leader, the top part of the main stem, the weevil seriously affects tree form and consequently the commercial and aesthetic potential of the tree. In poorly stocked plantations, repeated weevilling of trees 1 to 10 metres in height can result in a commercially worthless stand of trees.

The adult weevils hibernate in the litter under infested trees and emerge from their winter quarters when maximum daily air temperature exceeds 15°C (60°F), usually in April. They move to the upper part of the leader, where they feed by inserting their snout into the inner tissues of the bark; during this period of about 1 week they mate. The eggs are laid in the feeding punctures over a period of a month or more. The copious flow of resin from the tiny feeding punctures on the leader indicates attack. The eggs hatch in about 2 weeks and the tiny legless larvae tunnel downward, usually arranged in a ring formation in the inner bark. When the conducting tissues in the bark are severed, the top whorl of shoots withers (beginning in mid-July), eventually turns red and assumes the shape of a shepherd's crook. The mature larvae, about 7 mm long, tunnel into the wood.

Deformed tree

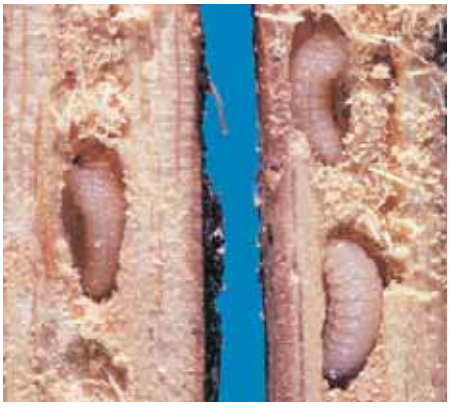
White pine weevil adult

White pine weevil feeding punctures

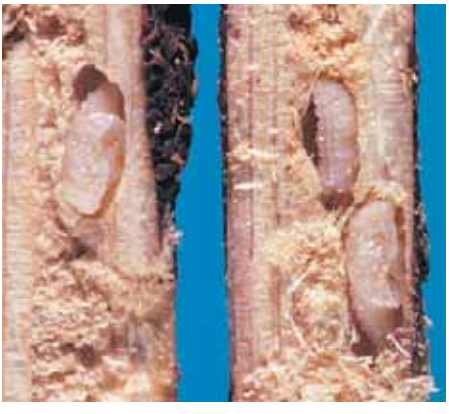
Withered top whorl

They construct chip-like plugs at the entrance hole and transform to pupae in the pith. The slim maggot-like larvae that are frequently found under bark in weevilled leaders are the immature forms of a small fly, *Lonchaea corticis* Taylor, whose role as a predator has been established. Weevil adults emerge from the infested stem in August and September and, after some feeding, seek hibernating sites.

To date, natural control agents do not appear capable of maintaining tolerable levels of damage by weevils, especially in white pine plantations. However, if white pine is grown under a canopy of broad-leaved trees, it is relatively free from weevil injury. Trees that are infested should be hand pruned down to the green foliage about mid-July and the wilted, infested leaders destroyed to prevent population increase. Another



White pine weevil mature larvae



Pupae and larva

Maggot-like larvae

Weevil adult

means of control is the use of a pesticide at 3- to 4-year intervals until the trees are over 10 metres tall. Stomach poisons with good residual qualities applied in the spring as soon as the adults are observed have been most effective to date.

European pine shoot moth

The European pine shoot moth, *Rhyacionia buoliana* (Denis & Schiffermüller), first reported in North America in 1914 from the New York area and later found in Ontario and Nova Scotia in 1925, has become a common pest of pine in southern Ontario. Elsewhere in eastern Canada it occurs at scattered localities, sometimes in high numbers. Although all species of pine are attacked, red and Scots pine are preferred. Repeated attack on red pine has been especially damaging because of the resulting stem deformity . The moths emerge in June and July and lay their eggs singly or in small groups on needle sheaths, buds or needles of the current year's growth. The eggs hatch in about 10 days, and the young larvae spin webs between a needle sheath and the twig; they feed within the sheath, and the needles discolour and die. In late summer and fall, the larvae bore into and hollow out buds, and they overwinter there or in resin-encrusted webs on the tree. In the spring the larvae move to an expanding bud or shoot where they complete their feeding. The most noticeable injury is caused at this time . When full grown, the larvae are about 13 mm long . The pupae are formed in silk-lined chambers in mined buds or shoots from late May to mid-July, and the adults emerge in about 14 days.

Although numerous parasites and predators attack the shoot moth and cause appreciable mortality, other control measures may

European pine shoot moth

Mature larva

Pupa

Deformed tree

Damaged shoot

still be necessary. In Scots pine Christmas tree plantings, shearing and pruning usually reduce populations to acceptable levels. Otherwise, application of a contact or stomach insecticide with good residual properties, in the spring when the larvae move from overwintering sites or in the summer after all the adults have emerged and before the young larvae start to feed in early July, should provide relatively good control.

A pine candle moth, *Exoteleia nepheos* Freeman, found only in southern Ontario where it has been of little consequence, has caused some serious injury in Christmas tree plantations south of the Great Lakes. The larvae are pale reddish and about 6 mm long when full grown, and feed in flowers or shoots from the latter part of May to mid-June.

Pine shoot borers

In this group there are three species and they may be separated as follows:
Attacked trees less than 1 metre high, and the lower part of trees up to 8 metres tall, larvae red- brown up to 7 mm long . . . . . *Rhyacionia adana* Heinrich.
Attacked trees more than 1 metre high, larvae red up to 9 mm long, on jack pine. . . . . *Rhyacionia granti* Miller
on red pine or Scots pine . . . . . *Rhyacionia busckana* Heinrich.
Attacked trees more than 1 metre high, larvae grey to brown up to 20 mm long, on red pine . . . . . *Dioryctria resinosella* Mutuura.

The known Canadian distribution of the pine tip moth, *Rhyacionia adana*, is currently restricted to Ontario where it is the most common tip moth on red, jack and Scots pine. It is also found in the northern and northeastern parts of the United States.

The adults emerge in early spring while there are still patches of snow on the ground. The eggs are laid just above the needle sheath, and the young larvae, on emerging, mine a small area of needle above the egg site. Later, when they are from 2.5 to 5 cm long, they move to the new shoots and feed within a needle sheath or tunnel in the shoot. Following completion of feeding in mid-June to late July, the larvae drop to the ground and construct their overwintering cocoons in the root collar area of the tree. Damaged shoots are inconspicuous until they turn brown , by which time the insect has gone. However, the cocoons at the root collar will confirm the identity of the causal agent.

Pine tip moth damage

Jack pine shoot borer damage

Red pine shoot moth damage

Red pine shoot moth larva

The Canadian distribution of the jack pine shoot borer, *Rhyacionia granti*, encompasses northern Ontario and southeastern Manitoba. In northern Ontario the larvae complete their feeding in early July and drop to the ground to pupate. The dead jack pine tip with the silken tube ▭, on trees over 1 metre high, will identify the causal agent.

The red pine shoot borer, *Rhyacionia busckana*, is closely related to *R. granti*. In the past, these two species have been confused with one another. They have a similar life cycle and distribution, but *R. busckana* is found on red and Scots pine trees over 1 metre high.

The third shoot tip borer, the red pine shoot moth, *Dioryctria resinosella*, is regularly found in small numbers on red pine in southern Ontario. However, in the northern United States, extensive shoot injury has been reported. The dead tip ▭ and the large dark-coloured larva, up to 20 mm long ▭, will be diagnostic characteristics.

Among these tip borers, chemical control measures have been attempted only against *Rhyacionia adana*. However, the chemical used is no longer acceptable, and no satisfactory alternative is known. Systemic poisons, which to date have not been too successful against borers in conifers, would still seem to offer the best chance of success in controlling these pests.

Eastern pine shoot borer

Broken jack pine leader

The eastern pine shoot borer, *Eucosma gloriola* Heinrich, occurs throughout the natural range of white pine except in the Atlantic provinces. It has not been a problem in natural stands but is often abundant in poorly managed or thinly stocked plantations or wherever a closed crown canopy does not occur. It feeds on all species of pine with heaviest attacks usually occurring in shoots in the upper part of the tree. When the leader is killed and one of the lateral shoots becomes the new leader, a crooked stem results.

Moths emerge from overwintering cocoons in May. Eggs are laid on the needle sheaths or elsewhere on the developing shoots. The larvae bore directly into the pith and feed towards the base of the new shoot. Near the end of its feeding period, usually in July, the larva reverses direction and widens the original tunnel. The full-grown larva is almost 13 mm long with a pale body and yellow-brown head. Finally, it

Eastern pine shoot borer larva in shoot

Wilted shoot

Yellow jack pine shoot borer damage

cuts a hole to the outside and drops to pupate in a cocoon in the soil. The injured shoots wilt and break readily at the last point of feeding. As with other borers in shoots, large-scale chemical control measures have been relatively unsuccessful or too costly. In ornamental situations, hand pruning of damaged shoots while the larva is still present is perhaps the best means of control.

Another pale shoot borer is the yellow jack pine shoot borer, *Rhyacionia sonia* Miller, which has been found at scattered locations from Maine to Manitoba, mostly on jack pine but also on pitch pine. The yellowish larvae, which attain a length of about 9 mm, mine the tips of new shoots of these pines in late June and in July . The silk and excreta among needles of the dead shoot tip are diagnostic characteristics. Serious injury has not been recorded and no specific control measures are known.

Shoot beetles

With the introduction of exotics, such as the pine shoot beetle, it is increasingly more difficult to identify shoot beetles. Beetles and damage should be submitted to an expert for identification.

On jack and Scots pine. . . . . red pine cone beetle
(see page 113 for damage to red pine cones)
On Scots pine and others . . . . . pine shoot beetle

The red pine cone beetle, *Conophthorus resinosae (=banksianae)* Hopkins, formerly known as the jack pine tip beetle, feeds primarily on jack pine shoots and red pine cones and is found in Ontario and the northern United States and less commonly in the Maritime provinces. The red to black adult beetles are about 2.5 mm long. They bore into tips of jack pine twigs to feed in May and leave a characteristic pitch-encrusted entrance hole. In early June, egg tunnels constructed by the female cause the new growth to wilt and die ▭. The tiny larvae, usually two to three per tip, extend the egg tunnels into the current year's growth. The parent beetles produce two or more broods each summer. In the fall the adults attack the shoots near the base of the bud ▭, mine the bud and cause the needles near it to turn brown. The mined shoot tips are very fragile and easily broken off by the wind. The beetles overwinter on the ground inside the fallen tips. Although the red pine cone beetle has occurred in relatively large numbers in localized areas from time to time, it has not caused serious injury. No chemical control measures are known.

Damaged shoots

Damaged tip in fall

Pine shoot beetle damage

Pine shoot beetle damage to Scots pine

Pine shoot beetle and damaged shoot

The pine shoot beetle, *Tomicus piniperda* (Linnaeus), was first discovered near Cleveland, Ohio, in 1992 and is now found in nine states in the United States and throughout southern Ontario. The adults range in size from 3 to 5 mm with a black head and thorax and reddish to black wing covers. They have the potential of infesting all pines within their range, but in Ontario they have been found on Scots, jack and white pine. Adults tunnel in the current or 1-year-old shoots of pine throughout the summer and fall. A round hole, often surrounded by pitch, and a debris-free tunnel, 1–4 inches long, indicate that the shoot has been infested . A single adult beetle may infest more than one shoot and some shoots may have several short tunnels. In Scots pine, this maturation feeding causes the tunnelled shoots to become discoloured and to droop, die and fall from the tree . After a hard frost in the fall, adults fly to the base of the tree on which they last shoot-fed, chew a niche in the bark and overwinter. Recently, cut or dying pine trees, stumps or logs may also be chosen for overwintering sites. During the late winter or early spring, adults mate and lay eggs. Larvae feed between the wood and the bark in small tunnels that radiate away from the egg gallery. A combination of sanitation, monitoring populations and chemical insecticide applications may control populations of this beetle.

Plantation shoot tiers

This is a group of closely related species that have caused serious injury to young plantation trees growing on weedy, former agricultural land. The larvae normally feed on herbaceous ground-cover plants such as clover and alfalfa but move to adjacent trees up to 1.2 metres high to feed on the new shoots, which they tie together with silk in May and June. The best means of control is to remove herbaceous plants from young plantations, particularly in the immediate area around each tree.

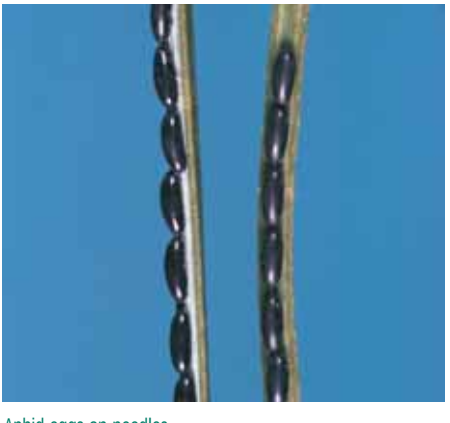
The species in this group are the tortricids, *Aphelia alleniana* (Fernald), *Choristoneura rosaceana* (Harris), *Xenotemna pallorana* (Robinson) and *Sparganothis sulfureana* (Clemens). When full grown, larvae of the first three species are more than 20 mm long and the last named is about 16 mm. All are active larvae that move very quickly when disturbed.

Shoots tied together

Pine bark aphids

A number of species of aphids of the genus *Cinara* occur on pine. One or more of these are found on each of the pines in central and eastern Canada. They pierce the bark with their long feeding tubes and feed on the sap from shoots ▭, twigs, branches, stem or roots. Some feed singly, others in small to large colonies, which are usually attended by ants that feed on the droplets of excreted liquid. These aphids vary in colour from grey to brown or black and are less than 5 mm long. All species overwinter on the needles in the egg stage. The eggs are blackish and are usually laid singly or in twos on short-needled pines and in an end-to-end row of up to eight or more on the long-needled pines ▭. Six generations in 1 year are not unusual, and succeeding generations often move to new sites on the tree as the season progresses. The life cycle is complex; e.g., adults of the intermediate, summer generations consist of females only, some winged and others wingless, which give birth to living young. Males occur only in the late fall generation, which produces the overwintering eggs. No large-scale chemical control measures have been required for pine aphids. When control on ornamentals is necessary, a contact type insecticide should be satisfactory.

Aphid colony on shoot



Aphid eggs on needles

Pine adelgids

Pine leaf adelgid adults

Damaged shoot

Six species of adelgids of the genus *Pineus* occur on pine at some time in their complex life cycle, which usually includes spruce as the primary host on which a gall is formed. Although white pine is the secondary host of five of the species, other pines such as Scots, red and Austrian also serve as hosts. The separation of species is difficult, and identification is best left to the entomologist.

The species most commonly found on shoots is the pine leaf adelgid, *Pineus pinifoliae* (Fitch). The females, about 2.5 mm long, settle in a row along the needles of white pine in June, always facing towards the needle base, a diagnostic characteristic of this species. The eggs are laid in clusters on the needle. The females, their wings providing a shelter for the eggs, die on the needle and usually remain attached there well into winter. The eggs hatch in early July, and the young move to new shoots where they feed by inserting their fine tubular mouth parts into the sap stream. They develop white woolly fringes. After passing one winter on the pine, the young resume development and a winged form is produced, which returns to the spruce where their progeny produce galls the following year. The winged form produced in the gall returns to the pine. The species is known as one of the most serious pests of white pine where it grows adjacent to red or black spruce in the Atlantic provinces and the northeastern United States. Heavy feeding by the young adelgids on pine shoots, which occurs in alternate years, will kill the shoots. Large-scale chemical control measures using a systemic insecticide on both pine and spruce have been relatively unsuccessful. However, control on ornamentals could be effected by early removal of the galls on spruce or the use of a contact insecticide on pine.

Pine bud moth

Bud and needle damage

Mined needles

The pine bud moth, *Exoteleia dodecella* (Linnaeus), another introduced species, was first reported in the Niagara Peninsula in 1928. Although this moth is particularly injurious to young pines in Sweden, in Ontario the greatest injury has been to roadside plantings of older Scots pine, but mugho pine is also frequently attacked. The young larvae overwinter in needle mines and enter the buds in early spring. They are reddish brown and about 6 mm long when full grown. The pupa is formed in the bud in June, and the adult moths emerge in late June or early July. The presence of a dead bud associated with a number of needles with the top half mined is characteristic of the pine bud moth . No chemical control has been required to date.

Pine grosbeak damage

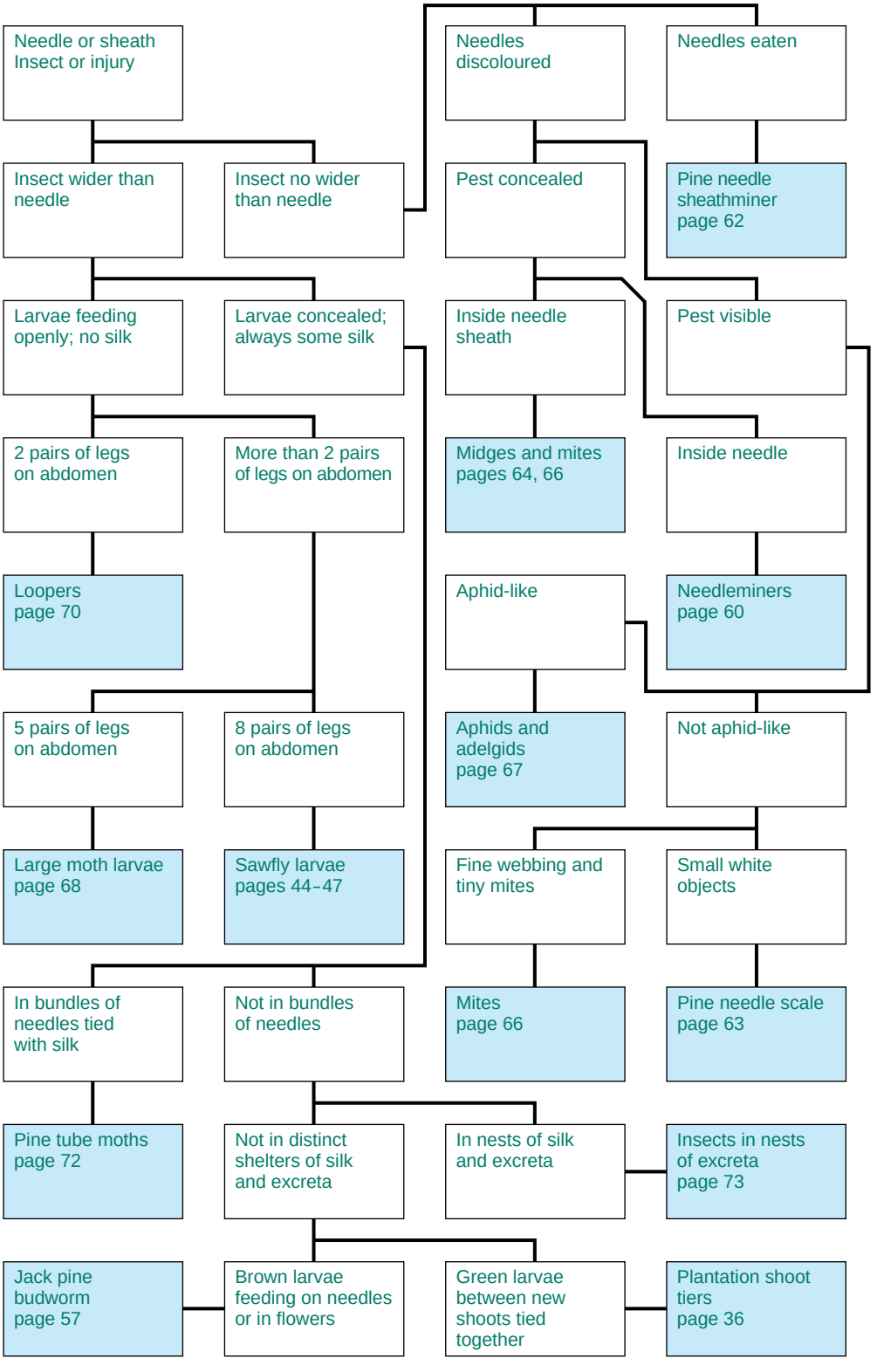
Winter food of the pine grosbeak , *Pinicola enucleator* (Linnaeus), consists almost entirely of buds, seeds and fruits of both hard- and softwoods. In some years when these birds move from their breeding grounds in the northern spruce/fir forests into plantations, at any time from fall to early spring, their feeding may result in complete loss of buds. The reasons for the sporadic occurrence of heavy feeding and severe damage in some areas and not in others are obscure.

The feeding damage on pine by this grosbeak is quite typical. All or nearly all of the green portion of the bud is removed by the sharply hooked upper bill, and the outer bud scales are left almost intact. Usually the central bud in a cluster is removed , which results in multiple leaders, but all buds may be destroyed in severe feeding. Grosbeak feeding is of primary concern to Scots pine Christmas tree growers because loss of buds may delay harvest for a year or two or result in poorly shaped trees. Repellents may reduce this type of injury, but the necessity for their application is not predictable, and due to the cold temperatures when the birds are feeding, application is not always possible.

Terminal bud loss

Needle or Sheath

Needle or sheath



Pine sawflies

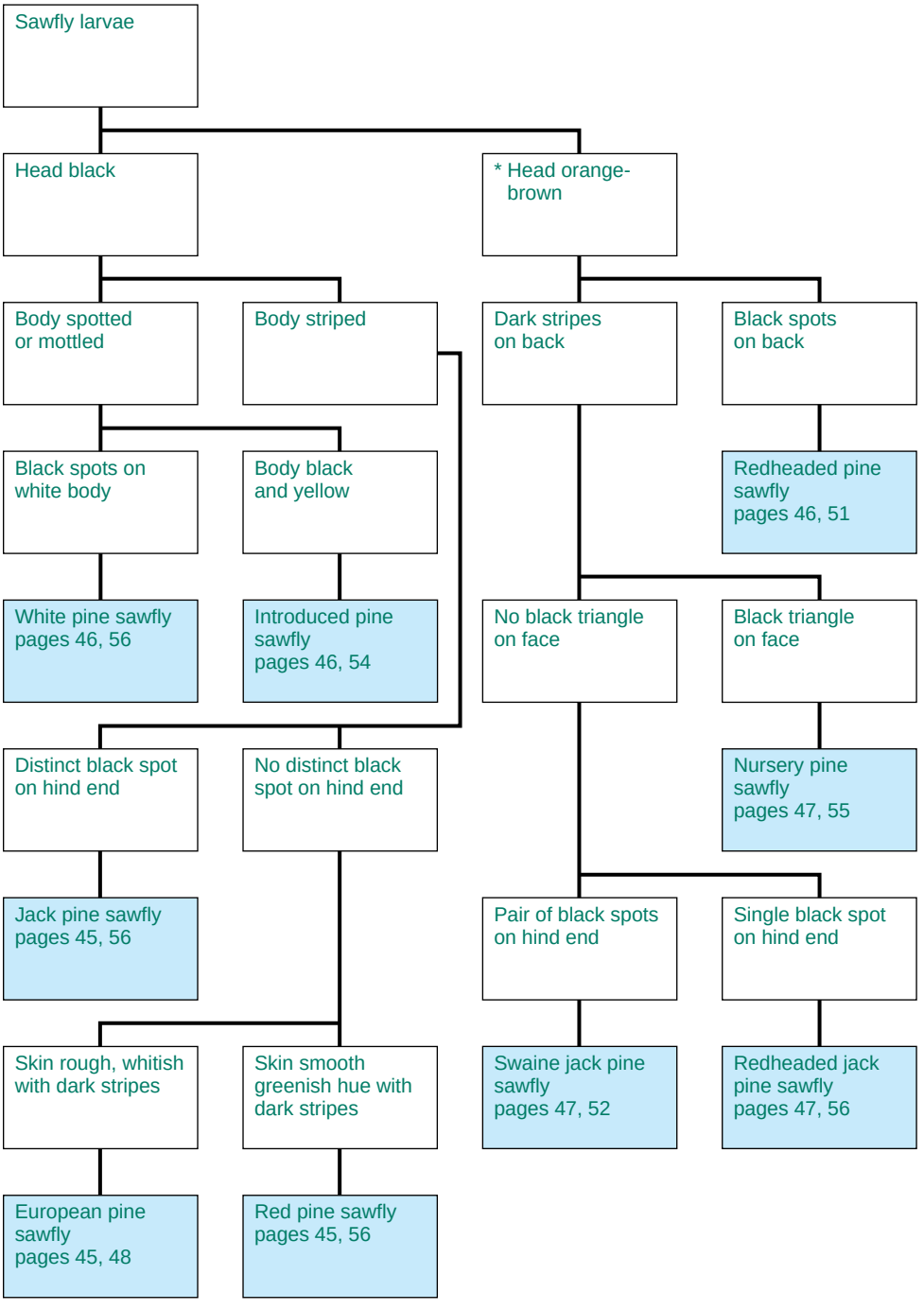
Fourteen species of sawflies, mostly native but some introduced species, are open feeders on the needles of pine in central and eastern Canada. Some have been serious defoliators of pine and are assuming increasing importance in the cultivated forests that are often composed of a single species, an environment that generally enhances the survival chances of pests. Since species are often similar, a key to separate the full-grown larvae of the common species is provided (page 44). The most important species are dealt with in sufficient detail to provide information for control purposes; other less common species are dealt with only superficially.

Three relatively rare species of sawflies are not included in the key or text. They are *Neodiprion compar* (Leach), *Neodiprion abbotii* (Leach) and *Neodiprion nigroscutum* Middleton.

The name sawfly is derived from the tiny saw-like structure at the tip of the female's abdomen that is used to cut holes in plant tissue into which the eggs can be inserted. The eggs of pine sawflies are laid singly in slits cut in the needle edge. Upon hatching, the young larvae usually feed together (colonies), and members of some species remain more or less together throughout most of their feeding stages, frequently stripping needles off whole branches before moving on to another. When the feeding stage is completed, the larvae spin oval, tough, paper-like cocoons most frequently in the humus but sometimes attached to twigs of the host tree or to groundcover plants. The smaller cocoons generally contain males and the larger ones females. The adults emerge in the spring or fall, depending on the species, and the cycle is repeated.

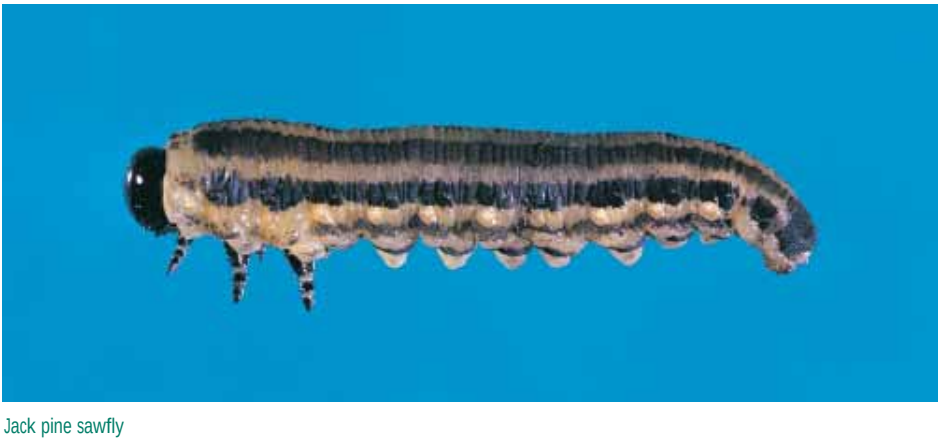
Sawfly larvae

*Some individuals in a colony may have dark brown heads.



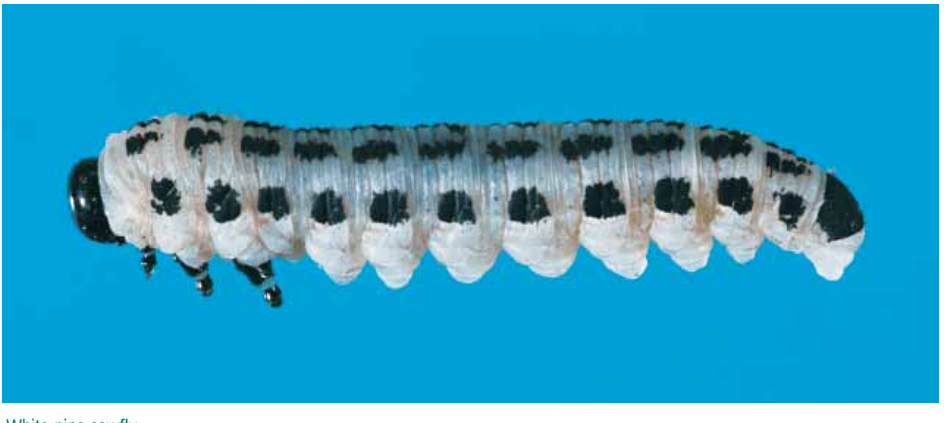
European pine sawfly

Red pine sawfly

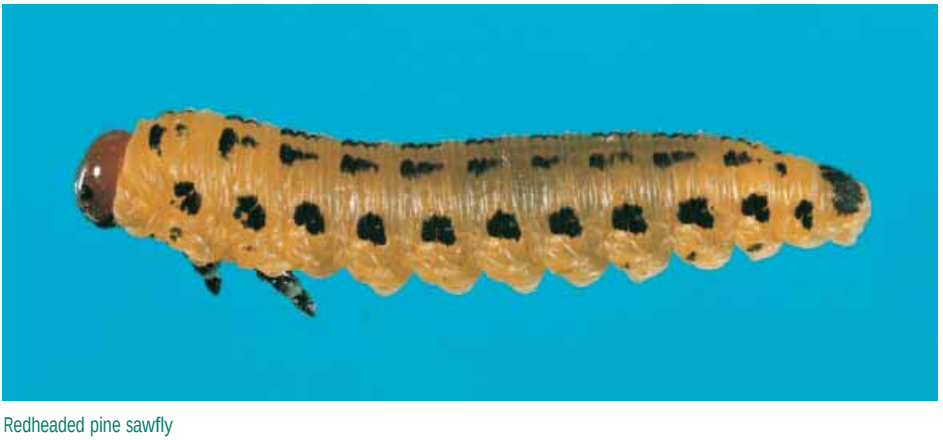


Jack pine sawfly

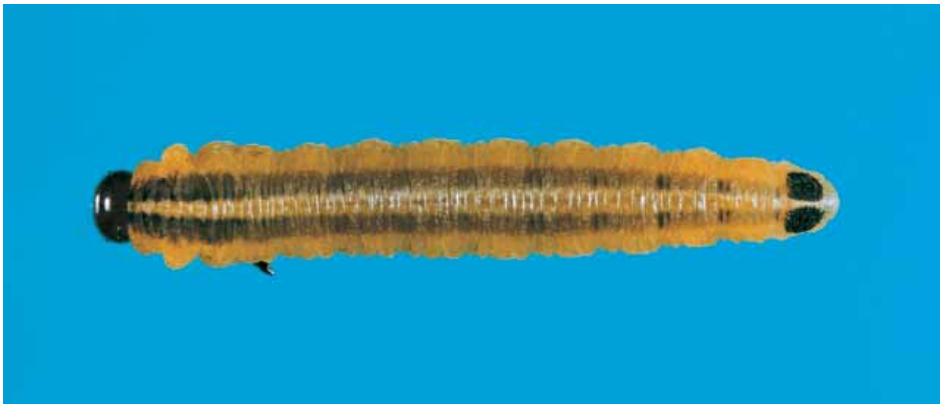
Introduced pine sawfly



White pine sawfly

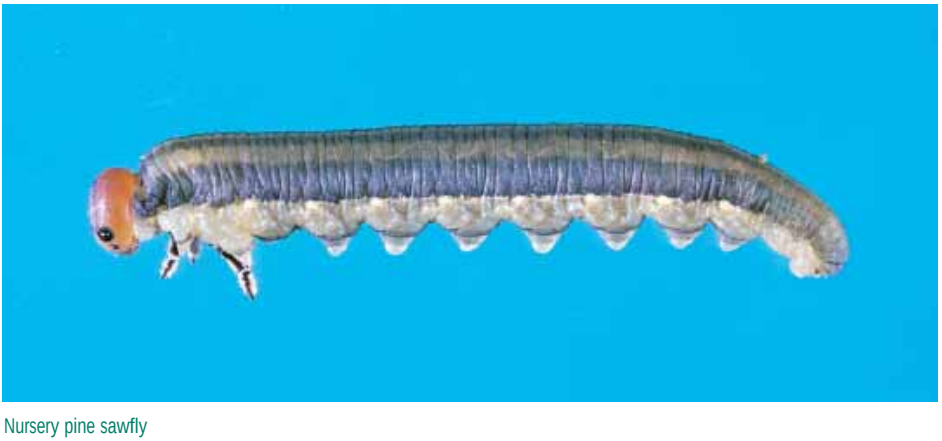


Redheaded pine sawfly



Swaine jack pine sawfly

Redheaded jack pine sawfly



Nursery pine sawfly

European pine sawfly

The first Canadian record of the European pine sawfly, *Neodiprion sertifer* (Geoffroy), was in 1939 at Windsor, Ontario. Over the next three decades, this pest spread slowly to its present boundaries. Its eventual spread throughout Ontario appears to be inevitable because of the movement of vast quantities of nursery material. It is now established in Newfoundland and has been collected in the other Maritime provinces and Quebec. The threat to natural stands of susceptible species is a major concern. Although it feeds on many species of pine, this insect is a particular pest in Scots pine plantations, and consequently is a threat to Christmas tree crops, particularly in southern Ontario. Heavy damage to red pine is illustrated .

The adults are in flight in late August and September, and the eggs are laid in the needles in late September and October. The following spring the eggs hatch as the new shoots are developing , and the larvae feed until mid-July on foliage produced in previous years. When full grown, the larvae are about 22 mm long. Their feeding completed, the larvae drop to the ground where they spin tough, golden-brown cocoons page 50.

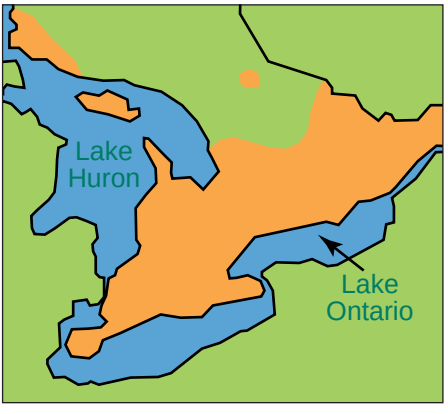
Parasites, predators and disease organisms all play a role in generally regulating populations at acceptable levels. Parasites include both native and introduced species. One of the most common parasites that attacks the insect in the cocoon stage is an introduced species,

European pine sawfly female

Male

Sawfly eggs in needles

Early feeding damage



Distribution of the European pine sawfly in Ontario in 1998

Damaged red pine

Colony of larvae

*Pleolophus basizonus (*Gravenhorst) . Of the predators, small rodents are probably the most important. A nuclear polyhedral virus often causes considerable mortality and may bring about the collapse of infestations. The value of the virus as a mortality factor is now being enhanced by using it as one would use an insecticide, preferably applying it to the very young larvae to bring about mortality before harmful defoliation occurs. The effectiveness of the virus decreases as the larvae reach maturity. However, replication of the virus occurs in the midgut of affected larvae and can be secreted with the frass to contaminate eggs and other surfaces. In this way, the virus can be passed to other generations. If in certain instances populations increase to levels that threaten tree crops and chemical control is necessary, a contact or stomach poison should be applied as early as possible both to increase its effectiveness and to reduce foliage loss.

Parasite attacking cocoon

Virus-killed larvae of European pine sawfly

Redheaded pine sawfly

The redheaded pine sawfly, *Neodiprion lecontei* (Fitch), is probably the most serious pest of red pine plantations in southern and central Ontario and south-central Quebec. A complete defoliation kills small trees, but less extensive feeding results in poor diameter growth and often the death of defoliated branches. Although red pine is the preferred host tree, jack, Scots and other pines are attacked as well. Adults emerge and eggs are laid in the needles in June and July. The larvae may be found from July to early October feeding in colonies and show a preference for needles of the previous year's growth, although in heavy infestations all needles are consumed. The full-grown larva is about 25 mm long. The winter is passed in a cocoon in the litter.

Extensive mortality of pine sometimes occurs in young plantations in spite of a host of natural controls such as parasitic insects; insect, bird and rodent predators; and virulent disease organisms, especially a polyhedral virus that often causes the collapse of heavy infestations. If necessary, a contact or stomach poison may be applied when the larvae are first seen to prevent serious loss of foliage.

Defoliated tree top

Colony of redheaded pine sawfly larvae

Swaine jack pine sawfly

Colony of Swaine jack pine sawfly larvae

The Swaine jack pine sawfly, *Neodiprion swainei* Middleton, is the most destructive sawfly on jack pine in eastern Canada. It has killed thousands of acres of merchantable trees between the 46th and 49th parallels, mostly in Quebec but also in northeastern Ontario. Within this area outbreaks have been periodic and centred in a number of apparently highly susceptible stands. Jack pine plantings in the northern part of the Lake States have also been attacked.

The adult sawflies emerge in late June and early July, and the females characteristically lay one pair of eggs in each of the needle pairs . Eggs hatch in about a month, and colonies of larvae may be found feeding from July into October; feeding often results in complete loss of needles . The full-grown larva is about 18 mm long. The cocoons are spun in the soil beneath the tree, and the winter is passed there.

Severe needle loss

Eggs on needles

Due to the threat by this sawfly to valuable stands of jack pine, large-scale aerial applications of some of the less persistent insecticides and also of a polyhedral virus have been made to reduce potential losses. Any currently acceptable stomach or contact insecticide should prove effective against this pest.

Introduced pine sawfly

The introduced pine sawfly, *Diprion similis* (Hartig), was first recorded in Canada in 1931 near Oakville, Ontario, and it had not spread much beyond 120 kilometres of that point. In 1970 light infestations were found in mature white pine near Fort Frances, probably as extensions of infestations in the Lake States, and larvae were found on white and Scots pine in 1970 and 1971 in Sault Ste. Marie. Although it was first found in southern Quebec in 1940, it does not appear to have spread and has remained a rare species there. Though all pines are attacked, white and Scots pine appear to be preferred hosts.

Larvae are found as early as June, but because there is commonly a second generation they may be more abundant in late August and September. Initially, the larvae feed gregariously but they separate sooner than other sawflies, and needle loss is more diffuse. The full-grown larva is about 28 mm long. Cocoons are spun among needles or elsewhere on the tree, as well as in the ground litter. Overwintering larvae in exposed cocoons are probably killed by low winter temperatures.

Populations of this sawfly appear to be maintained at relatively low levels by natural control factors. However, if chemical control becomes necessary, a contact or stomach poison applied when the larvae are small should be effective.

Introduced pine sawfly larva and cocoon

Adults

Nursery pine sawfly

Nursery pine sawfly larva on needle

Frontal view of larva

The nursery pine sawfly, *Gilpinia frutetorum* (Fabricius), is another introduced species, first found in Canada at Niagara Falls in 1934. Since then it has been found mostly on Scots but also on red pine throughout the southern row of counties in Ontario and into south-central Quebec. The full-grown larva is about 22 mm long and is mainly a solitary feeder. Populations of this sawfly fluctuate at low levels and are apparently synchronized with the introduced pine sawfly. Their life histories and habits are similar and both species are often found on the same trees. The distinct markings of the larvae readily separate the species. Chemical control measures have not been necessary.

Other pine sawflies

Insect	Pine	Feeding period of the larvae					
		May	June	July	Aug.	Sept.	Oct.
White pine sawfly *Neodiprion pinetum* (Norton)	White						
Red pine sawfly *Neodiprion nanulus nanulus* Schedl	Red						
Redheaded jack pine sawfly *Neodiprion virginiana* complex	Jack						
A jack pine sawfly *Neodiprion pratti banksianae* Rohwer	Jack						
A jack pine sawfly *Neodiprion pratti paradoxicus* Ross	Jack						
A jack pine sawfly *Neodiprion maurus* Rohwer	Jack						

None of the above sawflies has caused damage sufficient to require large-scale control measures. However, any stomach or contact insecticide would provide adequate control.

Jack pine budworm

The jack pine budworm, *Choristoneura pinus pinus* Freeman, is a major jack pine pest, having caused widespread tree mortality in the northwestern and central parts of Ontario, as well as in Manitoba and Saskatchewan. In addition, trees that are not killed are often deformed, because the heaviest feeding usually occurs first in the top of trees, which causes top-kill and crooked or multiple leaders. Past outbreaks have not lasted long, but trees are damaged somewhere in Ontario every year. Both red and white pine are also damaged, especially in mixed jack pine stands. Heavy feeding has been reported in Scots pine Christmas tree plantations, where any loss of foliage is serious.

The tiny budworm overwinters under bark scales or in other protected places and begins feeding in the spring in the male flowers (see page 111) or on the developing foliage of the new shoot. Later, the larva feeds under loose silken webbing spun about the flowers or needles of the new shoot. When mature, the larva is about 21 mm long. The pupa is usually formed on the shoot. Moths emerge in July or early August, and following mating, eggs are laid on the needles in clusters of about 40. Upon hatching in 2 weeks' time, the tiny larvae, without feeding, spin their silken overwintering shelters.

Damaged tree top

Jack pine budworm mature larva

Egg cluster

During the adult stage and under certain weather conditions, mass flights of moths have initiated new infestations far removed from the original site.

Since jack pine is primarily a forest tree, chemical control measures, in the past, have been applied by government agencies using aircraft only when valuable stands have been threatened. To date some jurisdictions allow a jack pine budworm infestation to collapse naturally. Cultural practices and the use of biological insecticides are alternatives being used to combat infestations or to protect high-value trees. The application of biological insecticides demands precise timing and generally involves the co-ordinated efforts of specialists. In the case of Scots pine Christmas trees or other trees of high value, chemical insecticides are still available and can be applied when the pollen is being shed to reduce foliage destruction.

Jack pine budworm pupa

Adult

Damaged stand of jack pine

Needleminers

At least six kinds of larvae bore into and mine the needles of pine during all or part of their feeding stage but rarely do they attract attention. The most common one is a pine needleminer, *Exoteleia pinifoliella* (Chambers), which occurs primarily on jack pine and occasionally on Scots and red pine in Ontario and Quebec. The tiny moths fly in June and early July and lay their eggs on the needles. On hatching, the larvae construct a mine at the base of the needle inside the sheath. This kills the needle, which turns yellow by late July. In the fall the larvae mine the tips of new needles and overwinter there. Feeding resumes in the early spring, and three to seven more needles are mined by the dark brown larvae, which attain a length of about 6 mm before they pupate in the mine about mid-May. At this time the mined portion of the needle is brown and conspicuous . Although this miner has been occasionally abundant, control measures have not been developed and are probably not necessary.

Typical mined needles

Other less common needleminers can be identified as follows:

On Jack Pine

(a) Pale green or straw-coloured hollow needles containing 8-mm-long banded red and cream larvae in the fall . . . . . banded jack pine needleminer, *Coleotechnites (=Eucordylea) canusella* (Freeman).

(b) Two to four cream to brown needles tied together with silk with one or two of the needles eaten out from one side, in the fall . . . . . jack pine tube moth, *Argyrotaenia tabulana* Freeman (see also page 72).

On Red Pine

(a) Brownish hollow needle associated with bundles of needles tied with silk . . . . . a needlemining tube moth, *Ocnerostoma* species (see also page 72).

(b) Brownish hollow needle containing 9-mm-long red-brown larva and with no associated bundles of tied needles . . . . . red pine needleminer, *Coleotechnites (=Eucordylea) resinosae* (Freeman).

On Scots and Mugho Pine

Tips of needles only mined by young larvae before they enter the buds in early spring in south and southeastern Ontario . . . . . pine bud moth, *Exoteleia dodecella* (Linnaeus) (see also page 39).

Pine needle sheathminer

The pine needle sheathminer, *Zelleria haimbachi* Busck, is a common pest of jack pine from Quebec to Saskatchewan. The moths fly in July and early August and lay their eggs singly on the needles. On hatching, the young larva bores into the needle and overwinters there. In the spring the small tan and dull orange larva migrates to the new growth where it constructs a tube of silk. Later it spins a mass of silken webbing about the bases of needles, which are fed upon by mining the basal area within the sheath . Feeding is completed in late June or July when the larva is about 14 mm long and the change to the pupa occurs on the shoot. No control measures have been necessary for this insect in the past. An insecticide with some fumigant or systemic mode of action would offer the best means of control.

Dead needles and silk

Pine needle scale

Scale insects get their name from the variously shaped hard or soft coverings that the female excretes over her body and that eventually form a protective covering over the eggs. Most people do not realize that such immobile objects are insects. But these insects have passed through a mobile stage, usually of a few days' duration, as minute crawlers before settling down for the remainder of the life cycle. The adult male is a tiny winged insect that is seldom seen.

The pine needle scale, *Chionaspis pinifoliae* (Fitch), occurs on all species of pine throughout their ranges as well as on other conifers. This insect overwinters in the egg stage under the scale, and hatching of the deep red eggs begins in the spring just before the new needles break out of their sheaths. Following the crawler stage, two tiny yellowish scales, the second larger than the first, are produced before the much larger elongated white scale covering of the female is produced. By mid-August development is complete, and eggs may be found under the scale which is about 2.5 mm long . Heavy attack causes the needles to drop prematurely. The scale insects are often preyed upon by lady beetles, and control in the forest has not been necessary. On the other hand, ornamental pines are often heavily attacked , and a dormant oil treatment applied in the early spring or the use of an insecticide may be necessary to maintain the aesthetic quality of the tree. Dormant oil treatments can be used on most pines except for white pine. A contact insecticide would be most effective if used during the crawler stage.

Eggs under scale exposed

Heavy scale on mugho pine

Midges

Three kinds of tiny, maggot-like larvae , less than 3 mm long when full grown, have caused severe premature needle drop on shoots in the upper crown of red, Scots and white pine from Ontario and Wisconsin to the Atlantic. Until recently the identity of the species involved was uncertain. Larvae of the midges that feed inside the needle sheath, usually near the needle base, cause pockets on the surface of the developing needles. When all the needles on the shoot are killed, the shoot dies.

The red pine needle midge, *Thecodiplosis piniresinosae* Kearby, causes late fall browning on the current needles of red pine . Although the larvae feed throughout the summer, the needles do not discolour until late September. The larvae may drop from needles before they are shed or fall to the ground with the needles and spend the winter there.

The European pine needle midge, *Contarinia baeri* (Prell), causes needle droop in red pine and caused needle loss without droop symptoms in Scots pine Christmas trees in recent years. A typical damaged red pine tree is shown . By the time the red pine needles droop, the larvae have dropped to the soil. In the case of Scots pine, the larvae spend the winter in the cast needles.

The white pine needle midge, *Resseliella pinifoliae* (Felt), causes the needles of white pine to drop before they are full grown and while the needle sheath is still present. Larvae apparently overwinter in the soil.

Exposed midge larva

Since the larvae of these three midges live inside the needle sheath, control of these pests will require insecticides with some systemic or fumigant action.

Red pine needle midge damage

Needle droop and larva

European pine needle midge damage

Mites

Two kinds of microscopic worm-like creatures that are species of mites are commonly found inside the needle sheath.

The red pine needle mite, *Setoptus jonesi* (Keifer), is associated with needle droop on red pine. Sporadic, widespread damage appears during the winter or early spring, and large numbers of mites are found on the needles inside the needle sheath. Whether or not there is a causal connection is unknown.

The white pine needle mite, *Trisetacus alborum* (Keifer), is found on white pine, where it prevents needle development, usually in a single cluster that is situated in a yellow discolouration on the shoot . Following heavy attacks, all needles on the shoot will be rusty red the following spring and the buds will be dead. Small shaded trees are particularly susceptible.

No damage prevention measures are known for these mites.

The pine spider mite, *Oligonychus milleri* (McGregor), creates fine webbing among needles and the tiny mites have dorsal setae much shorter than the interval between their bases.

Needle droop caused by red pine needle mite

White pine needle mite damage

Aphids and adelgids

Aphids less than 3 mm long and a similar group, the adelgids, occasionally cause discolouration of pine needles. Some of the species are active, others sedentary; some are covered with a white or grey woolly substance while others are naked. Winged or wingless forms may be present. There are usually many different body forms for one species in a single year.

The spotted black pine needle aphid, *Eulachnus agilis* (Kaltenbach), is a potentially serious pest in plantations of Scots and red pine. It is green to yellowish with dark specks and very active. Its feeding causes discolouration and needle drop of year-old needles, especially in the tops of young trees, with serious consequence for the Christmas tree grower.

Another pest of red and, less often, of jack pine, is the woolly pine needle aphid, *Schizolachnus piniradiatae* (Davidson). It is dark olive green and usually covered with a whitish woolly substance.

Control measures have not been necessary for either of these pests in Canada, but the spotted black pine needle aphid has caused economic losses in the United States. Systemic poisons would appear to offer the best means of control.

Adelgid wool

Winged aphid

Large moth larvae

Larva of imperial moth

Although many species of large moths are associated with pine, only the larvae of a few have caused appreciable feeding injury. The larvae of the imperial moth, *Eacles imperialis* (Drury) , are the largest, about 80 mm long, and are usually found on red and white pine from mid-July to mid-September. They have caused severe defoliation on a few occasions. Their distribution is south of a line from Sault Ste. Marie to Lake Temagami and adjacent areas in Quebec.

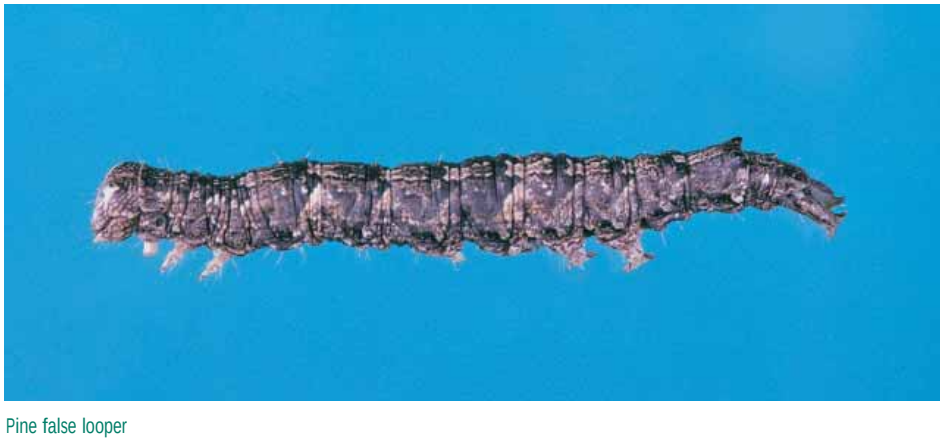
Although larvae of the northern pine tussock moth, *Dasychira (=Parorgyia) plagiata* (Walker), have severely defoliated jack pine stands in Wisconsin for a number of years, these larvae have apparently never appeared in large numbers on pine in eastern Canada. The more common hosts in Canada are white spruce and balsam fir. Full-grown larvae are about 35 mm long and occur mainly in June and July. Three colour phases are shown .

Larvae of the pine tree sphinx, *Lapara bombycoides* Walker , and the pine false loopers of the genus *Zale* , the latter varying in colour, occur commonly but in small numbers, and noticeable injury to pine is unknown. The larva of the pine tree sphinx is about 65 mm long when full grown and occurs mainly in August, while the false loopers are about 40 mm and are usually found in July.

A contact or stomach poison should provide satisfactory control for the larvae of all large moths and many lepidoptera are susceptible to the biological insecticides now available.

Larvae of northern pine tussock moth

Larva of pine tree sphinx



Pine false looper

Loopers

Small pine looper

Pine looper

Striped pine looper

A large group of larvae, due to the arrangement of the abdominal legs, move with a looping or measuring motion. Three of these loopers are found commonly on various pines in late summer and fall. They are the small pine looper , *Eupithecia palpata* Packard, about 18 mm long; the pine loopers of the genus *Caripeta*, about 37 mm long; and the striped pine loopers of the genus *Semiothisa*, about 22 mm long. Moths of these loopers are often attracted to lights. *Caripeta piniata* Packard is a typical moth of this group. None of these solitary larvae has been known to cause serious injury to pine, but should control ever become necessary, a contact or biological insecticide would be effective.

Pine looper adult

Pine tube moths

Pine tube moth damage

The pine tube moth, *Argyrotaenia pinatubana* (Kearfott), probably occurs throughout the range of its host plant, white pine. The greenish larvae live singly in tubes or bundles of needles tied together with silk and feed on the tips of the tube needles. No serious injury is known.

Two additional species with somewhat similar habits, but occurring more rarely, are the jack pine tube moth, *Argyrotaenia tabulana* Freeman, and needlemining tube moths of the genus *Ocnerostoma* on white and red pine. The larvae of these two species do not eat the ends of the tube needles .

Jack pine tube moth damage

Needlemining tube moth damage

Insects in nests of excreta

The nests of coarse excreta and needles tied together with silk usually on red pine and occasionally on other pines, are made by the webspinning sawflies of the genus *Cephalcia* . These web spinners are exceptional among sawfly larvae because of the prominent antennae on the head, the pair of "feelers" at the hind end of the body and the lack of abdominal legs. They are about 22 mm long when full grown. Although these sawflies are occasionally abundant in the Maritime provinces, no large-scale control measures have been carried out.

An introduced species of webspinning sawfly, the pine false webworm, *Acantholyda erythrocephala* (Linnaeus), creates silken tubes among the needles, often incorporating bits of excreta. The larvae are similar to those of *Cephalcia*, although the nests are more tubular around the twig. This sawfly occurs on most species of pine throughout southern Ontario and in northwestern Ontario. Chemical insecticides applied with force would offer the best means of control.

Nest of a sawfly of genus *Cephalcia*

Pine false webworm larva

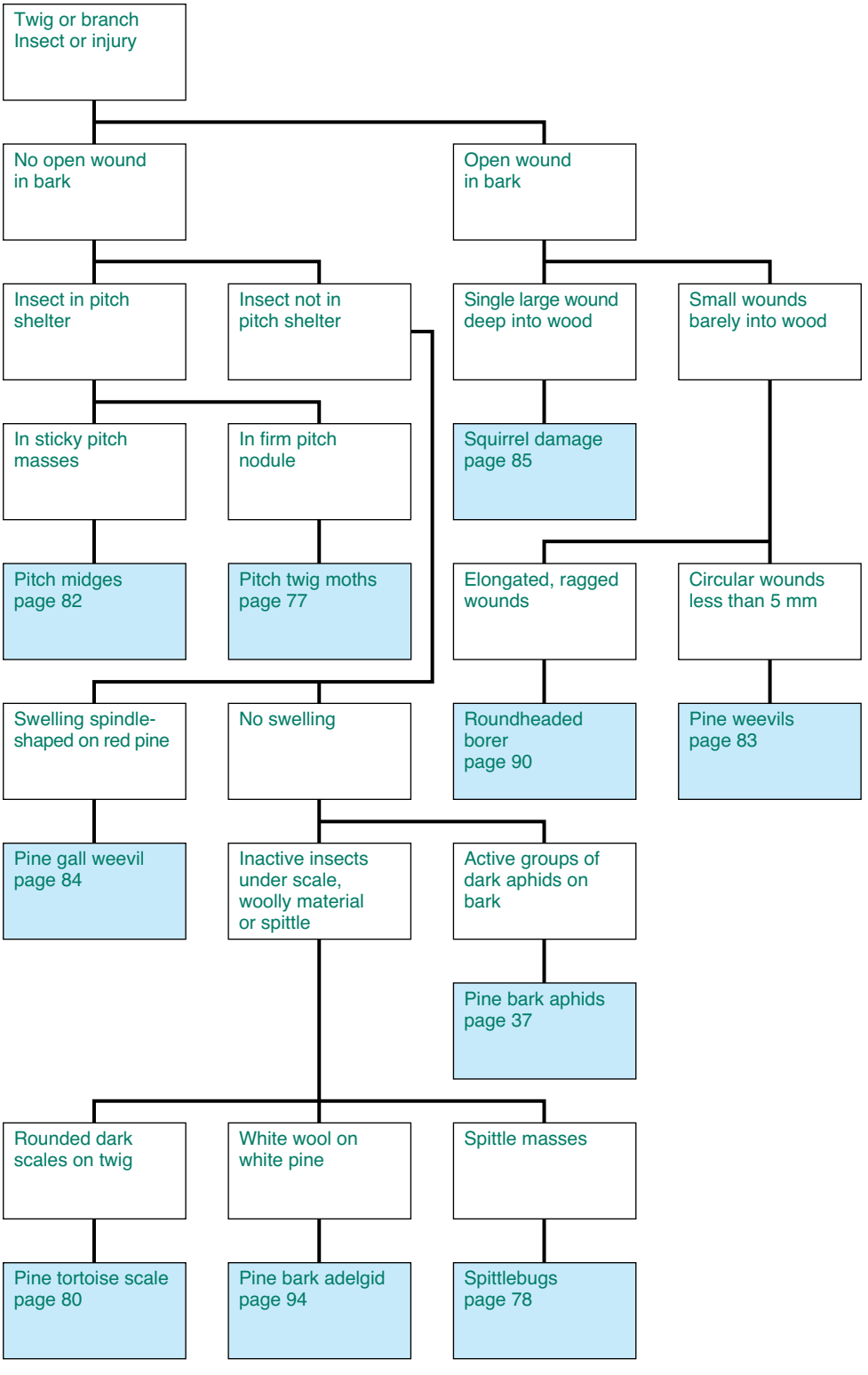
Pine false webworm nest

Nests of fine excreta and needles on jack pine, mainly in southeastern Manitoba and southwestern Ontario, are caused by the pine webworm, *Pococera* (=*Tetralopha*) *robustella* (Zeller) . The larvae are about 15 mm long and can be distinguished from the foregoing sawflies by the presence of five pairs of abdominal legs and the absence of prominent antennae or feelers. Chemical insecticides are registered for use but must be applied with enough pressure to penetrate the nest. During light infestations, handpicking or pruning the infested shoots offers an alternative to using chemicals.

Nest of pine webworm

Twig or Branch

Twig or branch



Pitch twig moths

The northern pitch twig moth, *Retinia (=Petrova) albicapitana* (Busck), is found throughout the range of its primary host, jack pine, and it is occasionally found on other pine. This species is occasionally abundant in local areas, and feeding injury has adversely affected tree form. Two years are required to complete its life cycle. The moths fly in late May to July. The eggs are laid on the new shoots. Upon hatching, the larvae construct their first nodule of pitch and silk where they overwinter. Feeding on bark and wood is resumed in early spring, and a second nodule is constructed adjacent to the original one. In May or early June, the larvae move to the stem and form their final hollow nodules at a crotch where they feed throughout the summer and where they spend the second winter. When full grown the following spring, the pale reddish larvae with yellow-brown heads are about 15 mm long. They pupate in the nodules, completing the life cycle.

Two less common species of pitch twig moths have been reported from eastern Canada, *Retinia (=Petrova) metallica* (Busck) on jack pine and *Retinia (=Petrova) comstockiana* (Fernald) on pitch pine. Chemical control of the nodule makers is difficult because of the larva's concealed feeding habit, and no large-scale measures have been undertaken. Handpicking and destruction of the nodules on high-value trees would provide adequate control.

Pitch nodule

Spittlebugs

The pine spittlebug, *Aphrophora cribrata* (Walker), occurs throughout central and eastern Canada and is a serious pest in Scots pine Christmas tree plantations in Ontario. It is often abundant on white, jack and pitch pines as well as other conifers. The eggs overwinter on the tips of twigs. On hatching in the spring, the young pierce the bark to feed on the sap and soon cover themselves with a frothy mass of spittle made up of tiny air bubbles coated with the partially digested sap. The bubbles protect the insect and are formed by a series of movements of the abdomen while the young spittlebug is feeding. From May to July the young move periodically inward on the branch and when full grown in July they have usually reached the main stem, where many bugs often feed together under large masses of spittle. When the young change to adults in July, the spittle masses soon dry up and a black sooty mould often develops at feeding sites. The adults, which are from 8 to 11 mm long, also feed on the tree's sap throughout July and August but do not form spittle. They do, however, eject undigested sap in the form of a fine mist that drops from heavily infested trees like very light rain. Heavy infestations of spittlebugs may cause twig, branch and tree mortality the following year.

In natural stands, population build-up is often prevented by a fungal disease. In plantations control may be required. Contact or fumigant insecticides are recommended and will be more effective if sprayed when the spittle mass is first seen and the nymphs are young. Since the spittle masses protect the young, insecticide sprays must be applied with force.

Spittle mass

Young spittlebug

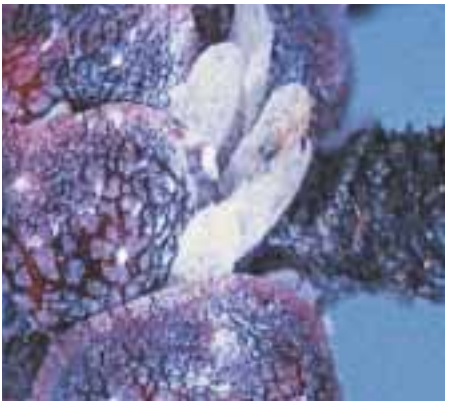
Spittlebug adult

Infested twig

The adults of the Saratoga spittlebug, *Aphrophora saratogensis* (Fitch), have also caused serious injury, primarily to red pine. The spittle masses produced by the young of this species, however, do not occur on pine but on ground-cover plants, especially sweetfern.

Pine tortoise scale

Female pine tortoise scale



Male scale

The pine tortoise scale, *Toumeyella parvicornis* (Cockerell), which is so named because the hard cover of the insect resembles the shell of a tortoise, probably occurs throughout the range of jack pine, its primary host. Populations of sufficient size to cause damage occur somewhere within its range every year and tree mortality has been reported from Saskatchewan to Quebec City. This scale is also found on Scots pine but rarely on red pine. The fertilized females overwinter as dark, wrinkled, half-grown scales. In the spring they become more rounded and change to a reddish-brown colour, reaching about 6 mm in diameter. Eggs are extruded in June to early July and the young crawlers emerge within a few hours. They move to feeding sites on shoots and twigs where they settle and gradually assume the typical scale form. The male scales are long, narrow, flattened and whitish in colour. The tiny, winged adult males emerge in late July or early August to mate with the immature females to complete the cycle. Fertilized females secrete a liquid known as honeydew, and when

Scale and fungus

Black fungus

Lady beetle larva

ants are not present to consume this liquid it spreads over twigs and needles where it supports the growth of a conspicuous sooty black fungus . In the past, infestations have not been of long duration, partly as a result of heavy predation by the woolly white larvae of lady beetles that feed voraciously on both eggs and crawlers. Also, unfavourable weather is apparently an important factor in reducing populations. If chemical control measures become necessary on high-value trees, the crawler stage, in the spring, is the most susceptible and a contact type insecticide should be satisfactory.

Scale and predator

Pitch midges

Pitch midges have been found throughout the range of jack pine. The most common species is the jack pine resin midge, *Cecidomyia resinicola* (Osten Sacken), which often causes twig mortality . Although it is not a serious pest on larger trees, it is capable of killing small trees. The adults emerge from late May to mid-June and lay their eggs on needles or the bark of the new shoots. The tiny larvae feed in pitch masses occurring naturally on the new growth and they stimulate continued flow of pitch by injuring the twig. They overwinter as partly grown larvae, and by the following spring the encrusted pitch masses contain one to three orange larvae that are about 4 mm long. Orange or black pupae are found from May to mid-June. When the adults have emerged, the empty pupal cases remain half protruding from the pitch masses. No chemical control measures are known.

Another species of pitch midge, *Cecidomyia piniinopis* Osten Sacken, also occurs on jack pine but in small numbers and it has not been known to cause serious twig mortality. The larvae are usually found singly in pitch globules near the base of new shoots but leave this site to pupate in characteristic oval whitish cocoons attached to a needle near its tip.

Twig mortality

Orange larvae in pitch

Pine weevils

Pine weevils of the genera *Pissodes* and *Hylobius* are found throughout the range of pine in Canada. In undisturbed forests, damage caused by the feeding of adult weevils is rarely noticed. However, where an abundant supply of brood material such as dead stumps occurs, populations often increase rapidly and feeding by the adults on the tender bark of twigs and young trees may cause considerable twig and tree mortality. The pales weevil , *Hylobius pales* (Herbst), and the northern pine weevil , *Pissodes nemorensis (=approximatus)* Hopkins, often occur in large numbers in areas where Scots pine Christmas trees are being harvested. The removal or treatment of stumps to make them unsuitable as breeding sites will keep population levels down.

Another group of insects that cause small round holes through the bark are bark beetles, in which case small legless larvae and tiny dark beetles will be found in the tunnels. (A bark beetle attacking the stem is described and illustrated on page 92.)

Pales weevil damage

Northern pine weevil damage

Pine gall weevil

Gall

The spindle-shaped galls on branches of red pine are caused by boring larvae, up to 3 mm long, of the pine gall weevil, *Podapion gallicola* Riley, which requires 3 years to complete its life cycle. Adults occur from June to August and apparently do not overwinter. Some may be present each year since three broods are often present in any locality. Although it is a very widely distributed insect, serious injury has not been reported, and control has not been necessary.

Squirrel damage

Tree with discoloured twigs

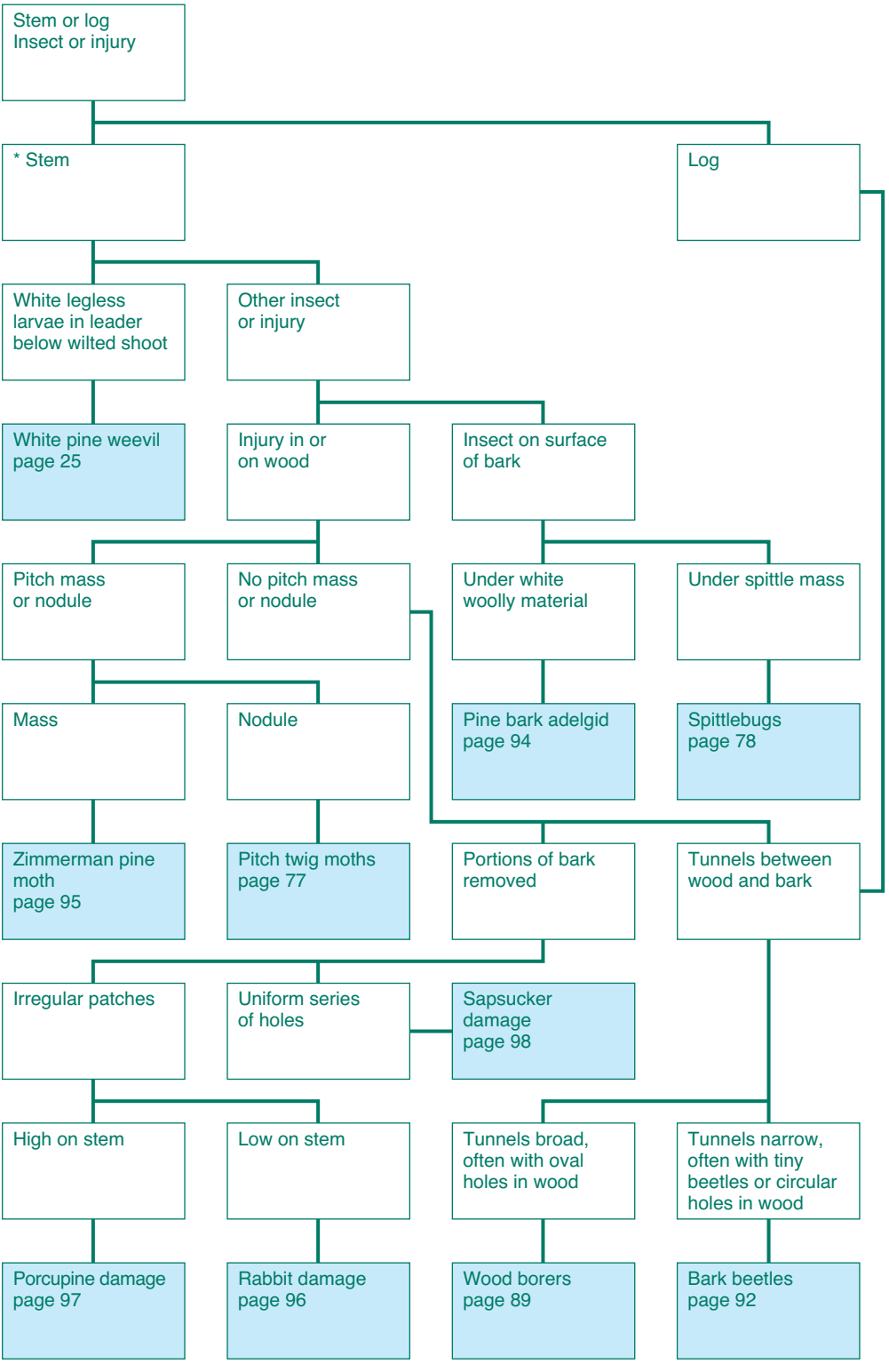
Wound on twig

The red squirrel, *Tamiasciurus hudsonicus* Erxlehen, a common inhabitant of coniferous forests, feeds mainly on nuts, pine cones and fungi. Early in the fall while the cones are still green, squirrels collect and cache them in the ground as a source of winter food. Because cones are deeply attached, large deep wounds are created when the cones are torn from the twigs ▭. Often the twig beyond the scar will die, resulting in discolouration the following spring ▭. Damage may be severe on scattered clumps of jack, red and Scots pine, but no control is usually necessary since damage is seldom repeated the following year. Cone collectors often seek out areas where squirrels are collecting and rob them of their winter food.

Stem or Log

Stem or log

* With thin-barked young stems see also Twig or branch, page 76.



Wood borers

The losses in pine in eastern Canada due to wood borers are probably as great as those caused by any other group of insects. These losses occur in damaged or decadent stands or in wood that has been cut and not removed from the forest. Following a forest fire or other catastrophe, borers concentrate their attack on the abundant brood material; attempts to salvage the wood are usually frustrated by borers that have riddled the wood with their tunnels. In a healthy vigorous forest, borers are of little consequence; indeed they are generally beneficial in that they hasten the return of dead wood to the humus. They are usually considered to be a secondary insect in that they attack dying or recently dead trees. Two families of borers are commonly encountered in pine, the roundheaded and the flatheaded.

A common roundheaded borer is the northeastern borer, *Monochamus notatus* (Drury). Adults are in flight in early and mid-summer. They lay their eggs in slits cut in the bark. On hatching, the young larva proceeds to the wood surface, which is heavily scored by subsequent feeding. The early shallow tunnels on the wood surface are packed with chips of wood and excreta, and in late summer the larvae tunnel into the wood through oval-shaped holes and overwinter deep in the wood. The larvae continue to develop the second summer until they are about 45 mm long, extending their tunnels through the wood but returning occasionally to the wood surface. Pupation occurs at the end of the tunnel just below the wood surface. The adults cut circular exit holes about the size of a lead pencil and emerge. After mating and feeding they seek other dead or dying trees. When adults are abundant following harvesting operations or catastrophes, their feeding on the twigs may cause noticeable flagging on the remaining trees in the stand.

Flatheaded borers, such as the genus *Chrysobothris*, are generally considered to be less important since the larvae, about 30 mm long, do not tunnel as deeply into the wood as the roundheaded borers. Typical entrance holes into the wood are usually quite flat, and the adult emergence holes through the wood and bark are elliptical. Adults feed on foliage or bark, and when populations are high, their feeding can be conspicuous.

Information on the control of borers in logs may be obtained from the appropriate Forestry Centre (see page 12). When borers attack damaged or dying shade trees, control is seldom warranted.

Roundheaded borer

Roundheaded borer adult

Larva

Larval scoring and entrance

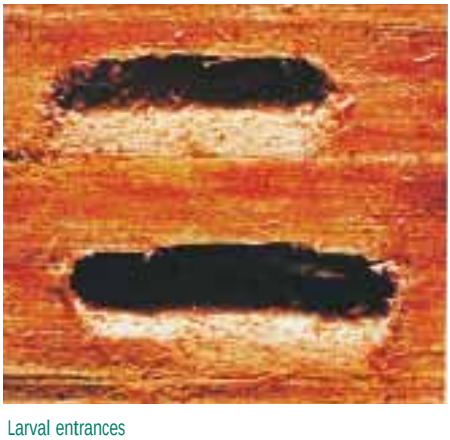
Adult exit holes

Damage from adult feeding

Flatheaded borer

Flatheaded borer larva

Adult



Larval entrances

Bark beetles

Pine engraver adult

There are at least eight species of bark beetles, Scolytidae, that breed on the various species of pine throughout their respective ranges. In central and eastern Canada bark beetles are usually considered to be secondary insects in that they breed in recently dead or dying trees. However, young trees suffering from drought are occasionally attacked and killed. Some bark beetles as well as being host specific may also restrict their breeding sites to particular parts of the tree, i.e., fine branches, large branches or certain portions of the stem.

One of the most common and aggressive species of the bark beetle is the pine engraver, *Ips pini* (Say) . It overwinters in the adult stage in the humus and emerges in the spring, at which time the male cuts a hole through the bark to the wood where a nuptial chamber, the centre of the radiating arms , is formed. The galleries of most species are characteristic of the species. Two to four females join the male and they construct the radiating egg galleries for the first brood. On hatching, the tiny legless larvae

Galleries

Adult exit holes

mine at right angles to the egg gallery and construct a pupal cell at the end of the mine. A generation requires 4 to 5 weeks, and two generations may be produced in 1 year. The original adults may start a second brood at another site. Adults cut small round holes through the bark when they move to new breeding or overwintering sites.

The closely related ambrosia beetles tunnel directly through the bark and a short distance into the wood. The wood above and below the mine becomes darkly stained by the fungus that is the food of both the adult and the legless larvae and from which the name ambrosia beetle is derived.

Ambrosia beetle tunnel with stain

Pine bark adelgid

The pine bark adelgid, *Pineus strobi* (Hartig), probably occurs throughout the range of its principal host white pine; however, serious injury in Canada has been reported only from Quebec, Ontario and, to a lesser degree, Manitoba. Other species of pine are occasionally attacked. Infestations are made conspicuous by the masses of white woolly material secreted on the stem and underside of branches. Young trees may be injured or killed by large populations . Tiny purplish to yellow soft-bodied insects, less than 1 mm long, feed under the woolly material. There are a number of generations each year, and the life cycle includes many different forms, as indicated for other adelgids (see page 38). Control measures have not been required in the forest. Infestations on specimen trees should be treated in the spring with a contact or fumigant insecticide. A dormant oil treatment is also recommended for the control of the pine bark adelgid on all pines except for white pine.

Woolly material on stem

Twig and shoot damage

Zimmerman pine moth

The Zimmerman pine moth, *Dioryctria zimmermani* (Grote), attacks all species of pine. Although an important pest in the northern United States, it is present but has not caused serious injury in central and eastern Canada. The young larvae overwinter under bark flakes and in the spring tunnel under the bark, and masses of pitch and excreta accumulate on the stem . The larvae are full grown in late June or July, grey-green and about 25 mm long . The pupae, light brown, darkening with age to near black, are formed in the tunnels. Adults are present in late summer. Trees with extensive feeding injury are easily broken by wind. If brood trees cannot be removed, control can be achieved by using a contact insecticide when the larvae become active in the spring or when they are entering the bark about mid-August.

Other larvae occasionally found under pitch masses on pine are the pitch mass borer, *Synanthedon (=Vespamima) pini* (Kellicott), with a pale body and a reddish-brown head; the fir coneworm, *Dioryctria abietivorella* (Grote), with a reddish-purple body and brown head (see page 115); and the pale flatheaded borer, *Chrysobothris* species (see page 91 for illustration of typical larva).

Pitch masses

Zimmerman pine moth larva exposed

Rabbit damage

At least two species of rabbits or hares injure pine during the winter when they feed principally on bark and buds of trees and shrubs. They are particularly destructive in young plantations and in natural regeneration; pole-size trees are seldom affected. Feeding usually occurs low on the stem, and the horizontal tooth marks about 3 mm wide are characteristic. Damage is seldom evident until mid- to late summer when whole trees turn red. For a number of years no damage will occur, and then when the peak of the population cycle is reached, dead trees are a common occurrence as a result of girdling. However, high rabbit populations are of short duration and occur only every 10 or 11 years. Constant vigilance and the prevention of large populations by hunting can reduce damage to a minimum.

Typical rabbit damage from feeding

Porcupine damage

The porcupine, *Erethizon dorsatum* Linnaeus, feeds on a wide variety of material including herbaceous plants and the bark of many kinds of trees. The latter forms the sole source of food when herbaceous food is not available, and it is during this time that trees are injured, especially near dens where 20 or more animals may shelter. Dens are located in hollow trees and logs or in caves among rocky outcrops. Feeding usually takes place high in the tree, and girdling resulting in dead tops is not unusual. Since porcupines are colonial most of the year, injury is concentrated but sporadic.

Girdled trees

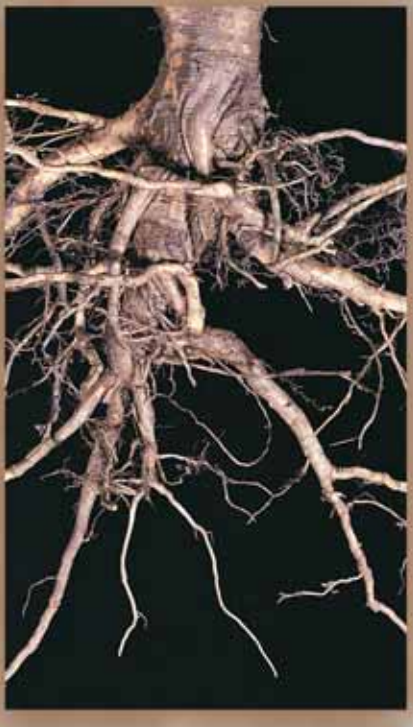
Sapsucker damage

The yellow-bellied sapsucker , *Sphyrapicus varius varius* Linnaeus, a member of the woodpecker family, is a migratory bird with a summer range that includes much of Canada. Although it feeds extensively on insects, it also attacks living trees to feed on the sap and bark tissues . The preferred tree species, birch and hemlock, are often severely injured or killed, but many other species of trees including pine are also attacked. Destruction of the bird or the tree is no guarantee that other nearby trees will not be attacked in the future.

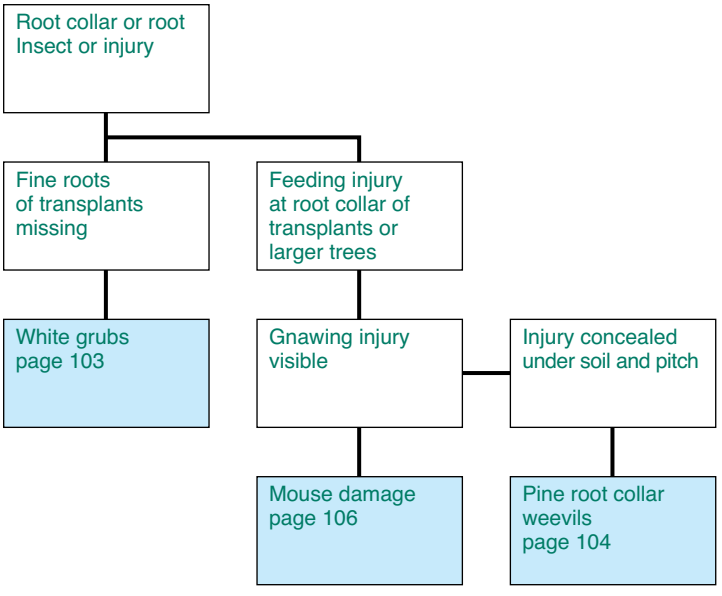
Sapsucker feeding injury

Healthy red pine stem

Root Collar or Root



Root collar or root



White grubs

When pine transplants are placed in soil with a heavy grass or weed cover, the fine roots are often eaten by white grubs, mainly of the genus *Phyllophaga*, causing death or retardation of growth. Severe injury has occurred from time to time in Manitoba, Ontario and Quebec. The various species of white grubs require 2 to 5 years to complete their life cycle depending on species and range. The larvae or white grubs, as they are called, live in the soil and are up to 30 mm long when full grown. They have a brown head and a robust cream-coloured body, the hind part of which has the dark body contents showing through the skin . They are normally found in the soil in a curled position. The adults are heavy-bodied beetles, light to dark brown in colour. They are commonly referred to as "June beetles". The much smaller white grubs of the genus *Serica* may also cause injury to conifer transplants but are a much less serious threat.

Trees planted in areas where white grubs are common should have their roots treated with a stomach poison.

White grub in soil

Adult

Pine root collar weevils

Pine root collar weevil larva

The pine root collar weevil, *Hylobius radicis* Buchanan, has caused extensive mortality of Scots pine in plantations in southern Ontario and in the Sandilands Forest Reserve in Manitoba. Other species of pine are attacked less often. The legless white larvae with brown heads feed under the bark at the root collar. The flow of resin at the points of feeding forms a heavy layer of pitch and soil about the root collar. Removal of the pitch-encrusted soil will reveal the girdling . In southern Ontario the weevil overwinters as a larva, pupa or adult. Larvae of various sizes may be found throughout the summer feeding season. When full grown and about 15 mm long, the larvae usually move out into the soil to pupate in earthen cells. The adults normally survive to breed for 2 consecutive years. They, too, feed on the inner bark at the base of the tree and occasionally on the bark of twigs and small branches. Mortality of trees from the feeding of the larvae is greatest in plantation trees less than 10 cm in diameter at breast height. Even before death, weakened

Girdled stem

Tree mortality

trees often lean over or topple in a strong wind. The pine root collar weevil is associated with trees growing in light sandy soil on dry sites. A closely related root collar weevil, *Hylobius warreni* Wood, with feeding habits similar to the preceding species, is found in all the provinces and has caused serious injury in pine plantations in Ontario, Quebec and Newfoundland. It attacks a wide range of conifers, especially when they grow on moist to wet sites.

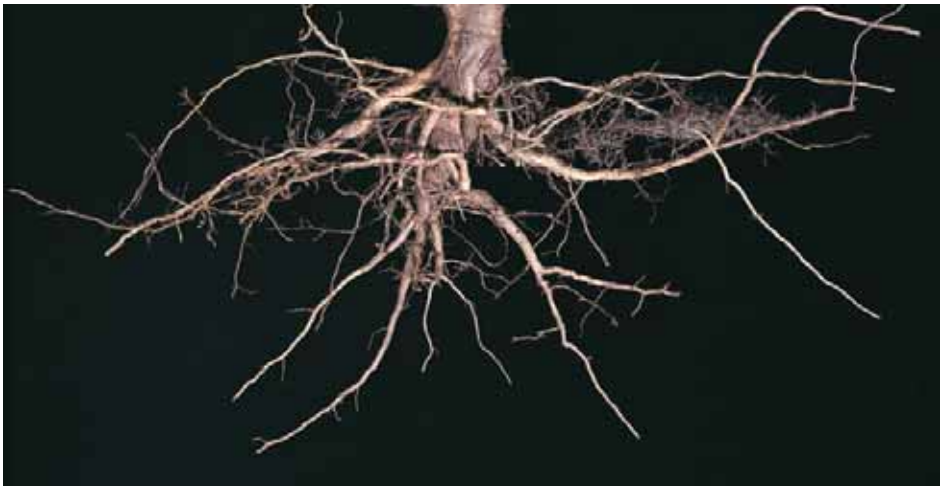
Control of the root collar weevils is difficult because the larvae are concealed feeders. A number of silvicultural practices have been suggested for reducing populations as well as sanitation and soil fumigants.

Pine root collar weevil adult

Mouse damage

Typical damaged plantation

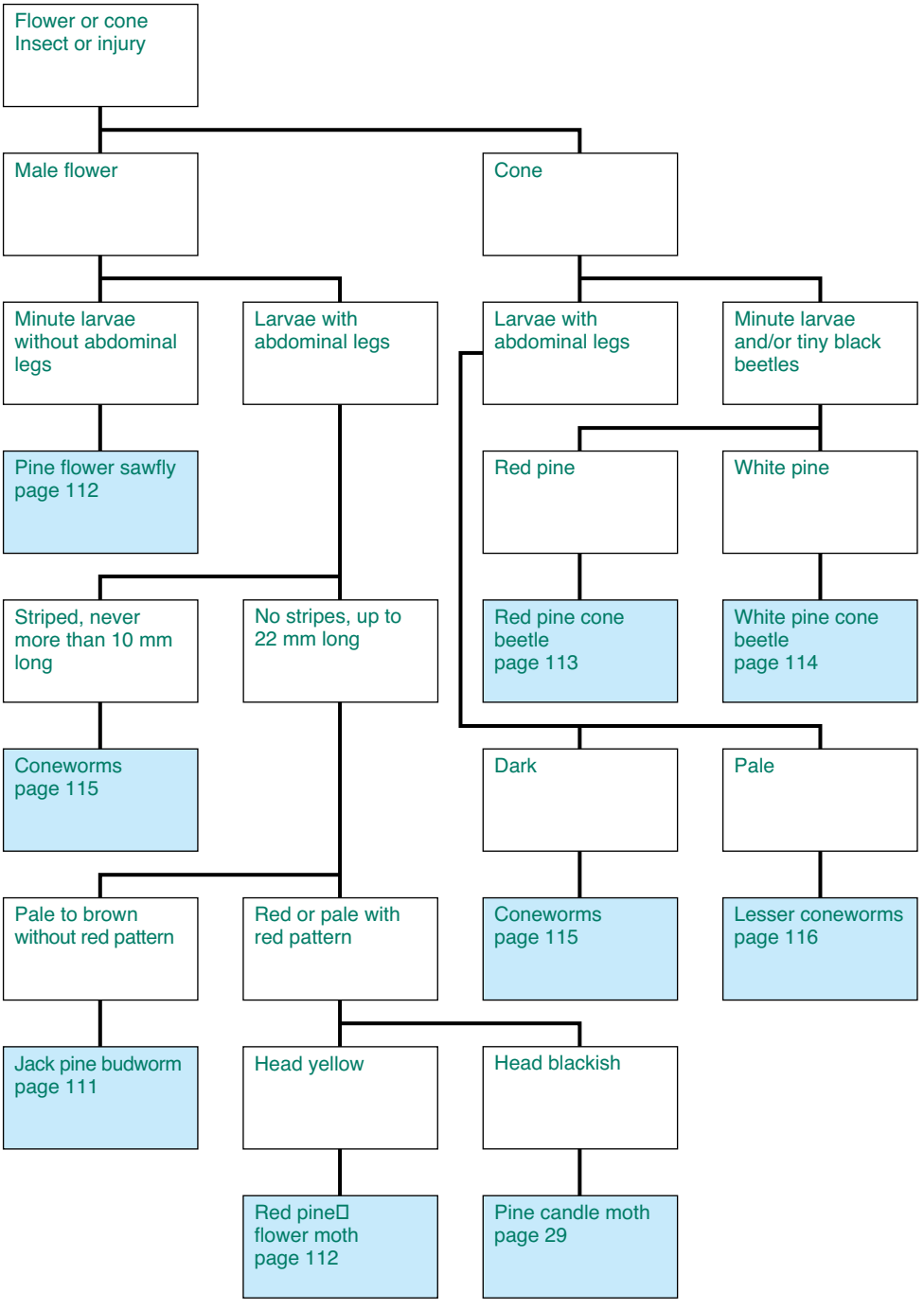
Mice often cause serious injury to young pine transplants. When snow is deep and other winter food becomes scarce, heavy feeding by mice on the bark at the base of trees often results in girdling. The full extent of the injury can usually not be assessed until the following fall, because many of the trees that were girdled do not die immediately. Heavy weed and grass cover in plantations provides favourable mouse habitat , so good weed and grass control should eliminate potential injury by the mouse. Knowledge of mouse populations would permit preventive measures to be taken when the pest is abundant.



Healthy Scots pine root

Flower or Cone

Flower or cone



Jack pine budworm

Flowering shoot

Young jack pine budworm larva

The jack pine budworm, *Choristoneura pinus pinus* Freeman, is often found in the male flowers of pine . The young larvae are pale orange or cream, darkening as they mature. For more information on this species, see page 57.

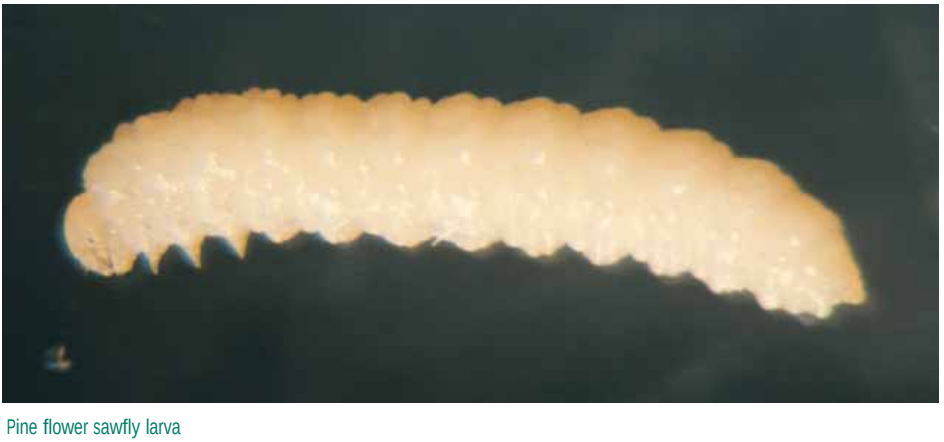
Red pine flower moth

A red pine flower moth, *Coleotechnites* (=*Eucordylea*) *florae* (Freeman), is often abundant in the flowers of red pine in southern Ontario and is found on jack pine in the Prairie provinces. In southern Ontario, the larvae have been collected from male flowers from late May to mid-July. They are about 9 mm long. The head is yellow and the body cream-coloured with a red pattern on the back . No control is known.

Pine flower sawfly

The pine flower sawfly, *Xyela minor* Norton, probably occurs throughout most of the range of jack pine in eastern Canada. The larvae have been found in the male flowers of jack and red pine in Ontario. The tiny whitish larvae have rudimentary legs on the thorax only and are about 5 mm long when full grown . No control is known.

Red pine flower moth larva



Pine flower sawfly larva

Red pine cone beetle

Red pine cone beetle adult

The red pine cone beetle, *Conophthorus resinosae (=banksianae)* Hopkins, is perhaps present wherever its host occurs in substantial numbers. In Ontario it is probably the most destructive pest of red pine cones. The adult beetles are red to black, cylindrical and about 2.5 mm long. They enter the second-year cones at the base and bore into the cone centre and lay their eggs there from May to mid-July. The larva is white with a yellow head. It feeds indiscriminately on seeds and scales and when full grown pupates in the cone. The new adults start emerging from the withered cones in late July and bore into small shoots and tunnel towards the bud. During the fall the mined shoots break off, and the beetles overwinter in the shoot tips on the ground . When cones are scarce, the beetles can complete their life cycle in red and jack pine shoots. Gathering and destroying the fallen shoots and cones appear to offer the best means of control.

Mined tips

White pine cone beetle

White pine cone beetle adult

The white pine cone beetle, *Conophthorus coniperda* (Schwarz), is an important pest throughout the range of its host, white pine. The shiny black adults ▭ (similar to one on page 113) overwinter mainly in cones on the ground. In the spring the female bores into second-year cones on the trees to lay her eggs. The small whitish larvae feed and eventually pupate in the larval tunnels. Pupae start changing to adults in late July and usually remain in the same cone until the following spring. The infested cones ▭, with petiole weakened by the entrance hole of the beetle, drop to the ground throughout the spring and summer. When 2-year-old cones are scarce, the beetles will attack conelets, new shoots, male flowers or buds. Control is the same as for the red pine cone beetle.

Damage in cone

Coneworms

Fir coneworm

Various kinds of coneworms occur on pine in central and eastern Canada, but only two species have been known to cause serious damage. The young larvae of the webbing coneworm, *Dioryctria disclusa* Heinrich, are striped white and purple. They feed in the male flowers in the spring and attack second-year cones in early June to July. Masses of characteristic reddish-brown excreta form in silk spun between the attacked cone and nearby needles. The full-grown larva is about 16 mm long with an olive green to purple-brown body with small pale spots. The head is pale brown to reddish.

The fir coneworm, *Dioryctria abietivorella* (Grote), feeds in the cones of pine as well as in a variety of sites on many conifers. It has a considerable overlap in generations, and larvae occur in cones from spring to fall. The full-grown larva is from 15 to 25 mm long, reddish purple and has a dark brown head. A systemic insecticide appears to offer the best means of controlling the coneworms.

Webbing coneworm larva damage

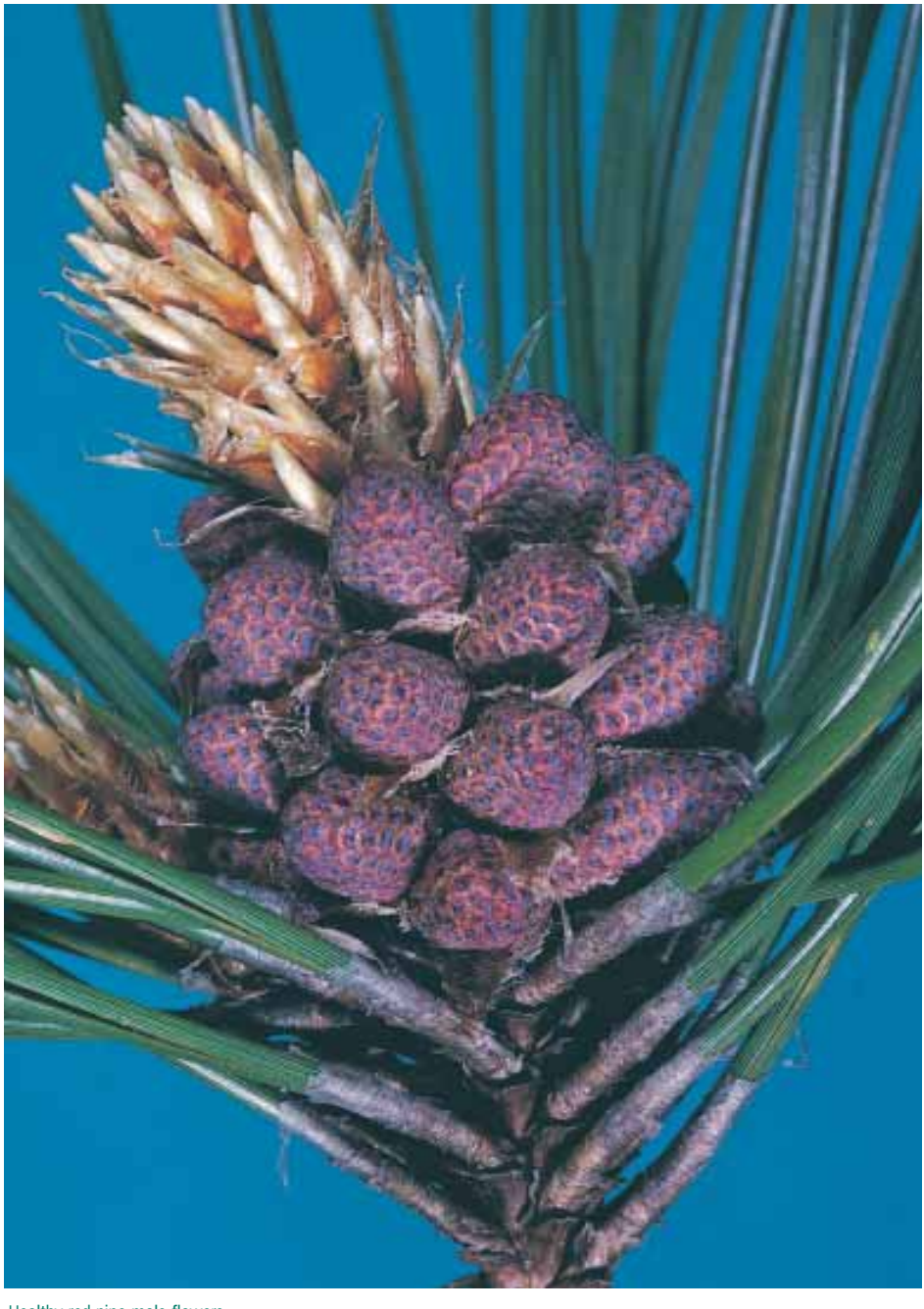
Lesser coneworms

The red pine cone borer, *Eucosma monitorana* Heinrich, is known from Ontario and Quebec. In Ontario the moths are in flight in May. The larvae burrow in the green second-year cones of red pine in June and July and pupate in the soil. When full grown, the larvae are about 12 mm long with pale body and orange-brown head.

The white pine cone borer, *Eucosma tocullionana* Heinrich, attacks the cones of white pine and is known from southern Ontario east to the Maritime provinces. The larvae are similar to *monitorana* in both appearance and seasonal occurrence.

The eastern pine seedworm, *Cydia (=Laspeyresia) toreuta* (Grote), feeds in second-year cones of jack and red pines in Ontario. The moths are in flight in June, and the larvae tunnel in the cones from early July to early September. They overwinter in the cone where they usually pupate in May.

Systemic insecticides appear to offer the best means of control.



Healthy red pine male flowers

Discoloured Foliage

Discoloured foliage

Needles on branches or whole trees sometimes turn brown, and no obvious cause of injury is found. This does not necessarily mean the death of an affected part. Indeed, when the oldest needles, those closest to or lowest on the stem, turn yellow-brown from late August on, a normal phenomenon is occurring, as pines annually drop needles that are 3 or more years old . On the other hand, in semi-urban areas where buildings and homes are being constructed, trees will turn brown and die because of radical changes in the underground environment, such as soil compaction or pollution, or changes in the water table level. Secondary insects soon attack these trees and they will be found under the bark. Air pollutants are also common causes of foliage injury. Noxious gases from manufacturing plants often cause fume damage to susceptible foliage throughout the crowns of trees over large areas . Indiscriminate use of pesticides will affect only that portion of the foliage contacted, and damage will not be widespread . Salt-spray injury is found along heavily travelled highways in the spring following the use of melting agents during the winter, and it affects only those parts of the tree above the snow line. Tree mortality does not occur in each instance of air pollution injury. Unless the injury is repeated, the trees will recover. Another cause of discoloured foliage is physiological in origin: winter browning , so called because the symptoms usually occur during the winter, is prevalent on exposed trees subjected to wide temperature changes and strong winds that desiccate the needles. Such damage may be widespread in some years, and again only parts of the tree above the snow line are affected, but whole trees may be killed when all foliage is affected.

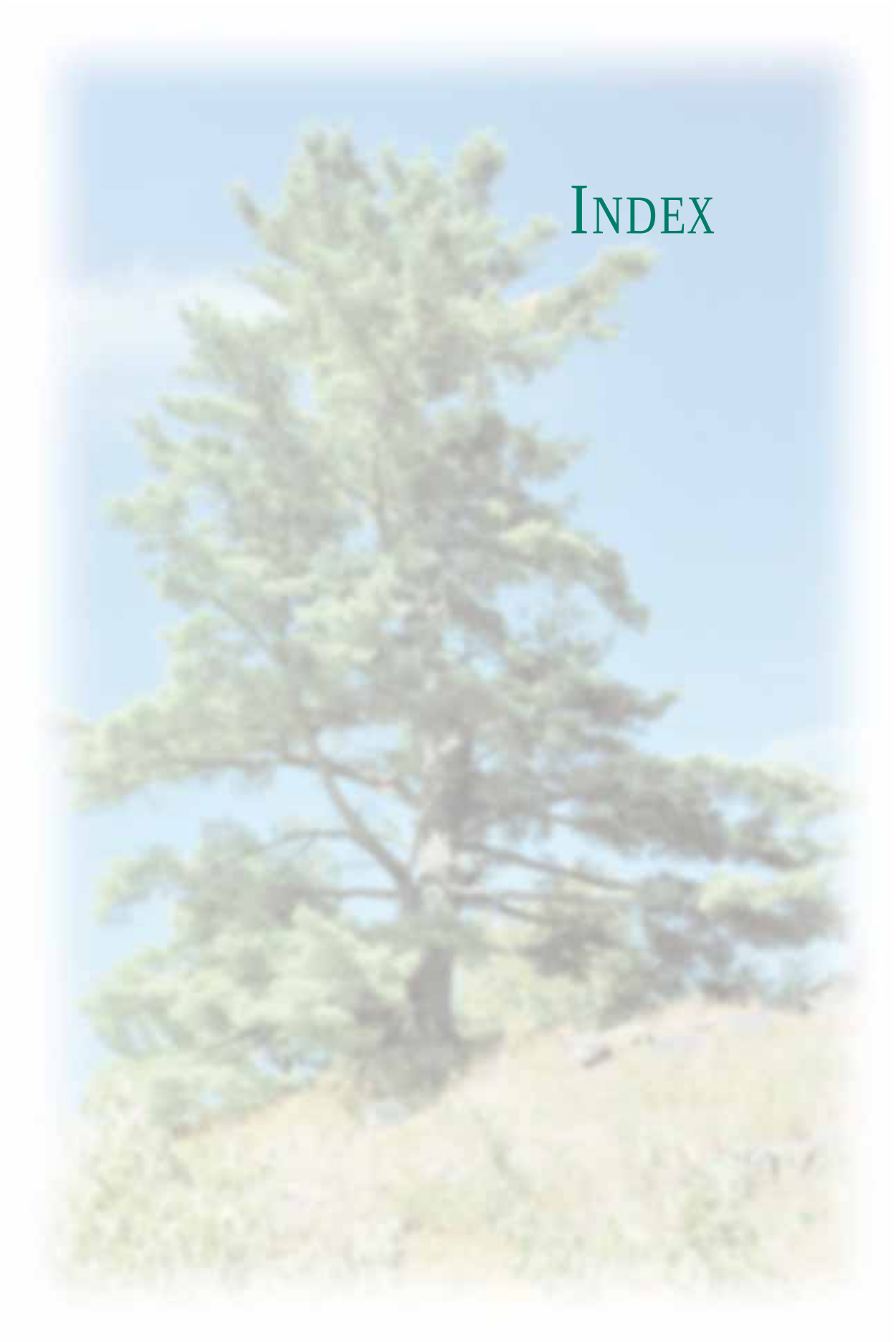
Normal needle drop

Winter browning

Fume injury

Salt injury

Herbicide injury



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